مجلة تاريخ العلوم العربية

مجلة تاريخ العلوم العربية

المجلد التاسع العددان الأول والثاني ١٩٩١

محتويات العدد

القسم العربي

الابحـاث :

ملخصات الابحاث المنشورة في القسم الاجنبي

مراجعات الكتب

افتتاحية وتعميم

تعود مجلة تاريخ العلوم العربية للظهور ثانية، بعدما تعثرت وتأخرت لأسباب خارجة عن إرادة معهد التراث العلمي العربي وإننا نأسف لذلك .

وإننا نشكر كافة المشتركين في المجلة من باحثين ومؤسسات علمية على صبرهم وتفهمهم لظروفنا الطارئة ، ونأمل بأن تصدر المجلة من الآن فصاعداً بانتظام كسابق عهدها .

ونظراً لعدم إمكانية اصدار مجلدات عن الفترة السابقة، فإننا اعتبرنا الفترة مابين ١٩٨٥ ــ ١٩٩٠ م فترة توقف ، مع المحافظة على تسلسل المجلدات وبالتالي على حقوق المشتركين كاملة .

ستجدون في هذا المجلد نتاج عمل الباحثين الدؤوب في الكشف عن التراث العلمي في الحضارة العربية والاسلامية ، وقد تضمن هـذا المجلد أبحاثاً غنية ومتنوعة تتطرق لمواضيع شتى في الطب والفلك والرياضيات .

مدير معهد التراث العلمي العربي
الاستاذ الدكتور خالد ماغوط

كتاب الشكوك على جالينوس *

لمحمد بن زكريا الرازي

مهدي محقق

ابو بكر محمّد بن زكريا بن يحيي الرّازي الملقّب بجالينوس العرب[1] وطبيب المسلمين[2] وعلاّمة علوم الأوائل[3] كان من أعظم علماء الإسلام شهرة وأشهرهم علماً. درس الرّازي عند عدّة من علماء بلاد خراسان وما وراء النهر وطبرستان مثل ابي العبّاس الإيرانشهرى النيّشابوري[4] وأبي زيد البلخي[5] وعليّ بن ربّن الطّبرى[6] وتوغّل في الأعمال الطبيّة في مستشفيات الرّى وبغداد حتّى اشتهر بالطبيب المارستاني[7] وكذا ناقض وناظر علماء زمانه من جملتهم ابو القاسم الكعبيّ البلخي[8] في العلم الإلهي ومسألة الزّمان وأحمد بن الحسن المسمعي[9] في مسألة قدم الهيولى وابو العبّاس النّاشى الأكبر[10] في إثبات الطب وابو الحسن شهيد بن الحسين البلخي[11] في

* ألقي البحث في الندوة العالمية الرابعة لتاريخ العلوم عند العرب بحلب في نيسان – ١٩٨٧ م .

١ – ابن ابي اصيبعه ، **عيون الأنباء في طبقات الاطباء** (بيروت ٦٣ – ١٩٦٥) ، ص ٤١٥ .

٢ – القفطى ، **أخبار الحكماء** (ليبزيك ١٩٠٣) ، ص ٢٧١ .

٣ – ابن تغري بردي ، **النجوم الزاهرة في أخبار مصر والقاهرة** (قاهره ١٣٤٨ – ١٣٦٩)، ج٣ ص٢٠٩ .

٤ – ناصر خسرو ، **زاد المسافرين** (برلين ١٩٤١) ، ص ٩٨ .

٥ – ابن النديم ، **الفهرست** (طبعة فلوجل) ، ص ٢٩٩ .

٦ – القفطى ، **اخبار الحكماء** ، ص ٢٣١ .

٧ – ابن جلجل ، **طبقات الأطباء والحكماء** (قاهره ١٩٥٥) ، ص ٧٧ « **مارستان** » مخفف « بيمارستان » بمعنى المستشفى .

٨ – ابن المرتضى ، **طبقات المعتزلة** (بيروت ١٣٨٠) ، ص ٨٨ .

٩ – المسعودي ، **التنبيه والإشراف** (بغداد ١٣٥٧) ، ص ٣٤٢ .

١٠ – ابن المرتضى ، **طبقات المعتزلة** ، ص ٩٣ .

١١ – ياقوت حموي ، **معجم البلدان** (ليبزيك ١٨٦٦) ، ج ٢ ص ١٦٧ .

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مسألة اللذّة وأحمد بن محمد ابو طيب السرخسي[١٢] في أثر الطعم المر واحمد بن كيال[١٣] في مسألة الإمامة .

والدليل على جلالة قدر الرازي في العلم أن ابا الريحن البيروني برغم انه كان مخالفاً للرازي في بعض عقائده الفلسفية والدينية ألف كتاباً ذكر فيه آثار الرازي على حسب الموضوعات المختلفة العلمية[١٤] أعنى الطب والطبيعيات والمنطق والرياضيات والنجوم وتفاسير كتب القدماء وتلاخيصها والفلسفيات والتخمينيات وما فوق الطبيعة والكيمياء والكفريات والفنون المختلفة الاخرى .

وفي جملة كتبه في الطبيعيات يذكر البيروني كتاب « الشكوك على جالينوس »[١٥] ومع الأسف ما بقي لنا من ذلك الكتاب القيم إلا ثلاث نسخ يظن انها ترجع إلى أصل واحد وبرغم ان الكتاب مفيد جداً لطالبي تاريخ الطب في الإسلام ما طبع حتى الآن . والغرض من كاتب هذه المقالة أن يعرّف الكتاب إلى العلماء الحاضرين في هذا المجلس الشريف على حسب الطاقة والاستطاعة .

قبل الخوض في أصل البحث لابد أن نشير إلى ان لفظ « الشك » يعادل اللفظ اليوناني **Aporia** الذي يؤدي معنى الضيّق والعسر والورطة والحيرة ، وفي مجال الجدال الفلسفي يدل على الصعوبة والمشكلة والمعضلة واقتران لفظ الشك أو مقابله اليوناني بالحرف « على » **Pros** يقربه من معنى الاعتراض والنقد[١٦] . فغرض الرازي في كتابه إثارة الشكوك أو الاعتراضات على مواضع مشكلة تورط فيها جالينوس في مؤلفاته .

ولد جالينوس في سنة ١٣٠ م . في مدينة **Pergamon** التي عربت بفرغامس أو فرغامن من بلاد آسيا الوسطى ومات في سنة ٢٠٠ م . في سيسيل وترك آثاراً عديدة في العلوم المختلفة خاصة في الطب والفلسفة . الف جالينوس في حياته فهرساً لمؤلفاته

١٢ — ياقوت حموي ، **إرشاد الاديب** (قاهرة ١٩٢٤) ، ج ١ ص ١٥٨

١٣ — مقدسي ، **البدء والتاريخ** (باريس ١٨٩٩ — ١٩١٩) ، ج ٥ ص ١٢٤ .

١٤ — نشرة بول كراوس (باريس ١٩٣٦) نشرة مهدي محقق مع المشاطة لرسالة الفهرست لغضنفر التبريزي (تهران ١٩٨٧)

١٥ — البيروني ، **الرسالة** ، رقم ٨٨ .

١٦ — عبد الحميد صبره ، **مقدمة الشكوك على بطلميوس لابن الهيثم** ، (قاهره ١٩٧١) ، ص م .

وذلك الفهرس يسمى « فينكس »[١٧] أو « بينكس »[١٨] من Pinax اليونانية بمعنى القائمة وألف كتاباً آخر في كيفية تقدم كتبه وتأخرها في القراءة ويسمى « في مراتب قراءة كتبه »[١٩] . اشتهرت آثار جالينوس بعده وكثر تابعوه وتلامذته وانتشروا في البلاد ودرسوا آثاره في المدارس والمعابد . وبعد مدة اختفت النصوص اليونانية في زوايا الأديرة والمعابد ونسيت أو كادت تنسى ولكن المترجمين الاسلاميين ترجموا جلّ آثاره من اليونانية الى السريانية والعربية ، وفي العصور الوسطى في اوربا ترجمت من العربية الى اللاتينية[٢٠] حتى انتهى الى عصر النهضة الذي اكتشفت فيه آثاره اليونانية وترجمت الى اللاتينية ثم الى اللغات الأخرى .

اشتركت في ترجمة آثار جالينوس في العصر الاسلامي عدد كثير من المترجمين ولحنين بن اسحق العبادي المشهور بحنين الترجمان المتوفى سنة ٢٦٠هـ[٢١] سهم كبير في امر ترجمة كتب جالينوس وقد بقيت منه رسالة يذكر فيها الكتب التي ترجمها من جالينوس[٢٢] وهذه الكتب كانت سبباً في شهرة جالينوس بين المسلمين حتى صار اسمه في الادب دالاً على الكمال في فن الطب يقول المتنبي :

لما وجدت دواء دائي عندها هانت عليّ صفات جالينوسا[٢٣]

كان الرازي من أقدم العلماء الذين توجهوا نحو آثار جالينوس واستفادوا منها حتى انه وجد كتبا له لاتوجد في فهرست حنين بن اسحق ولا في فهرست جالينوس نفسه[٢٤].

١٧ — حنين بن اسحق ، **الرسالة** ، ص ٢ « وسماه فينكس وترجمته الفهرست » .
١٨ — ابن ابي اصيبعة ، **عيون الأنباء** ، ص ١٣٤ .
١٩ — في اللاتينية **De Ordine Librorum** .
٢٠ — ارجع **Durling, R. J. Achronological Census of Renaissance Editions and Translations of Galen, *The Journal of the Warburg and Courtanld Institute*, Vol. XXIV, Nos 3 – 4 , 1961, P. 233** .
٢١ — ابو زيد حنين بن اسحق العبادي المتوفى ٢٦٠ (ابن النديم) أو ٢٦٤ (ابن ابي اصيبعه) علي بن ربن الطبري يذكره مع لقب « الترجمان » ، **فردوس الحكمة** (برلن ١٩٢٨) ، ص ٨ .
٢٢ — **رسالة إلى علي بن يحيى في ذكر ما ترجم من كتب جالينوس بعمله وبعض ما لم يترجم**، مع الترجمة التي عملها برجستراسر **Bergstrasser** (ليبزيك ١٩٢٥)
٢٣ — **ديوان المتنبي** (طبعة ديتريصى برلن ١٨٩١) ، ص ٩٤ .
٢٤ — يذكر ابن أبي اصيبعه كتابا للرازي باسم : « **فيما استدركه من كتب جالينوس ولم يذكرها حنين ولا هي في فهرست جالينوس** » **عيون الا نباء** ، ص ٤٢٤ .

وقد كان الرازي متابعا لآراء جالينوس لا في الطب فقط بل كان يحذو حذوه في الفلسفة والأخلاق أيضاً فلا عجب أن نرى أنه يصرّح في ابتداء كتاب الشكوك بهذه العبارة :

« ... إذ كنت قد بليت بمقابلة من هو أعظم الخلق على منّة وأكثرهم لي منفعة ، وبه اهتديت وعلى أثره اقتفيت ومن بحره استقيت بما لاينبغي أن يقابل به العبد سيّده والتلميذ استاذه والمنعم عليه ولي نعمته »[٢٥] وكذا نجد بعض عناوين كتب الرازي تطابق عناوين كتب جالينوس نحو « البرهان » و « فيما يعتقده رأيا » و « في منافع الأعضاء »[٢٦] وقد لخص الرازي بعض الكتب المهمة لجالينوس نحو « اختصار كتاب النبض الكبير » و « تلخيص لحيلة البرء » و « تلخيصه للملل والأعراض » و « تلخيصه للأعضاء الآلمة »[٢٧] وهو يصرّح في كتاب الشكوك كان مقدما على ارسطو بهذه العبارة :

« ولقد كان رجل وجيه بمدينة السلام ممن يميل إلى ارسطاطاليس يقرأ معي كتب جالينوس فإذا بلغ إلى أمثال هذه المواضيع أكثر لومي وتعسفى على تفضيله وتقديمه وكان يعلم الله كثيراً ما يخجلني علو حجته عليّ في هذه الاشياء »[٢٨] وجدير بالذكر ان الرازي يميل إلى افلاطون في كثير من المباحث التي يخالف جالينوس فيها ارسطاطاليس ويوافق افلاطون مثل مسألة اللذة والألم ومسألة النفوس الثلاثة ولهذا يقول صاعد الاندلسي في حق الرازي : « وكان شديد الانحراف عن ارسطاطاليس وعائبا له في مفارقة معلمه افلاطون وغيره من متقدمي الفلاسفة في كثير من آرائهم »[٢٩] .

الف الرازي كتاب الشكوك بعد قراءة مصنفات جالينوس المهمة ولهذا وجد مواضع الشكوك في كتبه المختلفة والتناقض فيها في المسائل المتعددة. وقد يسمى ابو الريحان

٢٥ – الرازي ، **كتاب الشكوك** ، مخطوط مكتبة ملك تهران مجموعة ٤٥٧٣ ، ص ١ من نفس الكتاب.

٢٦ – ابن ابي اصيبعة ، أرقام ٢ ، ١٩٠ ، ١٩١ من آثار الرازي . حنين بن اسحق ، **الرسالة** ، ارقام ١١٥ ، ١١٣ ، ٤٩ من آثار جالينوس .

٢٧ – البيروني ، **الرسالة** ، ارقام ١٠٨ ، ١٠٩ ، ١١٠ ، ١١١ من آثار الرازي . حنين بن اسحق ، **الرسالة** ، ارقام ٢٦ ، ٢٠ ، ١٤ ، ١٥ من آثار جالينوس .

٢٨ – الرازي ، **كتاب الشكوك** ، ص ١٦ .

٢٩ – ابو القاسم صاعد بن احمد ، **طبقات الأمم** (بيروت ١٩١٢) ، ص ٣٣ .

البيروني في فهرسته هذا الكتاب « الشكوك على جالينوس »[٣٠] وابن ابي اصيبعه يسميه « الشكوك والمناقضات التي في كتب جالينوس »[٣١] وقد وجدنا في النسخة التي استفدنا منها ونرجع إليها هذا العنوان « كتاب الشكوك للرازي على كتاب فاضل الأطباء جالينوس في الكتب الذي نسب إليه »[٣٢] .

ويجب أن نذكر ان الاسكندر الافروديسي[٣٣] نقض آراء جالينوس[٣٤] قبل الرازي وكذلك يحيى النحوي الإسكندراني وضع كتابا سماه الشكوك أورد فيه ما يزعمه اغلوطات جالينوس[٣٥] .

وقد أشار محمد بن سرخ النيشابوري الفيلسوف الإسماعيلي في كتابه الذي يشرح فيه قصيدة أبي الهيثم الجرجاني إلى كتاب الشكوك للرازي ثم يذكر ان رجلا في زمان الرازي وضع كتابا وسماه الشكوك على محمد بن زكريا وإذا رأى الرازي هذا الكتاب قال : « منزلتي عنده كمنزلة جالينوس عندي » ثم اقر الرازي باشتباهات نفسه[٣٦] ولنا شك في صحة هذه الاسطورة ولكن من المسلم به ان ابن ابي صادق[٣٧] وابن رضوان المصري[٣٨] وابا العلاء بن زهر[٣٩] وضعوا كتباً باسم « حل شكوك

٣٠ – البيروني ، **الرسالة** ، رقم ٨٨ .

٣١ – ابن ابي اصيبعة ، **عيون الأنباء** ص ٤٢٢ .

٣٢ – مخطوطة مكتبة ملك تهران ، ص ١ .

٣٣ – **Alexander of Aphrodisias** .

٣٤ – يذكر ابن ابي اصيبعة منه : « مقالة في الرد على جالينوس في المقالة الثامنة من كتابه في البرهان » «مقالة في الرد على جالينوس فيما طعن على قول ارسطاطاليس ان كل ما يتحرك فانما يتحرك عن محرك » مقالة في الرد على جالينوس في مادة الممكن » **عيون الأنباء** ، ص ١٠٦ .

٣٥ – يقول علي بن رضوان المصري في رسالة منه إلى ابن بطلان البغدادي : « وأعجب من هذا ان يحيى النحوي وضع كتاباً سماه الشكوك يوضح فيه ما يزعمه اغلوطات جالينوس » **خمس رسائل** (قاهره ١٩٣٧) ، ص ٧٥ .

٣٦ – محمد بن سرخ النيشابوري، **شرح قصيدة ابو الهيثم احمد بن حسن الجرجاني** (تهران ١٩٥٥) ص٥٢ .

٣٧ – يقول ابن ابي اصيبعة عند ترجمة احوال ابو القاسم عبد الرحمن بن ابي صادق من رجال القرن الخامس : «وكتب ابو القاسم بخطه حل شكوك الرازي على كتب جالينوس»، **عيون الأنباء**، ص٤٦١

٣٨ – يذكر ابن ابي اصيبعة لابي الحسن علي بن رضوان المصري المتوفى ٤٥٣ كتاب « في حل شكوك الرازي على كتب جالينوس » ، **عيون الانباء** ، ص ٥٦٧ .

٣٩ – يذكر ابن اصيبعة لابي العلاء زهر بن ابي مروان **Avenzoar** المتوفى ٥٢٥ كتاب « حل شكوك الرازي على كتب جالينوس » **عيون الأنباء** ، ص ٥١٩ .

الرازي على كتب جالينوس » . ويشير ابن ميمون القرطبي إلى رد ابن رضوان وابن زهر في كتاب فصوله[٤٠] وكان كتاب ابن رضوان في يد ابن أبي اصيبعه[٤١] ولكنه الآن مفقود ولكن بقي لنا من كتاب ابن زهر نسخة في مكتبة مدرسة نواب بمشهد – ايران[٤٢] وعنوان النسخة هكذا « البيان والتبيين في الانتصار لجالينوس » ويظنّ ابن زهر أن أحدا من السوفسطائية ابتدع هذا الكتاب ونسبه إلى الرازي أو ان الرازي الف الكتاب في أحد طرفي عمره : إما في أوله قبل أن يفهم كتب جالينوس وإما في آخره عند اشتغاله بالصناعة أعني الكيمياء وتسلط روائح الزرانيخ والكباريت على دماغه[٤٣] يبتدىء الرازي كتاب الشكوك بهذه العبارة :

« إني لأعلم ان كثيرا من الناس يستجهلوني في تأليف هذا الكتاب »[٤٤] وهو يدافع إيراد هذه الجماعة بقوله : « إن صناعة الطب والفلسفة لايحتمل التسليم للرؤساء والقبول منهم ولا مساهلتهم وترك الاستقصاء عليهم ولا الفيلسوف يحب ذلك من تلاميذه والمتعلمين منه » ثم يجيب لائميه بقوله :

« وأما من لامني وجهلني في استخراج هذه الشكوك فاني لاعده فيلسوفاً إذ كان قد نبذ سنّة الفلاسفة وراء ظهره وتمسك بسنّة الرعاع وتقليد الرؤساء وترك الاعتراض عليهم هذا ارسطاطاليس يقول : « اختلف الحق وفلاطن وكلاهما صديقان إلا أن الحق لنا أصدق من فلاطن »[٤٥] ثم يقول الرازي :

٤٠ – رد موسى بن ميمون القرطبي Maimonides على جالينوس في الفلسفة والعلم الالهي ، **مجلة كلية الآداب بالجامعة المصرية** ، المجلد الخامس ، الجزء الأول (١٩٣٧) ، ص ٧٧ .

٤١ – **عيون الأنباء** ص ٤٢٩ .

٤٢ – **مجلة آستان قدس رضوى** ، مشهد – ايران ، الدورة السابعة عدد ١ ، ص ١١٦ .

٤٣ – ابن زهر ، **البيان والتبيين** ، مخطوطة مشهد ، ص ١ يقول ابن زهر : « قال السوفسطائي » بدلا من « قال الرازي » .

٤٤ – الرازي ، **كتاب الشكوك** ، ص١ اقتبس الرازي مبتدء كتابه من جابر بن حيان لأن الأخير يبتدء كتابه « التجميع » وكذا « السر المكنون » بعبارة : « ان قوما يستجهلوني ... » ارجع إلى **جابر ابن حيان** لبول كراوس **Paul Kraus** (قاهره ٤٣ – ١٩٤٢) ، ج ٢ ص ٢٥٢

٤٥ – علي بن رضوان المصري حينما ينقل في رسالته إلى ابن بطلان هذا القول لارسطاطاليس يضيف اليه قول فرفوريوس **Porphyry** الذي قال : « إن قتل آباءنا أهون إلينا من قبول الآراء الفاسدة» **خمس رسائل** . ص ٧٦ .

« وإن سئلت عن السبب الذي من أجله يستدرك المتاخرون في الزمان على أفاضل القدماء بمثل هذه الاستدراكات . قلت إن لذلك اسباباً : منها السهو والغفلة الموكلة بالبشر ، ومنها غلبة الهوى على الرأي فانه ربما طمس الهوى عين الرأي في رجل من الناس لأمر ما حتى يقول فيه ما خطا إما هو يعلم خطأه وإما هو لا يعلم خطأه حتى إذا تصفح ذلك القول رجل لبيب عار من ذلك الهوى لم يذهب عليه ما ذهب على الرجل الأول ولم يدعه الهوى إلى ما دعاه إليه . ومنها ان الصناعات لاتزال تزداد وتقرب من الكمال على الأيام ... فإن قيل لي هذا يدعو إلى ان يكون المتاخرون من أهل الصناعات أفضل فيها من القدماء . قلت إني لا أرى أن اطلق ذلك إلا بعد ان اشترط في وصف هذا المتآخر في الزمان إذا كان مكملا لما جاء به القديم .

أورد الرازي في كتابه شكوكا على جالينوس في المسائل الطبية والفلسفية ولهذا اعترض ابن ميمون في كتابه الذي سماه « الفصول » على الرازي بأن الرازي في كتاب الشكوك بذل جهده في المسائل الفلسفية وأهمل المسائل الطبية[٤٦] ولكن ايراد ابن ميمون مدفوع بأن جالينوس نفسه بحث في كتبه الطبية عن المسائل الفلسفية مثل الحدوث والقدم والكون والفساد والزمان والمكان والهيولى والخلاء والملاء وذلك بأن القدماء كانوا يعتقدون بأن الطب والفلسفة يكملان أحدهما الآخر حتى روى عن بعضهم ان الطب فلسفة البدن والفلسفة طب الروح[٤٧] . وهذا جالينوس الف كتاباً سماه « في أن الطبيب الفاضل يجب أن يكون فيلسوفاً »[٤٨] وكذلك كانت سيرة أطباء الاسلام أن يذكروا المسائل الفلسفية في كتبهم الطبية ليكون أثرهم جامعا لطب الأبدان وطب الأنفس معا ونجد هذا الاسلوب في كتاب فردوس الحكمة لعلي بن ربن الطبري وهكذا في كتاب المعالجات البقراطية لأبي الحسن الطبري. ويجب أن نذكر ان الرازي خرج عن مسألة الطب والفلسفة مرة واحدة وذلك حين اعترض على قول جالينوس في مسألة اللغات . قال جالينوس : « إن لغة اليونانيين أعذب اللغات لأن لغات سائر

٤٦ — رد موسى بن ميمون القرطبي .... ، ص ٧٧ .

٤٧ — ارجع : Owsei Temkin, " Studies on Late Alexandrian Medicine" . *Bulletin of the History of Medicine*, 1935, P. 418 .

٤٨ — حنين بن اسحق ، **الرسالة** ، رقم ١٠٣ . طبع هذا الكتاب في غوتينغن من بلاد آلمان سنة ١٩٦٦ مع الترجمة الالمانية .

الأمم يشبه بعضها صياح الخنازير وبعضها نقيق الضفادع » وقال الرازي في رده : « إن هذا كلام عوام الناس لأن الألفاظ انما يخف ويعذب بالاعتياد وان لغة العرب عند العرب كلغة اليونانيين عندهم وان العرب يستثقل لغة الروم كما يستثقل الروم لغة العرب »[٤٩] ويشير ابن حزم إلى كلام جالينوس بهذه العبارة : « هذا جهل شديد لأن عالم كل لغة ليست لغته ولايفهمها فهي عنده في النصاب الذي ذكره جالينوس ولا فرق[٥٠] والكتب التي أورد الرازي الشكوك عليها تكون من أهم كتب جالينوس مثل : آراء بقراط وافلاطون ، الأخلاق ، الأدوية المفردة الأسطقسات على رأي بقراط ، اصناف الحميات ، الأعضاء الآلمة ، الأغذية ، الأمراض الحادة، البحران، البرهان ، التجربة الطبية ، تدبير الأصحاء ، تشريح الحيوان ، تفسير كتاب البقراط في طبيعة الإنسان ، تفسير كتاب الفصول ، تقدمة المعرفة ، حركة العضل ، حيلة البرء ، الذبول ، الرعشة والنافض ، الصناعة الصغيرة ، العلل والأعراض ، قاطاجانس ، القوى الطبيعية ، في أن قوى النفس تابعة لمزاج البدن ، في ما يعتقده رأيا ، المزاج ، منافع الأعضاء ، المنى ، الميامر ، النبض الكبير . وهكذا ذكر الرازي في كتاب الشكوك أقوالا طبية وفلسفية من الحكماء اليونانيين مثل افلاطون وارسطاطاليس وبقراط وثاسطيوس وثاوفرسطس وخروسبس وابندقلس وديوقلس وثالس واسقليبيادس وديوسقوريدوس وارسسطراطس[٥١] ومن العلماء الاسلاميين مثل حنين بن اسحق ومحمد بن موسى[٥٢] وكذا أشار إلى رجل وجيه وصديق نبيل كان يقرأ معه كتب جالينوس ولم يصرح باسمه[٥٣] .

وحينما يورد الرازي الشكوك على جالينوس يشير إلى بعض كتب نفسه التي فقدت على مر الدهور وهذا يمكننا أن نعلم بعض مطالب كتب الرازي التي لم يبق لنا حتى الآن إلا أسماؤها ومن جملتها :

٤٩ — الرازي ، **كتاب الشكوك** ، ص ٢٩ .

٥٠ — ابن حزم الأندلسي ، **الإحكام في اصول الأحكام** (قاهره مطبعة الا مام) ، ج ١ ص ٣٢ .

٥١ — **Plato, Aristotle, Hippocrates, Themistius, Theophrastus, chrysippus, Empedocles, Diocles, Thales Asclepiades, Dioscurides, Erasistratos.**

٥٢ — محمد بن موسى المنجم، **عيون الأنباء** ، ص٢٨٢ والرازي يسميه «فيلسوف العرب» **الشكوك**، ص١٦ .

٥٣ — الرازي ، **كتاب الشكوك** ، ص ٨ ، ١٦ ، ٢٨ .

« سمع الكيان » ، يقول في الشكوك :

« وقد أفردنا لبعض رأى من زعم ان التغيرات كمون وظهور في كتاب سمع الكيان من قرأها علم ان في هذا الكلام تقصيراً عما يحتاج إليه »[٥٤] .

في الرد على السرخسي في امر الطعم المر ، يقول في الشكوك في بحث الاستدلال على عمل الدواء من جهة الطعم : « وقد أفردنا لهذه المطالبات مقالة جعلنا رسمها في الرد على أحمد بن الطيب السرخسي في امر الطعم المر »[٥٥] في أن مركز الأرض ينبوع البرد ، يقول في الشكوك :

« وكان جالينوس يرى ان الركن البارد هو الأرض وقد وجب عليه ان الأرض باردة باطلاقه والبارد باطلاق هو الذي لاشيء أبرد منه فهو إذن أبرد من الجمد وفي ذلك مخالفة الحسّ وتحتاج في حلّ هذا الشك إلى كلام كثير وقد أفردنا لذلك مقالة »[٥٦].

في كيفية الإبصار ، يقول في الشكوك :

« وقد أفردت النظر في هذا الرأي مقالة ضخمة وبينت أن الابصار يكون بتشبح الأشباح في البصر و تعصب ماقاله في هذا الراي في كتاب البرهان وفي سائر كتبه تعصبا شافيا وما قلته ههنا يجري في غرض كتابنا هذا »[٥٧] .

في الأزمنة والأهوية ، يقول في الشكوك حينما ينقل رأي جالينوس من أن احوال بعض الطباع يكون أجود في الصيف : « ولكن لاينبغي أن يطول الكتاب بحله ولا بالجملة شيء من الشكوك التي في كلامه في الأزمنة لانها كثيرة جداً ونحتاج فيها من الكلام إلى أضعاف هذا الكتاب ولأنا عازمون وبالله التوفيق على عمل كتاب في الأزمنة نخصه بهذا المعنى ونبحث فيه عما في هذه المقالة وما في كتاب الأهوية بحثا مستقصى إن شاء الله تعالى »[٥٨]

في جوّ الأسراب ، يقول في الشكوك :

٥٤ — الشكوك ، ص ١٠ .
٥٥ — الشكوك ص ١٧ .
٥٦ — الشكوك ، ص ١٧ .
٥٧ — الشكوك ، ص ٥ .
٥٨ — الشكوك ، ص ٢٥ .

« وقد بينا في مقالة مفردة ان الحرارة التي نحسها في الشتاء في ماء العيون وأهوية المواضع الغامرة ليست من أجل انها في انفسها في هذه الحالة أسخن منها في الصيف لكن نحن نحسها من أجل برد أبداننا كذلك كما نحس الماء الفاتر بعد دخول الحمام وسخونة أبداننا بارد وإن شئت تقف عن جميع ماقلناه في هذا الباب فاقرأ هذه المقالة»[٥٩].

النفس الكبير ، يقول في الشكوك :

« وفيما رد به على خروسبس في عوارض النفس شكوك كثيرة لم يجب أن يطول بها هذا الكتاب لانا عازمون على أن نكتب في هذا الفن كتابا نستقصيه إن شاء الله تعالى ونذكر في هذا الكتاب ما يتشكل عليه في كتاب الأخلاق »[٦٠] .

وكذلك نجد في كتاب الشكوك المطالب العلمية التي تكشف عما قاله الرازي في بعض كتبه التي فقدت وإن لم يصرح نفسه باسماء تلك الكتب .

هذا ما تيسر لي من تعريف ذلك الكتاب القيم على حسب مقتضى الحال والمقام وأوصي الباحثين في آثار جالينوس والرازي وافكارهما الطبية والفلسفية أن يتلقوا الكتاب باهمية خاصة وأرجو من الله أن يوفقني لتصحيحه ونشره لأخدم بذلك طالبي تاريخ العلوم الاسلامية ومحبيها إن شاء الله تعالى .

٥٩ — الشكوك ، ص ٢٣ .

٦٠ — الشكوك ، ص ٢٤ .

الرازي واندريا فيساليوس*

سيمون الحايك

ولد ابو زكريا الرازي على الارجح عام ٨٦٥ بالري . سافر إلى بغداد واقام بها مدة . تعلم صناعة الطب عن كبر ، ومعلمه هو علي بن ربن الطبري .

كان الرازي كبير الرأس مسفطه وكان يجلس في مجلسه ودونه التلاميذ ودونهم تلاميذهم ودونهم تلاميذ أخر ، فكان يجيء الرجل فيصف ما يجد لاول من يلقاه ، فان كان عندهم علم والا تعداهم إلى غيرهم فان اصابوا والا تكلم الرازي في ذلك .

وقال الرازي :

لعمري ما ادري وقد اذن البلى — بعاجل ترحال إلى أين ترحالي
واين محل الروح بعد خروجه — من الهيكل المنحل والجسد البالي

له مؤلفات عديدة منها كتاب « الحاوي » وقد نقل إلى اللاتينية . كتاب « المدخل إلى الطب » كتاب « الفصول في الطب » او « المرشد » وكتابه « المنصوري » وهو الذي يهمنا فقد ظل يدرس في الجامعات الاوروبية حتى اواخر القرن السابع عشر ، يتبع فيه طريقة جالينوس النظرية وطريقة ابقراط التطبيقية .

الف هذا الكتاب للامير منصور بن اسحق بن اسماعيل بن احمد صاحب خراسان وتحرى فيه الاختصار والايجاز مع جمعه لجمل وجوامع ونكت وعيون من صناعة الطب علمها وعملها ، وهو عشر مقالات :

المقالة الأولى : في المدخل إلى الطب وفي شكل الأعضاء وخلقها .

المقالة الثانية : في تعريف مزاج الابدان وهيئتها والاخلاط الغالبة عليها واستدلالات وجيزة جامعة من الفراسة .

* ألقي البحث في الندوة العالمية الرابعة لتاريخ العلوم عند العرب بحلب في نيسان – ١٩٨٧ م .

مجلة تاريخ العلوم العربية – المجلد التاسع ، ١٩٩١ – ص ١٥ – ٢٨

المقالة الثالثة : في قوى الأغذية والأدوية .
المقالة الرابعة : في حفظ الصحة .
المقالة الخامسة : في الزينـــة .
المقالة السادسة : في تدبير المسافرين .
المقالة السابعة : جمل وجوامع في صناعة الجبر والجراحات والقروح .
المقالة الثامنة : في السموم والهوام .
المقالة التاسعة : في الأمراض الحادثة من القرن إلى القدم .
المقالة العاشرة : في الحميات وما يتبع ذلك مما يحتاج إلى معرفته في تحديد علاجها .
مقالة اضافها إلى كتاب « المنصوري » وهي في الامور الطبيعية .
يسمي البيروني هذا الكتاب : «الكناش المنصوري» وهو عرض للطب في عشرة كتب.

مخطوطاته :

- باريس المكتبة الوطنية رقم ٢٨٦٦ ، ٦٢٠٣
- بودليانا ٥٢٩/١ : ٥،٤ ، ٥٧٧ ، ٥٩٢
- درسدن (المانية) : ١٤٠
- الاسكوريال : ٨١٩ ، ٨٢١ ، ٨٥٨ ، ٨٦٠
- مدريد : ٥٦١ : ١

ويقول بروكلمان : ويكاد المنصوري يعتمد اعتماداً تاماً على مصادر يونانية :

فالمقالة الأولى في التشريح ومنافع الاعضاء تعتمد على ابقراط وجالينوس واورباسيوس.
المقالة الثانية في الامزجة تعتمد على ابقراط وجالينوس وبولس الاجانيطي .
المقالة الثالثة في الادوية البسيطة تعتمد على ابقراط وجالينوس .
المقالة الرابعة في حفظ الصحة تعتمد على جالينوس وبولس الاجانيطي .
المقالة الخامسة في أمراض الجلد والدهون تعتمد على جالينوس .
المقالة السابعة في الجراحة تعتمد على ابقراط وبولس الاجانيطي .
المقالة الثامنة في السموم تعتمد على بولس الاجانيطي .
المقالة التاسعة من المنصوري وهي التي تهمنا وكانت شائعة في القرون الوسطى

باسم: في أمراض الأعضاء المختلفة اعتمد فيها على ابقراط Hypocrates وعلى جالينوس.

ترجم كتاب المنصوري إلى اللاتينية «جيراردء الكريموني» Gerardo da Cremona في طليطلة من أعمال اسبانية وقد طبعت الترجمة في ميلانو عام ١٤٨١ . والبندقية عام ١٤٩٧ وليون عام ١٥٢٠ ، وباسيل عام ١٥٤٤ ؛ وطبعت الترجمة اللاتينية للمقالة التاسعة تحت هذا العنوان : Paraphrasis in nonum librum Rhazae بالبندقية في السنوات : ١٤٨٣ ، ١٤٩٠ . ١٤٩٣ . ١٤٩٧ وبادوا ١٤٨٠ .

يستهل كتاب المنصوري بمقدمة هي هذه :

« هذا كتاب ابي بكر محمد بن زكريا الرازي الذي سماه المنصور بن اسحق ابن محمد رحمة الله عليه . قال ابو بكر بن زكريا الرازي : « اني جامع للامير اطال الله بقاءه ، في كتابي هذا جملا وجوامع ونكتا وعيونا من صناعة الطب ، متحرٍ في ذلك الاختصار والايجاز ، وذاكرٍ من حفظ الصحة ومعالجة الأمراض وتوابع ذلك ولواحقه ما لايزال يحدث وتدعو الحاجة إلى معرفته ، ويمكن اهل العقول والرأي مشاركة الأطباء فيه وتارك ذكر ما لايكاد يحدث الا في المدة الطويلة وما يحتاج في معرفته إلى وغول واعراق في الصناعة وجاء كتابي هذا عشر مقالات في كل مقالة فصول معلمة بالحروف على ما ينبغي من مراتب اعدادها ليسهل اصابة ما يراد منها . والله أسأل التوفيق والعون على ما يرضي الامير اسعده الله ويقرب إليه ويدني منه .

المقالة التاسعة التي تهمنا تتضمن اثنين وتسعين باباً وهي :

باب في الصداع والشقيقة وعلاجهما	باب في الماليخوليا .
باب في الــدوار .	باب في الزكام .
باب في البرسام .	باب في الرمد في العين .
باب في السكتة .	باب في القروح في العين .
باب في السبات .	باب في البياض الحادث في العين .
باب في الشخوص .	باب في الجرب والسبل .
باب في الفالج .	باب في الحكة في الآماق .
باب في الخدر والرعشة .	باب في الطفــرة .
باب في اللقوة	باب في الطرفة .

باب في التشنج .
باب في الصرع .
باب في الكابوس .
باب في الشعر المنقلب الذي في منخس العين .
باب في الغشاء في العين .
باب في الناصور الحادث في الآماق .
باب في القرحة في الاذن .
باب في ثقل السمع .
باب فيما ينشب في الأذن .
باب في القروح في الأنف .
باب في عدم الشم .
باب في قلع الاسنان .
باب في الضرس الذي يتوجع اذا مسه شيء بارد .
باب في اللثة الدامية .
باب في العلق .
باب في ثقل اللسان .
باب في الوجع الحادث في الاعضاء الظاهرة .
باب في الاورام الحادثة في اللسان .
باب في السعال .
باب في ذات الجنب .
باب في نفث الدم ونخعه .
باب في الخفقان .
باب فيما يقوى المعدة
باب في الفواق .
باب في اوجاع الكبد
باب في الاستسقاء
باب في القولنج .

باب في الدمعة .
باب في ضعف البصر .
باب في انتفاخ الاجفان .
باب في الماء النازل في العين .
باب في الانتشار في العين .
باب في الوجع الحادث في الاذن .
باب في الدوى والطنين .
باب في الدود والهوام الحاصلة في الاذن .
باب في الرعاف .
باب في النواسير الحادثة في الانف .
باب في علاج وجع الاسنان .
باب في الضرس والخدر في الاسنان .
باب في القلاع .
باب في سقوط اللهاة .
باب فيما نشب في الحلق .
باب في اذلاع اللسان .
باب في الغدة الكائنة تحت اللسان وتسمى الضغدع
باب في الخوانيق .
باب في الربو .
باب في ذات الرئة .
باب السل .
باب في الهيضة .
باب في الوجع والورم في المعدة .
باب في الشهوة الكلبة .
باب في اليرقان .
باب في اوجاع الطحال .
باب في الخانفة (آخر طعم الطعام) .

باب في عسر البول .
باب في الورم الحادث في الكلى والمثانة .
باب في الدود الكائنة في البطن والمقعدة .
باب في نتق المقعدة والرحم .
باب في ادرار الطمث .
باب في الورم في الرحم
باب في اختناق الارحام .
باب في الشق والفتق .
باب في الحدبة .
باب في داء الفيل .
باب في الحصاة .
باب في حرقة البول .
باب في البواسير والنواصير والشقاق الكائن في المقعدة .
باب في قطع الطمث .
باب في الشقاق في القبل .
باب في القروح في الارحام .
باب في العلة المسماة الرحا .
باب في النقرس وعرق النسا .
باب في الدولي .
باب في تقرح القطاة .

تمت المقالة التاسعة بحمد الله وعونه

من هو اندريا فيساليوس ؟ طبيب بلجيكي اشتهر بعلم التشريح. ولد في بروكسيل عام ١٥١٤ على الارجح . ابوه صيدلي ، رافق الامبراطور كارلوس الخامس عندما – في عام١٥١٧ – اعلن ملكا على قشتالة وارغون. قضى اندريا فيساليوس طفولته في بروكسيل . دخل اندريا عام ١٥٣٠ في معهد Collège du Château ولم تطل اقامته فيه اذ غادره عام ١٥٣١ ليلتحق بمعهد Collegium trilingue اي معهد اللغات الثلاث : اللاتينية واليونانية والعبرية . مكث في هذا المعهد ثلاثة اعوام تعلم فيها الفلسفة الطبيعية بما فيها منطق ارسطاطاليس ، وعلم ما وراء الطبيعة .

تعمق في اللغة اللاتينية واليونانية وله بعض الالمام باللغة العبرية . درس في جامعة لوفين البلجيكية التي كانت في اوائل القرن السادس عشر تضاهي جامعة باريس شهرة تأسست عام ١٤٢٦ . انتقل فيساليوس إلى باريس عام ١٥٣٢ بايعاز من نيقولاس فلوريناس Nicolas Florenas طبيب الامبراطـور كارلوس الخامس وصديق والد فيساليوس ، واهداه بعد سنوات اطروحته في الدكتوراه عنوانها Paraphrasis in nonum librum Rhazae شرح المقالة التاسعة للرازي في كتابه المنصوري ، كما سنرى .

وجامعة باريس في ذلك العهد تختلف عن الجامعات الايطالية ، فتعتبر الحصن المنيع في الدفاع عن النظريات التقليدية في اواخر القرن الخامس عشر واوائل القرن السادس عشر بحيث لو ان طالبا تجاسر ولفظ كلمة quisquis « اي شي » أو qualis « ماذا » بطريقة تختلف عن الأسلوب المتبع في القرون الوسطى لعوقب في الحال .

يعتبر فيساليوس تلميذا لجالينوس مثل بقية اساتذة جامعة باريس مثل يعقوب سيلفيوس Sylvius وغيره، انما فيساليوس كان مستعداً لتصحيح الأخطاء التي وقع فيها جالينوس اذا ثبت له انها اخطاء. بينما الآخرون يتبعون جالينوس بدون تحفظ ويثقون به ثقة عمياء .

ويعقوب سيلفيوس الذي اشرنا إليه اعلاه معلم فيساليوس ، ولد في اميان بفرنسة عام ١٤٧٨ وتوفي عام ١٥٥٥ . كان من المتحمسين لجالينوس .

معلم آخر لفيساليوس: كايوس Caius وهو من تلامذة جالينوس ، يرى ان الأخطاء المنسوبة إلى المعلم اليوناني تعود إلى تشويه في المخطوطات اليونانية وإلى ترجمات فاسدة . بينما يعقوب سلفيوس يقول : ان ما نجده من الفوارق بين ما قال جالينوس وما اثبته العلم الحاضر لايعود إلى أخطاء ارتكبها جالينوس بل إلى فساد الجنس البشري منذ ذلك العهد إلى يومنا هذا اي إلى النصف الأول من القرن السادس عشر الذي تميز بنبوغ عدد لايستهان به من الأطباء المعروفين نذكر منهم على سبيل المثال ميخائيل سيرفيتوس واندرس لاغونا Andrés Laguna ، وغونتير Gunther معلم فيساليوس .

وفي عام ١٥٣٦ عاد إلى لوفين دون ان يتدرج في الطب ، وانصرف في هذه الجامعة إلى التشريح ، فعمد إلى سرقة الجثث والهياكل العظمية ، وهذه من الامور المحرمة في ذلك العهد .

في عام ١٥٣٧ انتقل إلى مدينة البندقية ماراً بباسيل في سويسرة للاتصال بروبرت ونتير Winter لاعداد الطبعة الثانية لاطروحته في الدكتوراه .

وجد في البندقية جواً ملائماً للعلوم والفنون اذ ان هذه الجمهورية في ذلك العهد حكمتها الارستقراطية وهيمن عليها الجاه والثروة والثقافة والجمال وتنشيط التقدم ،

بينما بقية الجمهوريات الايطالية خاضعة لحكم الارهاب . وموقع البندقية الجغرافي : ملتقى الطرق بين الشرق والغرب لا سيما بعد سقوط القسطنطينية في ايدي الاتراك عام ١٤٥٣ ، حولها إلى مركز سياسي وعسكري وتجاري وفكري وفني ، إلى جانب انها كانت محاطة بمدن هامة مثل فيرونة Verona وفيسنتزا Vicenza وترفيسو Treviso وبرغامو Bergamo وبدوا Padua بنوع خاص . وكان بترارکا قد اوصى بمكتبته الضخمة لهذه المدينة وعندما وصل إليها فيساليوس كان يحكمها الدوق اندريس غريتّي Andrés Gritti الذي وقع معاهدة تحالف مع الامبراطور كارلوس الخامس ضد فرنسة اتصل بالفنانين الايطاليين مثل تيزيانو Tiziano تعرف هناك على طبيب يهودي اسمه لعازر ، ساعده على استعمال الكلمات اليهودية والعربية الموجودة في مؤلفه « تركيب الهيكل البشري » Fabrica .

كما انه درس معه كتاب « القانون » لابن سينا .

بـــادوا : اسس جامعة بادوا الامبراطور فردريك الثاني عام ١٢٢٢ . وكانت تدرس فيها جميع المعارف وهي ميزة لم تسبقها إليها أية جامعة من الجامعات الأوروبية في ذلك العهد . يدرّس كل مادة استاذان ، احدهما من البندقية والآخر اجنبي وقد وصل عدد التلامذة فيها إلى ثمانية عشر الف تلميذ .

وصل فيساليوس إلى هذه الجامعة عام ١٥٣٧ ، وهنا تعرف على « كايوس » الذي ذكرناه آنفا (١٥١٠ — ١٥٧٣) ظل اندريا فيساليوس يعلم في هذه الجامعة حتى عام ١٥٤٢ ، ثم انتقل إلى باسيل في اوائل عام ١٥٤٣ للاشراف على طبع كتابه «تركيب الهيكل البشري» Humani corporis fabrica ظهر الكتاب في شهر حزيران يونيو عام ١٥٤٣ . في شباط فبراير عام ١٥٤٤ اصبح طبيب الامبراطور كارلوس الخامس واضطر لمرافقته في حروبه ضد الاتراك وفرنسة والبروتستانت . ولما مات الامبراطور ظل يعمل طبيباً في بلاط ابنه الملك فليب الثاني .

حجه إلى الأراضي المقدسة : نسجت مخيلة البشر الخصيبة اساطير حول رحلة اندريا فيساليوس إلى بيت المقدس . والاسطورة المعروفة أكثر من غيرها تزعم

ان ديوان التفتيش حكم عليه بالموت لانه شرح احد الاشراف في اسبانية ظناً منه انه مات ، ولكن تبين اثر التشريح ان القلب ما زال يضطرب . وصل الخبر إلى اسماع ديوان التفتيش فحكم عليه بالموت . ولكن بتوسط من الملك فليب الثاني ابدل حكم الاعدام بالحج إلى الاراضي المقدسة . ولكن ليس هناك ما يثبت صحة هذا الخبر . والارجح هو ان فيساليوس غادر اسبانية لان المناخ لم يوافقه فيها ولانه وجد ذاته في محيط يحسده على منصبه لقربه من الملك فليب الثاني الذي قيل عنه ان الشمس لاتغيب عن ممتلكاته .

المهم ان فيساليوس خرج من اسبانية في شهر شباط ووصل إلى البندقية في ١٠ آذار ١٥٦٤ . ثم توجه إلى قبرص في ٥ نيسان ١٥٦٤ بعد ان استلم رسالة من مجلس الشيوخ في البندقية يطلب منه ان يشغل منصب كرسي علم التشريح في جامعة بادوا براتب ضخم ، بعد عودته من بيت المقدس . زار الأراضي المقدسة . وفي عودته هبت عليه عاصفة ارغمت الباخرة على اللجوء إلى مرفأ جزيرة زانتي . فمرض ومات في كوخ حقير في مكان مقفر . ويقال انه قبل ان يموت رست باخرة قادمة من البندقية بالقرب من مكان الحادث . وبين ركابها صائغ من تلك المدينة فعرض ذاته للخطر في السير على طول الشاطىء حتى وصل إلى المكان المقفر الموجود به فيساليوس فألفاه على آخر رمق ، ولم يستطع انقاذه فاشترى قطعة ارض صغيرة ودفنه فيها .

وجزيرة زانتي Zante خاضعة لسلطة البندقية منذ عام ١٤٨٤ ، وكان يحمل بين اغراضه رسالة من حارس الاراضي المقدسة . وهو القاصد الرسولي هناك ، إلى الملك فليب الثاني باللغة الايطالية .

مؤلفاته :

يهمنا منها كتابه الذي يحمل العنوان :

Paraphrasis in nonum librum Rhazae medici arabis Clariss. ad Regem Almansorem de affectuum singularum corporis partium curatione, Andrea Wesalio Bruxellensi autore .

اي « شرح المقالة التاسعة من كتاب الرازي « المنصوري » في الامراض الحادثة لاعضاء الانسان من راسه إلى قدميه » .

شاء فيساليوس ان يشرح هذه المقالة الهامة من كتاب المنصوري للرازي لكي يصيره أقرب منالاً للطلاب في ذلك العهد واسهل فهماً عليهم . وهو أول تأليف يضعه فيساليوس متوخيا منه ومن المؤلفات التي تلته نشر معارف العلماء الاقدمين مطهرة من الأخطاء الفاضحة التي وقع بها مترجمون قليلو الخبرة . ثم ادخال الاكتشافات الجديدة في مؤلفات جديدة أيضاً رغبة من المؤلف، على حد قوله في مقدمته. في أن يزود طلاب الطب بالمعلومات الكافية المكتشفة في ذلك العصر لمساعدتهم في دراساتهم .

والجدير بالاشارة ان فيساليوس في مؤلفاته التي كتبها بعد اصدار كتابه « شرح المقالة التاسعة للرازي » ، اضاف إلى هذه المعلومات الخطية رسوماً وصوراً وجداول لكي يكمل هذه الطريقة أو المحاولة التي يسعى إليها في طريقته التعليمية التربوية .

قلنا اختار فيساليوس المقالة التاسعة من كتاب المنصوري ليكتب عنه شرحاً اهداه إلى صديقه ومرشده نقولا فلوريناس الذي جئنا على ذكره ، وهو الذي ساعده وحثه على **الذهاب** إلى جامعة باريس عام ١٥٣٣ .

لايعرف بالضبط المكان الذي كتب فيه فيساليوس رسالته للدكتوراه في الطب ، ومن المرجح انه كتبها في باريس لنيل اللقب من تلك الجامعة . ظهرت الطبعة الأولى من هذا الكتاب في اول شباط ١٥٣٧ بحجم كبير ، يشيد في المقدمة باحد معلميه في باريس اسمه يعقوب سيلفبوس . واذا اخذنا بعين الاعتبار انه لما اضطر فيساليوس إلى مغادرة باريس فجأة ولم يكن قضى فيها أكثر من ستة اشهر ، تبين لنا ان اعداد رسالة الدكتوراه تم على عجل . ويذهب بعضهم إلى الظن ان اندريا فيساليوس نال درجة الدكتوراه في « لوفين »، بلجيكا اذ ان الطبعة الأولى لكتاب « شرح الرازي » تقول : **" Autore Andrea Wesalio Bruxellensi medicinae candidato "** .

أي ان المؤلف هو اندريا فيساليوس من بروكسيل المرشح للدكتوراه في الطب .

بينما جاء في الطبعة الثانية : **" Andrea Wesalio Bruxellensi autore "**

أي « المؤلف هو اندريا فيساليوس من بروكسيل » .

رغم ان الفترة بين الطبعة الأولى والطبعة الثانية لاتزيد على شهر ونصف نال خلالها

فيساليوس لقب طبيب ، وهذا لا يدل على انه نال الدرجة حتماً في لوفين . كما انه من ناحية أخرى لاتوجد براهين ووثائق بهذا الشان اي نيل الدكتوراه من جامعة لوفين Louvain كما ان وبترز Wauters يقول : « ... ولكن لم ينل لقب دكتور في الطب في وطنه ، واستقبل اندريا فيساليوالبروكسيلي ابن اندريا آخر بدون معارضة في جامعة بدوا[1] .

يبتدىء فيساليوس في الرسالة التي وجهها إلى نقولاس فلوريناس ، طبيب الامبراطور كارلوس الخامس بالتذكير بانه منذ بضع سنوات سمع نصائح هذا الطبيب بشان الطريقة المفضلة في دراسة ابقراط الذي ما زال اسلوبه متبعاً . ثم يضيف انه يرى من الموافق مقابلة التصانيف العربية بالتصانيف اليونانية ، واسلوب المقابلة هذا دارج وقد اعتاد الأطباء البارسيون على ان ينصحوا تلامذتهم باستخدامه .

ويتابع فيساليوس كلامه قائلا : وعملا بهذه النصيحة الصادرة عن ابرز المعلمين الذين تخرجت على ايديهم ، اي يعقوب سيلفيوس ، وضعت بين يدى اولا كتاب الرازي المنصوري ، وفحصته بدقة مقابلا اياه مع ما كتبه اليونانيون . كما تفحص الاحجار الكريمة الآتية من ليديا ، لانني سمعت مراراً عديدة من معلمي واستاذي الكبير في الطب ، يعقوب سيلفيوس ، ان الرازي يعتبر من أحسن الخبراء في فن الشفاء بين الأطباء العرب .

ويقول فيساليوس في مكان آخر انه ابتدأ باعادة النظر في ترجمة مؤلفات الرازي ، والقصد من ذلك انقاذ اولئك الذين يترشحون مثلي لنيل شهادة الطب وهو عمل جبار . وفي الوقت ذاته لكي اتيح الفرصة للاطباء الذين يبحثون عن الدواء الناجع لكي يجدوه خالياً من الأخطاء الفاضحة التي ارتكبها بحقه الناقلون اللاتينيون ، اذ ان لغتهم اللاتينية المستعملة في هذه الترجمات غير مفهومة اطلاقاً عند القارىء اللاتيني ، فحاولت تبديل الجملة اللاتينية وصغتها بقالب مفهوم ، بحيث ان تلك النصوص المعقدة الغامضة الفاسدة في تركيبها أصبحت قريبة المنال واضحة سهلة الفهم فلا يجد القارىء ادنى صعوبة في ادراك المعنى المطلوب .

1. Wauters A. *quelques mots sur A. Vesale. .. Memoires couronnes.* T. LV : pag. 22 Bruxelles 1898.

وينتهي فيساليو معرباً عن رغبته في ان يجعل من هذا التاليف الذي اوصاه به معلمه سيلفيوس تاليفاً يوازي الشهرة التي ينعم بها الرازي ، وهو يأمل ان يدافع عنه ضد الحجج الواهية التي يتذرع بها خصوم الرازي ، ويصون اسمه من التحقير والنميمة والتشهير . وأخيراً يضع فيساليو حاشية صغيرة يطلب فيها من القارىء ان ينظر إلى تاليفه بعين التسامح إلى ان يتاح له اخراج تأليف جديد اوسع واوفى واكمل في الحقل الطبي السامي ..

نتبين من هذه الرسالة التي كتبها فيساليو لفلوريناس ان غرضه الأول هو تطهير كتاب المنصوري من جميع الأخطاء اللغوية وغير اللغوية التي وقع فيها المترجمون اللاتينيون الذين نقلوا كتاب المنصوري من العربية إلى اللاتينية . والناقل الذي اعرفه هو جيرارده الكريموني نقل هذا الكتاب في طليطلة في الثلث الأخير من القرن الثاني عشر . ثم التحريفات الكثيرة التي ادخلت على النص نظراً لكثرة الطبعات التي مرت بها المقالة التاسعة هذه من كتاب المنصوري ، ولتلاعب الناقلين بالنص الأصلي محاولين زيادة فهمه ولكن بالحقيقة لايزيدون الا في ابهامه وغموضه .

ثم يوضح فيساليوس فيقول ان الأسلوب الذي استعمله لم يأخذ فيه النص كلمة كلمة ، رغم انه يرى من واجب المترجم ان ينقل حرفياً الكلمات من العربية إلى اللاتينية ، غير انه استعمل التلخيص او الشرح اذ يعتبره الطريقة التي يفضلها ثم يضيف إليه ما يراه ملائماً وضرورياً لتوضيح النص والاسهاب في الكلام على تلك النصوص التي يعتبرها غامضة في نص الرازي. وعلى هذا النحو يبين لنا فيساليو لماذا اعطى رسالته الطبية هذا العنوان : " Paraphrasis in nonum librum Rhazae "

« شرح المقالة التاسعة للرازي » فانه قد خرج عن سربه من الأطباء الذين جاؤوا قبله وتخلص من نفوذهم وتأثيرهم .ويلمح في الملاحظة الأخيرة من مقدمته إلى نواياه في اصدار كتاب آخر أكبر حجماً . وقد يكون شاء الاعلان عن كتابه الشهير الذي نشره فيما بعد وعنوانه : " De Humani Corporis Fabrica "

« تركيب الجسم البشري » .

والغريب في الامر ان فيساليو طبع رسالته لنيل الدكتوراه قبل ان يحصل على هذه

الدرجة ويدافع عن الرسالة امام لجنة فاحصة كما هو جاري العادة على الأقل في اسبانية وفي البلدان أخرى كثيرة . طبعت رسالته للمرة الأولى في لوفين . كان صديقاً لاحد دور النشر اسمه روتجر ريش Rutger Resch ان عنوان هذه الطبعة الأولى :

Paraphrasis in Nonum librum Rhazae medici arabis clariss. **ad Regem Almansorem, de singularum corporis partium affectuum curatione, autore Andrea Wesalio Bruxellensi Medicinae candidato. Lovanii ex officina Rutgeri Resci Mense Februar 1537**

وقد ارفقت هذه الطبعة بقصيدة مهداة إلى فيساليو من يدوكوس فسيوس Jodocus Velsius من سان لاهاي. فبعد ان يشيد بالطبيب العربي الكبير الرازي وبخدماته الجلى للانسانية ينسب إلى المترجمين اللاتينيين القليلي الخبرة تشويه كتاب الرازي وجعله غير لذيذ القراءة. والآن بفضل المواطن فيساليوس اصبح تأليف الرازي سهل المنال ومقدرا حق قدره .

بعد سنوات قليلة نال فيلسيوس هذا لقب دكتور في الطب من جامعة لوفين عام ١٥٤١ اثر عودته من هولندة . والطبعة الأولى لشرح المنصوري نادرة الوجود ولايعرف منها سوى ثلاث نسخ في لندن وفيينا ونسخة رابعة في لوفين التهمتها النار في حرب ١٩١٤ . ولا يمكن القول ان هذه الطبعة جيدة من حيث الطباعة والحبر .

ومن المدهش حقا انه بعد شهر تقريباً ظهرت في باسيل من اعمال سويسرا الطبعة الثانية لكتاب شرح المنصوري تحت عنوان :

Paraphrasis in Nonum Librum Rhazae Medici Arabis Clariss. **ad Regem Almansorem de affectuum singularum corporis partium curatione. Andrea Wesalio Bruxellensi autore. Rerum ac verborum in hoc operememorabilium diligentissimus Index Basilae .**

وقد جاء في الصفحة الاخيرة رقم ٢٢٤ من هذا الكتاب ما يلي :

frigida experiatur primum fricanda est, deinde oleo costino et oleo iosmini et balanino paribus, modiceque tepantibus, circumlinetur. At si haec quoque ineficacia fuerint, ungentis. Capite de nervorum resolutione superius comprehensis, donec probe omni molestia aeger liberetur, inter ungendum utemur.

Paraphraseos Andreae Wesalii Bruxellensis in nonum Rhazae ad Regem Almansorem, de affectuum singularum corporis tertium curatione.

Finis

أما نص الرازي المطابق لهذه الفقرة الأخيرة من المقالة التاسعة في باب الوجع الحادث في الأعضاء الظاهرة . فيقول :

«وان كان العضو بارد اللمس فادلكه ثم امرخه بدهن القسط والزنبق الفاتر والبان ونحوها فان كفى والا فاستعمل المروخات (ما يدهن به من دهن أو غيره) المذكورة في باب الفالج حتى يبرا» . لايوجد فرق بين النصين الا ماذكره الرازي: « والا فاستعمل المروخات المذكورة في باب الفالج » وهذا النص غير وارد في النص اللاتيني لفيساليوس .

يوجد نسخة من هذه الطبعة الثانية في بروكسيل ، المكتبة الملكية الالبرتية ، والطباعة أفضل من السابقة وعلى كل حال فعلى الرغم من ان الاحرف واضحة على العموم غير انها لاتصل إلى الدرجة التي وصلت اليها طباعة « تركيب الجسم البشري » من الجودة . فالورق فيها يتراوح بين الجودة والرداءة دون اي رسم أو صورة أو جدول . والحبر فيها أيضاً ليس بالجيد . يقع هذا التأليف في ٢٢٤ صفحة ، ويتكلم على جميع الاعراض الحادثة بالانسان من قرنه إلى اخمص قدمه بما فيه الصداع والشقيقة وداء الفيل والوجع الحادث في الاعضاء الظاهرة الخ . بكلمة انه شرح للمقالة التاسعة من كتاب المنصوري بجميع ابوابه ، وقد جاء النص اللاتيني مطابقاً مطابقة حسنة للنص العربي . نعرف من هذه الطبعة ثلاث عشرة نسخة موجودة في المكتبة الملكية الالبرتية وقد نسخنا عنها الصفحة الأولى والأخيرة، وفي المكتبة الجامعية في غانت Gante ، وفي مكتبة الجيش في واشنطن وفي برسلو Breslau وفي امستردام وفي المعهد الملكي للجراحين في لندن وولير Waller وستريتر Streeter وترنت Trent .

والفرق بين الطبعة الأولى والطبعة الثانية قائم في الملاحظات المكتوبة على الهوامش .

هل يجيد فيساليو العربية ؟ هذا سؤال تصعب الاجابة عنه بالضبط فيرى سينغير ورابين ان هذا ادعاء باطل فاللغة العربية ، على قول سنغير ، كانت تستخدم في القرن السادس عشر فقط في الكتابات العبرية في اوروبة بحيث ان اليهود فقط كانوا يحسنون اللغة العربية . وينتهي سنغير إلى القول مؤكداً ان فيساليوس لايحسن العربية ولا العبرية . ويضيف قائلا : حتى بين علماء اللغة يصعب وجود اناس يحسنون اللغتين العربية والعبرية ويعتبر من الأمور الخارقة معرفة هاتين اللغتين في ذلك العصر[1] غير انه ظهر في مجلة القنطرة Al-Qantara الصادرة في مدريد سنة ١٩٨٤ المجلد الخامس — من صفحة ٢٩٣ حتى ٣٢٧ مقال عنوانه :

" Los terminos arabes en la Osteologia de Vesalio "

1. Synger and Rabin : *Prelude to modern science.* Cambridge, 1946, P. LXXVII .

« المفردات العربية في علم العظام عند فيساليو » في كتابه « تركيب الهيكل البشري » كاتب المقال هو « خوان خوسه بارسيا فويانس » ، لا بأس في ايراد بعض هذه الكلمات التي يصل عددها إلى اربعين كلمة تقريباً :

سنـــان senasen الاكليلي hachlilij سفودي sutura sagittalis
عظم الزوج esamot hazog الناجذ naghuit اسنان الحلم alhalm
الفائق وهو عظم ذو اربعة اضلاع Alfaic فقرات القطن Alchatin العجز Alaga
العصعص alhosos عظم الكتف Chateph اعضاد Hazad

نكتفي بهذه الكلمات التي لا يشك في صحة نسبتها إلى اللغة العربية وقد استعارها فيساليو من ابن سينا وعلي بن العباس والرازي . هذا ما يحملنا على الاعتقاد بانه كان على المام باللغـــة العربية وبعد ظهور الطبعة الثانية لشرح المنصوري في باسيل ظهرت اربع طبعات أخر ، ففي آذار سنة ١٥٤٤ ظهرت الطبعة الثالثة في باسيل وفي عام ١٥٥١ ظهرت طبعة أخرى في ليون بفرنسة ، أما الطبعة الخامسة فقد حصلت في ويتنبرغ عام ١٥٨٦ بعد وفاة فيساليو ، وفي المدينة نفسها ظهرت الطبعة السادسة عام ١٥٩٢ .

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ملخصات الأبحاث المنشورة في القسم الأجنبي

« مقالة تربيع الدائــرة » لابن الهيثم
برهان فلسفي أم رياضي

تامارا البرتيني

تعتبر مقالة « في تربيع الدائرة » لأبي علي الحسن بن الحسن بن الهيثم (٩٦٥ — ١٠٤٠ م) أول تجربة في حل هذه المسألة منذ القرن الثاني . وذلك بطريقة فلسفية وليس بطريقة رياضية ، وقد استعمل العالم العربي ابن الهيثم فكرة Concept الإمكانيــة ويظهر ذلك واضحاً بالاطلاع على كتابه المشهور كتاب المناظر .

الفليكون المسلمون في قصر جاي سينغ

فيرندرا شارما

برع ساواي جاي سينغ الهندي كفلكي في القرن الثامن عشر واشرف عــلى اعمال فلكيين من ديانات مختلفة .

تبحث هذه المقالة عن دور الفلكيين المسلمين وعن اسهاماتهم في برنامج جاي سينغ لتجديد علم الفلك في الهند ، وقد شارك الفلكيون المسلمون في نصب الآلات لمراصده . وجمعوا وترجموا النصوص . وجابوا البحار في مهمات علمية .

وكان داياناتا خان الفلكي المفضل لدى الراجا جاي سينغ . وربما لعب دوراً هاماً في برنامجه الفلكي .

شرق افريقية عند بطليموس من خلال الجغرافية العربية في أوائل العصور الوسطى

م . آ . تولما شڤا

كون الجغرافية العربية مدينة لكلوديوس بطليموس بشكل معترف به أثر ذلك تأثيراً عميقاً على تطور علم الجغرافية العربي الذي يذهب أبعد بكثير من مجرد ترجمات لكتابه *Geography* . من بدايات القرن التاسع وحتى نهايات القرن الخامس عشر معظم المؤلفين العرب الذين يكتبون في أنواع الجغرافية الوصفية أو الرياضية ، حاكوا بطليموس كمصدر للوصف المنهجي للأرض المأهولة .

وقد كان تأثير بطليموس قوياً على العلماء المسلمين في المجالات التاليــة : (١) الحقائق الجغرافية : وصف للبر والبحار ، تنسيق لمستوطنات ومعالم طبوغرافية ، (٢) نظريات جغرافية ، (٣) فن أو علم رسم الخرائط . (لاتناقش المقالة رياضيات وفلك بطليموس) .

هذه المقالة هي فحص ثانٍ لطبيعة ومدى التأثير الاغريقي على الجغرافية العربية المنسوبة عادة إلى بطليموس ، محصورة في الأعمال العربية خلال العصور الوسطى الأولى التي تظهر بوضوح تنسيقاً مع بطليموس على المستويات الثلاث ، تتضمن هذه: كتابات الرياضي الفلكي والجغرافي الشهير محمد بن موسى الخوارزمي (٢٣٢هـ/ ٨٤٦ ــ ٨٤٧ م) ، والأقل شهرة منه المصنف سهراب (النصف الأول من القرن العاشر بعد الميلاد) بالإضافة إلى « كتاب الزيج الصابىء » للفلكي الكبير البتاني (٣١٧هـ / ٩٢٩ م) .

ستدرس تلك المعلومات فيما بعد مع التركيز بشكل خاص على ما يتعلق بالجغرافية التاريخية لشرق افريقية . بالإضافة لذلك سوف تدرس بعض مسائل الميثودولوجيا العامة لتفسير معلومات مستمدة من مصادر عربية مخطوطة .

رغم أن النطاق العام للاقتباس العربي الجغرافي من بطليموس قد درس بشكل جيد ، فان حالة شرق افريقيا تستحق الاهتمام الخاص ، وذلك بسبب الاتفاقية الخرائطية غير المقررة بعد ، التي يمتد فيها البر الافريقي الرئيسي جنوب خط الاستواء على طول الخط شرقاً ليشكل الساحل الجنوبي للمحيط الهندي

في الحقيقة إن الجغرافيين العرب خلال العهد الاسلامي اتبعوا هذه الاتفاقية معتمدين على بطليموس ، وتلك الاتفاقية سمحت باعتبار المصادر الجغرافية العربية كمواصلة لتعاليم بطليموس خلال القرون التي كانت فيها أعماله مهملة لأوربا . هكذا تبدو الخرائط المنسوبة لبطليموس التي ظهرت في الغرب في القرن الخامس عشر متلائمة، ومعززة بالنصوص والخرائط العربية التي ظهرت في القرون الوسطى .

هناك بعض الملاحظات التمهيدية لتقدير مدى التأثير البطليموسي على المؤلفين العرب بشكل عام وفيما يتعلق بشرق افريقيا بشكل خاص .

أولاً ، تعليق موجز على إحداثيات خطوط العرض والطول ، إلى الحد الذي يعتبر فيه بطليموس الجغرافي الأول في تطبيقهم بشكل منهجي ، كل الجغرافيين المسلمين الذين استخدموا هذه الاحداثيات يمكن اعتبارهم بأنهم اختبروا وتقبلوا منهجه إلى حد ما ، وربما ذلك ليس على قدر من الأهمية لأن هؤلاء المؤلفين يمثلون أقلية في مجال الجغرافية الاسلامية ، مهما كان نتاجهم هاماً .

ثانياً ، استخدام بعض المؤلفين للإحداثيات لايتضمن الموافقة على رسومات بطليموس أو حتى على طريقته في حساب الإحداثيات . هذا يخص بالذات خطوط الطول . طبيعة التناقض وبعض الأسباب المؤدية لها مشروحة في المقالة .

ثالثاً : هناك مؤلفون يعترفون بأنهم مدينون لبطليموس الذي لايستخدم درجة الاحداثيات فقط بل يحول تصوراته الخرائطية أيضاً عندما يملأ الخريطة والنص بمعلومات حديثة .

رابعاً : لايمكن إيجاد ما هو بطليموسي صرف في النصوص العربية .

حتى الأعمال المترجمة عن **Geography** مثل **كتاب صورة الأرض** للخوارزمي **وكتاب عجائب الأقاليم السبعة** لسهراب لايحتويان على ترجمة عربية كاملة للنص أو للجداول الإغريقية . بالإضافة إلى اختلافهم عن الكتاب من الناحية البنيوية. وبالإضافة إلى ذلك ففي القرن التاسع يعتقد بان الخوارزمي صحح وأضاف إلى حقائق بطليموس معلومات حصل عليها من خلال جهود علماء من العباسيين الأوائل .

خامساً : أدخل نظام خطوط العرض الإغريقي لتقسيم الأرض المأهولة في سبعة

أقاليم في الجغرافية العربية مع إعادة الخوارزمي لأعمال بطليموس وعلى الرغم من الوجود المماثل على الأقل لنظامين آخرين في القرون الأولى للإسلام ، يصبح مسيطراً في مصادر لاحقة رغم عدم وجود تأثير اغريقي آخر .

سادساً : إذا كان أثر بطليموس أوضح . ومقصوراً على الأعمال في الجغرافية الرياضية . فإن مفاهيمه الرئيسية المتعلقة بالبر والبحر المحيط . والأقاليم السبعة ، وتضاريس أفريقية تعتبر نوعاً من الجغرافية الوصفية . أو قواميس وموسوعات .

سابعاً : ضمن البنية الخرائطية والمفاهيم المقبولة إلى حد بعيد وانسجام المعطيات الوصفية والإحداثية المعزوة مباشرة لبطليموس تسقط بعنف من ذروة أعمال « المدرسة الاغريقية » في القرن التاسع – العاشر إلى العدم حوالي منتصف القرن الحادي عشر .

علم المثلثات الإسلامي والبطليموسي ومسألة تحديد القبلة

ايفرت . م . بروينز

نحن نعلم منذ اكتشاف لوحات سوسة أنه قد تم حساب جدول صغير للأوتار في العهد البابلي القديم . وبعد ألفي عام تقريباً أعطى بطليموس جدوله الشهير للأوتار موضحاً فيه الأطوال ضمن دائرة نصف قطرها ٦٠ وحدة ، حينما يقابل قوساً معطى على المحيط . من هنا كان من الممكن ايجاد علم للمثلثات بالغ الدقة .

إذ أعطى بطليموس التحويل اللازم من علم المثلثات المستوية إلى علم المثلثات الكروية بواسطة اتباع نظرية منيلاوس وذلك باستبدال الأوتار بالأطوال – أي جيوب الزوايا – ومن هنا كانت العلاقات في المثلث القائم واضحة :

$$\cos C = \cos a . \cos b \quad , \quad \sin c . \sin A = \sin a,$$

$$\cos A . \sin c = \sin a . \sin b \ldots ,$$

وقد اوقع العلماء المسلمون أنفسهم في مشاكل وصعوبات بالعمل على الكرة عوضاً عن ثلاثية السطوح البطليموسية . كما انهم لم يتوصلوا إلى استعمال الجيب الكامل المساوي للواحد بل تابعوا العمل على نصف القطر البطليموسي المساوي لـ ٦٠ وحدة ، فيما عدا حالات الزوايا الثلاث المعطاة أو الأضلاع الثلاثة المعطاة ، فان المعلومات الثلاث عن المثلث تتضمن دائماً ضلعاً وزاوية مجاورة أي C , a .

وهكذا يمكن للمرء ان يقسم المثلث بسهولة إلى مثلثين قائمي الزاوية باسقاط الارتفاع على الضلع b ، والمحسوب بالعلاقة :

$$\sin h = \sin a \cdot \sin C$$

وبالمسقط p على الضلع b ، والمحسوب بالعلاقة

$$\cos p = \cos a \,/\, \cos h$$

وإذا اعطيت b فإن المرء يحصل حينئذ من :

$$q = b - p$$

على العلاقة التالية :

$$\cos c = \cos p \cdot \cos q.$$

واخيراً نحصل على الزواية A بواسطة قاعدة جيب الزاوية :

$$\sin h = \sin c \cdot \sin A = \sin a \cdot \sin C$$

هذه الطريقة هي الطريقة نفسها التي اتبعها البيروني في كتابه : **تحديد الأماكن** من أجل تحديد القبلة في غزنه وذلك بواسطة البيانات التالية :

خط عرض غزنه = $a = 33^{\circ}\,35'$

خط عرض مكة = $b = 21^{\circ}\,40'$

الفرق بين خطي الطول = $t = 27^{\circ}\,22'\,24''$ (وكأنه قد تم حساب $\frac{1}{6}$ الثانية من الزمن) . تعتبر كل مرحلة مصدراً محتملاً للاخطاء . ولذلك توجه الجهود في علم المثلثات للتقليل من عدد المراحل .

احتاج البيروني لتطبيق طريقته لـ ٢٠ مرحلة وبصعوبة لـ ١٧ مرحلة في الحقيقة طبق البيروني الطريقة الأساسية بدقة بالغة مما جعلته يهمل العلاقة المباشرة ، متجنباً حساب : q , p , h

$$\cos c = \cos a \cdot \cos b \cdot \cos t + \sin a \cdot \sin b$$

وقد حددت النتائج الحديثة للقبلة Q بالعلاقة :

$$\cot Q = (\sin a \cos t - tg\, b \cos a) / \sin t$$

(د . كينج ، دائرة المعارف الاسلامية) .

وتكون حينئذ مراحل الطريقة ٨ .

ويمكن تقليل المراحل إلى ست مراحل على اعتبار $tg\, 21^\circ 40' = \sin H$ بتطبيق العلاقة .

$$\cot Q = [\sin(a - t) + \sin(a + t) + \sin(a - H) - \sin(a + H)] / 2 \sin t$$

ان تقسيم ضلع (أو زاوية) إلى قسمين في حالات الأضلاع الثلاثة (أو الزوايا الثلاث) المعطاة يؤدي بسهولة إلى قواعد التجيب التي تحدد الزوايا (أو الاضلاع) .

ان دقة الأرقام المعطاة بواسطة الحواسيب المكتبية الصغيرة جعلت علم المثلثات غير ضروري .

اصل الانواء عند العرب : الفرق بين العلم والتراث

دانيل مارتن فاريسكو

من النظم القياسية في علم الفلك الاسلامي لتقسيم السماء إلى مواقيت منفصلة هو نظام منازل القمر الثمانية والعشرون والذي يقارب دائرة البروج القمرية عند أهل الهند . وقد ناقش العلماء لمدة قرنين أصل فكرة منازل القمر ولكن لم يظهر بعد أي دليل حول بدايات تطورها في كل من الحضارتين اليونانية والسامية .

زعم علماء العرب الاوائل – كإبن قتيبة – أن منازل القمر قد أشتقت من النجوم التي عهدها أهل الجاهلية في تفسير الظواهر الجوية كالمطر وغيرها . وسميت هذه النجوم الأنواء . وقد اعتقد بعض العرب أن هذه الأنواء كانت تسيطر على الأحوال الجوية ، وقد قدم سيدنا محمد عليه السلام هذا الاعتقاد في الحديث الشريف .

بحلول القرن الثالث الهجري ازدهرت بعض الكتب العربية في فقه اللغة حول موضوع الانواء . وقد احتوت هذه الكتب على مختارات من الشعر والسجع تتحدث عن تراث النجوم لأهل الجاهلية بينما اتفق علماء العرب لعـدة قرون على وجود علاقة تربط بين الأنواء ومنازل القمر وتساءل عدة مستشرقين عن صحة هذه العلاقة .

ترتكز هذه الدراسة على فحص الأساس المصاحب والمناقض للفكرة المطروحة في الأدب العربي عن نشوء منازل القمر في علم الفلك من نظام الأنواء في الجاهلية . وفي دراسة للكتب الموجودة حالياً حول الانواء نجد انها تشير إلى وجود عدة تقاويم ونظم كثيرة لتراث النجوم عند العرب . غير ان الاساس الذي يشير إلى علم الأنواء عند الجاهلية متناقض حيث أنه لايوجد أي ذكر لبعض منازل القمر في شعر الجاهلية أو سجعها . لذا لايكون الحل لهذه المشكلة من دراسة الكتب العربية فقط ، وإنما يجب ان يحتوي الحل على أمثلة حول كيفية استعمال تقاويم نجوم مشابهة لتلك النظم القديمة في عالم العرب حديثاً أو حالياً .

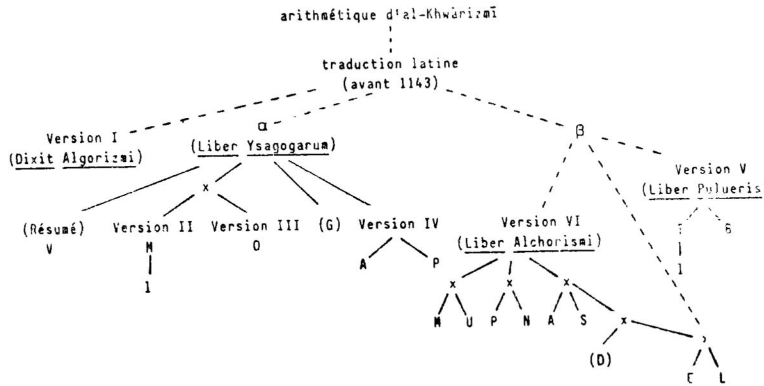
انتشار المؤلفات اللاتينية الأولى في الغرب المستمدة من كتاب « الحساب » الضائع للخوارزمي

اندريه الار

بسبب عدم إمكانية الإسناد إلى النص الأصلي من حساب الخوارزمي ، وعدم إمكانية المقارنة التامة بين نصوص القرن الثاني عشر الأكثر قدماً والمستمدة منه . كان يعتقد حتى الآن ان نص (Dixit Algorizmi) – المعروف كالعادة بمقدمته والوارد في مخطوط كامبريج الوحيد الذي يحتويه – الشاهد اللاتيني الأكثر قدماً للنص العربي الضائع ، كما أوحى بذلك محققه الرئيس

إن فحص المخطوطات المحفوظة — التي نرجو بأن تكون اللائحة كاملة اليوم — يفصح — بعكس ما سبق — عن ترجمات عديدة معَدّة بدءاً من ترجمة لاتينية ضائعة منجزة قبل ١١٤٣ م .

ان الوضع التاريخي لمختلف هذه التّرجمات . بعضها بالنسبة للأخرى ، يمكن تلخيصه بايجاز بالشكل التالي :



انه غير مجد ، الاعتقاد بأن كل واحدة من هذه التّرجمات ، تكون حالة نص متباعد أكثر فأكثر من النص الأصلي ، هذه الرؤيا ليست ممكنة إلا للتّرجمة VI التي يمكن عزوها قطعاً لـ Jean de séville ان مخطوطات معزولة أو مجموعات من المخطوطات لها أصالتها الخاصة ، ولكن مقارنة النصوص التي تحتويها وخاصة الأمثلة المنتخبة من قبل الباحثين . تشير ، من جهة ، إلى نقاط مشتّركة لجميع التّرجمات . ألا وهي انعكاسات أكيدة للتّرجمة اللاتينية الأولى ، اذا لم يكن للاصل العربي . ومن جهة أخرى علاقات غير منتظرة ولكنها ليست عرضية بين نصوص متباعدة ظاهرياً بعضها عن بعض . غير أن هذه التقاربات . التي ما استطاعت ان تكون حتى الآن إلا جزئية بنتيجة نصوص محققة غير كاملة . وقد تأكدت بفحص الأرقام في المخطوطات .

يمكننا اليوم اعطاء ، مع بعض التأكيد ، لوحة عن محتوى كتاب « الحساب » الضائع للخوارزمي ووصف الطرق الحسابية التي تحتويه وتأثيره على العصر الوسيط الغربي .

علم النفس عند ابن سينا « والكوميديا الإلهية » لدانتي

جوتهارد شتروماير

يمكن اعتبار دانتي أليجيري (١٢٦٥ — ١٣٢١ م) علامة رئيسية بسبب التأثير العظيم للفلسفة العربية على الفكر الأوروبي خلال القرن الثالث عشر . وكان هذا التأثير على وشك التراجع أثناء حياة دانتي ولكن « الكوميديا » التي ألفها ما تزال تكشف عن تطابق بعيد النطاق مع مذاهب ابن سينا على وجه الخصوص . ولقد قام رودولف بالجن مؤخراً — وهو مختص بدراسة الآداب عند دانتي — بإنجاز عمل كبير لإيضاح الفقرات الغامضة في « الكوميديا » وذلك بالإستعانة بالترجمات اللاتينية عن ابن سينا . وخلافاً للمنحى الذي سلكه جالينوس وفلاسفة مسلمون آخرون — والمشكوك في صحته شكاً قوياً — فإن ابن سينا كان معنياً بشكل خاص بإثبات خلود الروح البشرية . هذا الإثبات تبنته الفلسفة السكولاستية النصرانية . ففي فصل المطهر /٢٥/ يعيد دانتي نسخ مفهوم ابن سينا حول الروح العقلانية التي يتم خلقها من انبثاق فيض إلهي عندما تصل المادة كمالها الأعظم في الدماغ البشري . وبعد انفصالها عن الجسم فإن الروح العقلانية تحتفظ ببعض الخصائص المكتسبة أثناء حياة المرء . ولقد وجدت فكرة ابن سينا هذه مجالاً وافراً في شعر دانتي .

وببعض التباين قياساً على ارسطو فقد أقر ابن سينا بالتقسيم الأفلاطوني للنفس البشرية إلى جزء عقلاني وجزء حيوي وجزء رغبي ، وذلك لأن جالينوس في بحثه التشريحي عزز هذا التقسيم الثلاثي . ويؤكد ابن سينا في الوقت ذاته أن هذه الأجزاء يجب أن لاتفهم على أساس أنها ثلاثة أنفس متواجدة بمعزل عن بعضها . كما أكد دانتي الفكرة ذاتها في فصل المطهر /٤/ .

وبصرف النظر عن هذه الأجزاء الثلاثة للنفس البشرية يضيف ابن سينا أن كل مركب من « خمسة أحاسيس داخلية » كوحدة نفسية رابعة متوضعة في الدماغ أو في بطيناته وبكونها حقل الإنخداع والأوهام . ففي قصته الرمزية « حي بن يقظان » يصور ابن سينا هذه الأجزاء الأربعة للنفس كأربع شخصيات متميزة . الجزء العقلاني هو الراوي الذي يتحدث بصيغة المتكلم والمحاط بثلاثة أصدقاء أشرار . إن تصور دانتي الاستهلالي لفصل « الجحيم » يُظهر مخططاً شبيهاً جداً لذاك في قصة « حي بن يقظان » . ولكن عوضاً عن الأصدقاء الأشرار الثلاثة تظهر هنا ثلاثة وحوش تحمل المعنى الرمزي ذاته . هناك الكثير من التطابق بين قصة « حي بن يقظان » وقصيدة دانتي الضخمة، لذلك يمكن اعتبار قصة ابن سينا هذه أحد « المصادر » المحتملة، « للكوميديا » من « كتاب المعراج » أو أي مؤلف من هذا النوع .

مراجعات الكتب

جداول الكواكب الثابتة من كتاب المجسطي لبطلميوس في ترجمتين عربيتين : ترجمة الحجاج بن يوسف بن مطر وترجمة اسحق بن حنين باصلاح ثابت بن قرة .

تحقيق : باول كونيتش ، الناشر : اوتوهاراسوفيتش فيسبادن المانيا ١٩٨٦ ، ٣٤٤ صفحة

مراجعة سامي شلهوب

الجزء الأول وهو يتضمن النص العربي مع الترجمة الالمانية ويحوي جداول الكواكب الثابتة ويبلغ عددها ١٠٢٥ كوكباً مرتبة في ٤٨ مجموعة مع وصف لمواضعها ، وهكذا اصبح لاول مرة النص العربي لجداول الكواكب معروفاً ، وهذا له معناه التاريخي الهام ، ومن المعروف ان كتاب المجسطي لبطلميوس قد لعب دوراً هاماً حتى القرن الثامن للميلاد على الأقل ، وبقي المصدر الأساسي للفلك العربي والاسلامي ، واصبح في أوربا أيضاً مصدراً أساسياً للفلك هناك بعد أن ترجمه جيرهارد فون كريمونة إلى اللغة اللاتينية ، وبقي كذلك حتى كوبر نيكوس واعتمد بكل ذلك على الترجمات العربية للكتاب ولكن ربما اعتمد على الترجمة السريانية وهذا ما وسم بالنقل القديم في كتاب الكواكب والصور لعبد الرحمن الصوفي ويعتبر بالمحصلة كتاب المجسطي من أهم المؤلفات اليونانية في علم الهيئة ، بل ان الاساس الذي اعتمدت عليه كل الكتب اللاحقة في هذا المجال ، ويعتبر هذا الكتاب الهام بانه دون كل فروع علم الفلك القديم ووصل العملي بالنظري في جميع المسائل فلم يأتِ بقاعدة الا وبرهن عليها ، ولم يثبت شيئاً من حركات الاجرام السماوية إلا وبيّن كيف توصل الفلكيون إلى معرفته وقياسه ، ولم يجعل جدولاً الا واوضح اصول حسابه وبقي المجسطي لبطلميوس لعشرات السنين في واجهة الابحاث وما كتب بالعربية منه كان مركز ثقل أبحاث الاستاذ باول كونيتش وانجز ما يمكن انجازه ، وكان جدول الكواكب الثابتة واعتمد بذلك على

مجلة تاريخ العلوم العربية — المجلد التاسع ، ١٩٩١ م — ص ٣٩ — ٤٠ .

ترجمتي الحجاج بن مطر وحنين بن اسحق باصلاح ثابت بن قرة مستخدماً الأساليب المعروفة بامور تحقيق المخطوطات ثم ترجم ذلك إلى اللغة الالمانية وارفقهما بملحقين لكتابة الفروق بينهما وبين ما جاء في النص اليوناني لطبعة هايبرغ .

وقد اعتمد الأستاذ باول كونتيش على النسخ التالية * مجال تحقيقه للنص العربي بالنسبة لترجمة الحجاج بن مطر اعتمد على :

١ – نسخة لندن رقم ٦٨٠ والتي نسخت قبل ٦١٥هـ/١٢١٨ م .

٢ – نسخة لندن المكتبة البريطانية رقم ٧٤٧٥ والتي نسخت ٦١٥هـ/١٢١٨م ونسخة الاسكوريال رقم ٩١٤ بدون تاريخ .

٣ – نسخة باريس المكتبة الوطنية رقم ١١٠٠ والتي نسخت ١٤٧٥ م .

وبالنسبة لترجمة حنين بن اسحق باصلاح ثابت بن قرة اعتمد باول كونتيش على نسخ :

تونس المكتبة الوطنية٧١١٦ نسخت ٤٧٨هـ/١٠٨٥ م، الاسكوريال رقم٩١٥ نسخت ١٣١٤ م ، وهـــذا يعتبر كافياً لتحقيق نص بهذه السوية العلمية الجيدة .

واعتمد الأستاذ باول كونتيش على ان يكون الجزء الثاني مخصصاً للنص اللاتيني والذي ترجمه جيرهارد فون كريمونة .

أما الجزء الثالث فهو مخصص للمقارنة بين النصوص اليونانية والعربية واللاتينية والهدف العلمي الأساسي من عمل الأستاذ باول كونتيش هو جعل نص بطلميوس العربي والنص اللاتيني في متناول البحث ، وقد انجز ذلك ببراعة ودقة وبروح العالم الباحث وهذا معروف عن اعمال الأستاذ باول كونتيش في مجال تاريخ علم الفلك .

أما عن حياته فهو قد ولد في ١٩٣٠/٧/١٤ في كروسوف ، ونال شهادة الدكتوراه عام ١٩٥٦ من جامعة برلين ، وتابع ابحاثه في جامعات جوتنجن والقاهرة وكولونيا حتى عام ١٩٧٥ م والتحق بعدها كاستاذ في جامعة ميونيخ ولا يزال هناك وله مؤلفات عديدة في مجال تاريخ علم الفلك (انظر النص الألماني) .

المشاركون في هذا العدد

– **اندريه آلار** : باحث في مركز الأبحاث العلمية البلجيكي ، وهو مهتم بتاريخ الرياضيات عند الاغريق والعرب ، وله مؤلفات عديدة في ذلك المجال .

– **تامارا البرتيني** : باحثة في مجال الفلسفة والدراسات اللغوية ، حائزة على شهادة الدكتوراه في « نظرية المعرفة » . تعمل حالياً كأستاذة مساعدة في معهد لتاريخ الفكر وفلسفة النهضة .

– **ايفرت . م . بروينز** : كان استاذاً في جامعة امستردام في هولندا ، وقد شغل مناصب علمية عديدة ، وله مؤلفات كثيرة في تاريخ العلوم الرياضية والكيمياء والأشعة الكونية . وقد توفي في عام ١٩٩٠ م .

– **م . أ . تولماشفا** : تحمل شهادة دكتوراه في مجال الدراسات الجغرافية الوصفية . تعمل حالياً كأستاذة مشاركة في حقل التاريخ في جامعة واشنطن ولها دراسات ومؤلفات في ذلك الميدان .

– **سيمون حايك** : حاصل على شهادة الدكتوراه في الفلسفة من جامعة مدريد المركزية ، يعمل في حقل تاريخ العلوم عند العرب ونقل هذه العلوم إلى الغرب وتأثيرها فيه .

– **فيرندرا شارما**: استاذ علم الفلك والفيزياء في مركز جامعة ويسكونسن. وقد نشط في مجال تاريخ علم الفلك على مدى السنوات العشر الماضية ، وخاصة الفلك في الهند قبل الحكم البريطاني ، ونشر العديد من المؤلفات في هذا المجال .

– **جورتهارد شتروماير** : يعمل منذ عام ١٩٥٨ وحتى الآن كساعد علمي في أكاديمية العلوم في برلين . نشر حوالي ٢٠٠ مطبوعة في مجال تاريخ الطب والفلك والسيمياء وتأثير الحضارة الاغريقية في التراث العربي والاسلامي وبالتالي تفاعله مع الحضارة الغربية عن طريق العرب .

– **سامي شلهوب** : يعمل استاذاً مساعداً لمواد تاريخ الرياضيات والفلك والفيزياء لطلاب دبلوم تاريخ العلوم الأساسية في معهد التراث العلمي العربي بجامعة حلب ، بالإضافة إلى عمله كوكيل للمعهد ذاته ، وله مؤلفات في مجال تاريخ الرياضيات العربية .

– **دانيل مارتن فاريسكو** : عالم مختص بعلم الانسان ، وله مؤلفات عديدة في هذا المجال .

– **باول كونيتش** : استاذ في معهد اللغات السامية بجامعة ميونيخ ، ألف عدة كتب عن الفلك وعلم الهيئة عند العرب في القرون الوسطى . اختصاصه الرئيسي في أسماء النجوم ومصطلحاتها .

– **مهدي محقق** : استاذ اللغة الايرانية والآداب والفلسفة الاسلامية ، وقد نال شهادة الدكتوراه في اللغة الفارسية وآدابها ، وكان استاذاً زائراً في جامعة لندن ، وله مؤلفات عديدة في مجال تخصصه .

ملاحظات لمن يرغب الكتابة في المجلة

تقديم نسختين من كل بحث أو مقال إلى معهد التراث العلمي العربي . طبع النص على الآلة الكاتبة مع ترك فراغ مزدوج بين الأسطر وهوامش كبيرة لأنه يمكن أن تجرى بعض التصحيحات على النص ، ومن أجل توجيه تعليمات إلى عمال المطبعة . والرجاء ارسال ملخص يتراوح بين ٣٠٠ — ٧٠٠ كلمة باللغة الانكليزية إذا كان ذلك ممكنا وإلا باللغة العربية .

طبع الحواشي المتعلقة بتصنيف المؤلفات بشكل منفصل وتبعا للارقام المشار إليها في النص . مع ترك فراغ مزدوج أيضاً ، وكتابة الحاشية بالتفصيل ودون أدنى اختصار .

أ — بالنسبة للكتب يجب أن تحتوي الحاشية على اسم المؤلف والعنوان الكامل للكتاب والناشر والمكان والتاريخ ورقم الجزء وأرقام الصفحات التي تم الاقتباس منها .

ب — أما بالنسبة للمجلات فيجب ذكر اسم المؤلف وعنوان المقالة بين أقواس صغيرة واسم المجلة ورقم المجلد والسنة والصفحات المقتبس منها .

ج — أما إذا أشير إلى الكتاب أو المجلة مرة ثانية بعد الاقتباس الأول فيجب ذكر اسم المؤلف واختصار لعنوان الكتاب أو عنوان المقالة بالاضافة إلى أرقام الصفحات .

أمثلـــة :

أ — المطهر بن طاهر المقدسي ، كتاب البدء والتاريخ ، نشر كلمان هوار . باريس ١٩٠٣ ، ج ٣ ، ص ١١ .

ب — عادل انبوبا ، « قضية هندسية ومهندسون في القرن الرابع الهجري ، تسبيع الدائرة » ، مجلة تاريخ العلوم العربية . مجلد ١ ، ١٩٧٧ ص ٧٣ .

ج — المقدسي ، كتاب البدء والتاريخ ، ص ١١١ .
انبوبـــا ، « قضية هندسية » ، ص ٧٤ .

Notes on Contributors

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Bruins, E. M. : was a professor at the University of Amsterdam in Holland, and had occupied several scientific positions . He had many publications dealing with the History of Mathematical Chemistry as well as the Cosmic Rays . Died in 1990 .

Chaihoub, Sami : besides his being a Vice Director of the Institute for the History of Arabic Science , he is also an assistant professor of the History of Mathematics, Astronomy and Physics at the Institute . He has books in the field of the History of Mathematics.

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Varisco, Daniel Martin : PH. D. in Anthropology. He has many publications dealing with the fields of Anthropology, Ecology and Agriculture .

France in 1520 and finally in Basile, Switzerland in 1544. Meanwhile, the ninth article has been published alone in Venezia in 1483, 1490 , 1493 , 1497 , and in Badova in 1480 under the name of *Nonus Almansoris*, de *Curationes Aegritudinum Qui Accidunt A Capite Ad Pedes.*

A great doctor named Andreas Vesalius, who has waked up the Anatomy of the middle ages after a long dream , is also an anatomist who has been born in Bruxele in 1514 and studdied in Louvain, Belgica, and lateron in Paris, due to the instructions of a friend of him. In the University there was a doctor called Sylvius who has got a good fame for his works that always marked the line of Galen in a blindish way. and who beleived that the mistakes of that where in a matter of fact due to the incomplete manuscripts written in the Greek language or due to the incorrect translations of the Latin language. Sylvius thinks that the misunderstandings between what Galen have said and what really has been discovered later on is due to the corruption of the human bieng.

Vesalius became the doctor of the Emperador Carlos V and then the doctor of his son Philip II. He worked in the dissection of the bodies for what he was condemned by death as well as Miguel Servatius, but the intervention of the Prince Philip made that the sentence being changed to pilgrimage to Jerusalem. In his return he met with a storm which lead him to the shore of Zant where he died in 1564.

His doctorate written in latin under the name : *Parafrasis In Nonum Librum Rhazae* or the description of the ninth article of the book of Rāzī, the book has been published later on many times during the Renaissanse the most important in Basile in 1537 .

The book contained also a poem written to Vesalius by one of his friends called Jodocus Velsius in which he admires the arabic doctor Rāzī and his valueous works to the human being and accuses the translators who had little experience and who made the reading of Rāzī seem boaring and unlikely while the book and works of Vesalius showed the importance of Rāzī and made more likely the readings of that doctor.

The book known as the explanation of the ninth article of the *Manṣuri* written by Rāzī is considered as the introduction of the book of Vesalius which was very famous and which has appeared in 1543 under the name : *De Humani Corporis Fabrica* or *The Composition of The Human Body* .

Qatājanūs , *al - Quwā al - Ṭabī'iyah* , *Fi anna Quwā al - Nafs tabi'at li - Mīzāj al - Badan, Fī mā Ya'taqidu-hu Ray'an, Manāfi^{c} al - A'ḍā', al - Minā, al- Mayāmir*, and *al- Nabḍ al- Kabīr* .

Passages are also to be found in the *Shukūk* from some works of Razi the originals of which have been lost, such as *Sam' al - Kīyān, Fī al- Radd ^{c}alā al - Sarakhsī fī Amr al-Ṭa'm al - Murr, Fi anna Markaz al - Arḍ Yanbū' al-Bard, Fī Kayfiyat al-Abṣār, Fī al - Azminah wa - al - Ahwiyah, Fī Kayfiyat al - Ightidhā', Fī Wujūb al - Istifrāgh fī Awā'il al-Ḥummayāt, Ikhtiṣār K. al-Nabḍ al- Kabīr, Fī al- Baḥth 'ammā Qila fī K. al - Ustuqussāt wa - fī Tabī'at al- Insān, Mā Qālat al- Qudamā' fī al- Mabādi' wa- al - Kayfiyāt, Fī Jaww al - Asrāb, al - Nafs al - Ṣaghīr, al - Nafs al - Kabīr, Fī 'Illah allatī Ṣāra al-Kharīf Mumriḍan, Fī al - 'Illah allatī Yaḍīq al - Naẓar fī al-Nūr wa Yattasi'u fī al -Ẓulmah, Fī al-Ladhdhah, Fī ma Jara baynahu wa - bayn Shahīd al-Balkhī fī al - Ladhdhah* , and *Fī Miqdār mā Yumkin an Yustadrak min al-Nujūm ' ind man Qāla anna-ha Aḥyā' Nāṭiqah wa- man lam Yuqal dhālika.*

The value of the *Kitāb al - Shukūk* as a source for the works of Galen and al - Rāzī is increased further still by the fact that both Hunayn ibn Ishaq and Bīrūnī only give in their *fihrists* the names of various works , without an indication of the medical and philosophical topics to which they address themselves.

Rāzī and Vesalius

SIMON HAYEK

Is Abu Bakr Muhammad ben Zakaria Al- Rāzī (865 – 932) the best doctor of his age, he has a book titled : *Al- Ṭib Al- Manṣuri*, wrote it to the Prince Manṣur ben Ishaq ben Ismail ben Muhammad, chief of Khurāsan, in an abreviated manner. The book is of ten articles, of which the most important to us is the ninth : The illnesses that happen from the head to the foot .

The article was known in the Middle Ages by the name of "Nonus Almansoris " which deals with the different illnesses of the body.

The book has been translated to the Latin by Gerardo de Cremona, in Toledo, Spain, in the second half of the twelfth century and the translation has been published in Milano in 1481 and in Venezia in 1497 and in Leyon,

Summaries of Arabic Articles in This Issue

Al-Rāzī's Kitāb Al-Shukūk 'Alā Jālīnūs

MEHDI MOHAGHEGH

Muḥammad ibn Zakarīyah al-Rāzī was one of the greatest scholars of Islam . Although scholars in the last century have concentrated more on his philosophy, al-Rāzī was in fact originally best known for his medica and pharmacology . Al-Rāzī's eminence is attested by the fact that Abū Rayḥān al- Bīrūnī, despite the fact that he was opposed to al- Rāzī , composed a bibliography of his works.

Al- Rāzī was one of the first Islamic scholars to turn his attention to the works of Galen and to make use of them. He even referes to works of Galen found neither in the bibliography of Ḥunayn ibn Isḥāq nor in Galen's own autobibliography. Al- Rāzī followed the views of Galen not only in his medica, but also in philosophy and ethics.

Al- Rāzī had thus read all the most important works of Galen, and it is on this basis that he wrote the *Kitāb al - Shukūk*. His ' doubts ' concern passages in various writings, and inconsistencies in various matters. Al- Bīrunī records the title of al - Rāzī's work as *al - Shukūk ' alā Jālīnūs* , while Ibn Abī Usaybiʿah calls it *al - Shukūk wa- al - Munāqadāt allatī fi Kutub Jālīnūs* .

In the *Shukūk* Rāzī sets down some of the medical and philosophical pronouncements of Greek philosophers such as plato, Aristotle, and Hippocrates, as well as Themistius, Empedoclus, Diocles, Thales, Asclepiades, and Erasistratos, while also mentioning such Islamic scholars as Ḥunayn ibn Isḥāq and Muḥammad ibn Mūsā. He makes reference to ' a distinguished and noble man' man with whom he used to read the works of Galen - but he does not give the name of this person. The works toward which al- Rāzī directs his ' doubts ' are among the most important of Galen's writings, and include *Ārā ' Buqrāt wa- Aflāṭūn* , *al- Akhlāq*, *al- Adwiyah al- Mufradah*, *al - Ustuqussāt 'alā Ra'y Buqrāt Aṣnāf al-Ḥummayāt* , *al - A'ḍā' al-Ālimah* , *al-Aghdhiyah*, *al-Amrāḍ al -Ḥādduh*, *al -Buhrān*, *al -Tajribah al-Tibbīyah*, *Tadbīr al-Aṣiḥā' Tashrīh al - Ḥayawān* , *Tafsīr K. al-Buqrāṭ fi Ṭabi'at al-Insān*, *Tafsīr Kitāb al-Fuṣūl* , *Taqdimat al - Ma'rifah*, *Ḥarakat al- 'Aḍal*, *Ḥīlat al- Burr' al -Dhubūl*, *al-Ra'shah wa-al-Nāfiḍ*, *al-Ṣanā'ah Ṣaghīrah*, *al-'Ilal wa - al - A'rāḍ*.

- Escorial 915 (dat . 4. September 1314 span. Ära = 1276) , 138r – 119v (europäisch gezählt, im arabischen Sinn gegenläufig) .

Paul Kunitzsch promovierte 1956 an der Freien Universität Berlin. Er vertiefte seine Forschungen in Göttingen , Kairo und Köln. Seit 1975 ist er Professor an der Universität München .

Einige Seiner Veröffentlichungen:

- Arabische Sternennamen in Europa, Wiesbaden / Deutchland, 1959 .
- Untersuchungen zur Sternnomenklatur der Araber, Wiesbaden / Deutschland, 1961 .
- Ibn aṣ-Ṣalāḥ : Zur Kritik der Koordinatenüberlieferung in Sternkatalog des Almagest, Wiesbaden / Deutschland 1975 .
- On the Mediaeval Arabic Knowledge of the Star Alpha Eridanī, J. H. A. S., Vol 1 / Aleppo / Syrien, 1977 .

Dr. Sami Chalhoub
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Book Review

Der Sternkatalog des Almagest. Die arabisch - mittelalterliche Tradition **von Claudius Ptolemäus**

Die arabischen Übersetzungen,

von al-Ḥaǧǧaǧ u. von **Isḥāq** in der Bearbeitung durch Ṭābit.

Ins Deutsche übertragen u. bearbeitet von **Paul Kunitzsch**, Verlag Otto Harrassowitz - Wiesbaden / Deutschland – 1986, umfast 344 Seiten .

Rezension Dr. Sami Chalhoub

Band 1 : Arabischer Urtext und deutsche Ubersetzung

Sternkatalog - 1025 Sterne - angeordnet in 48 Sternbildern, mit Beschreibung ihrer Stellung innerhalb der Bilder und mit ekliptikalen Koordinaten verzeichnet .

Damit wurde erstmals das arabische Textmaterial, das Grundlage für den Sternenkatalog (seit dem späten 8. Jahrhundert) zugänglich gemacht.

Für die Geschichte der Astronomie in der arabischen Welt war der Almagest ein fundamentales Werk.

Inhalt, Form, Theorien, Methoden, Termininologie und Nomenklatur haben die arabische islamische Astronomie grundlegend geprägt .

Auch für Europa war der Almagest die Grundlage der Astronomie durch die Übersetzung von Gerhard von Cremona.

Benutzte Handschriften : al - Ḥaǧǧāǧ

- Leiden, cod. or. 680 (vor 615 H = 1218 / 19) , 111ʳ — 125ᵛ .
- London, British Library Add . 7475 (dat. Šaʿbān 615 H = Oktober 1218), 15ᵛ — 36ᵛ .
- Escorial 914 (nicht datiert), 74ʳ - 92ᵛ .
- Paris, B. N. hebr. 1100 (dat. 1475), 88ʳ - 104ᵛ (arabisch, in hebräischer Halbkursive) .

Isḥāq mit den Verbesserungen von Ṭābit

- Tunis, Bibliothèque Nationale 07116 (dat. Ǧumādā II 478 H = Oktober 1085) , 117ᵛ - 134ᵛ .

To Contributors of Articles for Publication in the *Journal for the History of Arabic Science*

1. Submit the manuscript in duplicate to the Institute for the History of Arabic Science. The text should be typewritten, double-spaced, allowing ample margins for possible corrections and instructions to the printer. In matters of paragraph-indentation and the indication of footnotes, please follow the style used in this journal.

2. Please include a summary – if possible in Arabic, but otherwise in the language of the paper – about a third of the original in length.

3. Bibliographical footnotes should be typed separately according to numbers inserted in the text. They should be double-spaced as well, and they should contain an unabbreviated complete citation. For books this includes author, full title (underlined), place, publisher, date, and page-numbers. For journals give author, number, year, and page-numbers.

Examples :

O. Neugebauer, *A History of Mathematical Astronomy* (New York: Springer, 1976), p. 123.

Sevim Tekeli, "Takiyüddin'in Sidret ül-Müntehâ'sına aletler bahsi", *Belleten* 25 (1961), 213-238.

After the first quotation, if the reference is repeated, then the author's name and the abbreviation *op. cit.* may be used. Alternatively, the books and articles cited may be collected into a bibliography at the end of the article, according to the above format, so that reference may be made to them in the footnotes by author or short title.

4. In the transliteration of words written in the Arabic alphabet the following system is recommended:

' ,	b ,	t ,	th ,	j ,	ḥ ,	kh ,	d ,	dh ,	r ,	z ,	s ,	sh ,		
ء	ب	ت	ث	ج	ح	خ	د	ذ	ر	ز	س	ش		
ṣ ,	ḍ ,	ṭ ,	ẓ ,	ᶜ ,	gh ,	f ,	q ,	k ,	l ,	m ,	n ,	h ,	w ,	y ,
ص	ض	ط	ظ	ع	غ	ف	ق	ك	ل	م	ن	ه	و	ي

Hamza at the beginning of a word is omitted in transcription. The *lām* of the Arabic article before sun-letters is not assimilated (thus *al-shams* and not *ash-shams*).

For short vowels, *a* is used for *fatḥa*, *i* for *kasra*, and *u* for *ḍamma*. For ong vowels diacritical marks are drawn over the letters: *ā*, *ī*, *ū*. The diphthong *aw* is used for 'وْ' and *ay* for 'يْ'. Long vowels before *hamzat al-wasl* are printed long (thus "abū'l-Qāsim" and not "abu'l-Qāsim").

active intellect ,[20] but despite this difference there is one word in Dante which reveals the Arabic origin . He says that the soul " becomes speaking " (" divenga fante ", v. 61) , and this must be an unsuccessful rendering of the term *nāṭiḳ* (" rational ") .

Ibn Sīnā extends his psychology even to the heavenly spheres which, according to his opinion , have souls that are aiming in love at their first cause, i. e. God, generating in this way their constant circular movement . Christian theologians like William of Auvergne (died 1249) rejected this as ridiculous.[21] But Dante in his poetic fiction developped this Avicennian idea still further . After ascending through the spheres and coming near to God he suddenly begins to revolve around him in the same manner as a star (Paradise XXXIII, 140 – 145).[22]

So Dante may be regarded as a witness of a very broad reception of Ibn Sīnā in the West, which went beyond the limits of the universities and was not affected by the polemics launched against him from the chairs of the universities . He was one of the most prominent figures of our common cultural heritage.

20. Davidson (see above note 12), p. 158 ; A. – M. Goichon. *La philosophie d'Avicenne et son influence en Europe médiévale*, Paris 1951, p. 46 – 49 .
21. L. Gardet , *La connaissance mystique chez Ibn Sīnā et ses présupposés philosophiques* (Mémorial Avicenne II), Cairo 1952 , p. 36 – 38 .
22. Cf. R. Palgen, Dante und Avicenna. In: *Anzeiger der Oesterreichischen Akademie der Wissenschaften, phil. – hist.* Kl. 88, 1951 , p. 159 – 172 .

himself has clearly indicated. So she corresponds to the third friend and to the lower part in Platonic and Avicennian psychology. The lion is a symbol of the wrathful part, and Abraham ibn Ezra had compared him expressly with a lion,[14] as did Plato in his dialogue *The Republic.*[15] Now the first animal, the female panther, must have something to do with falsehood and deception, as becomes clear from an allusion in Inferno XVI, 108, and there are other parallels in popular animal lore that point into the same direction.[16]

All the parallels between Ibn Sīnā's tale and that of Abraham ibn Ezra and Dante's Comedy are much more closely related to each other than those produced by Asīn Palacios and Cerulli, and they cannot be the result of mere chance. Now we might also expect that some of Ibn Sīnā's basic tenets reappear in the Comedy.

In Purgatory IV, 1 – 11 Dante dissociates himself from the opinion that there exist three separate souls in man, and some commentators took this as a refusal of the whole Platonic tripartition of the soul. But I think we have here instead an allusion to a chapter in the *Kitāb al-shifā*ᵓ, where Ibn Sīnā draws a sharp distinction between the tripartition of the one soul and the existence of three separate souls in one body.[17] This part of the *Kitāb al-shifā*ᵓ was accessible in Latin translation.

In Inferno III, 18 the souls in hell are described not simply as sinful but as those who have lost " the good of the intellect " (" il ben de l'intelletto"). This reminds us of Ibn Sīnā's idea that the eternal happiness of the immortal individual soul is dependent on the link that she could establish with the active intellect during her life on earth and that her punishment in the other world consists in the deprivation of the knowledge of the intelligible substances.[18]

In Purgatory XXV, 37 – 75 Dante describes the development of the human embryo out of the sperm of the father and the blood of the mother in accordance with Aristotle and Ibn Sīnā.[19] But when matter reaches the necessary perfection, then God, " the first mover ", intervenes from above making the embryo a real human being. Ibn Sīnā allots this function to his

14. Greive (see above note 7), p. 151 (v. 102).
15. IX, 588d – 589b. the same in Galen, *On the doctrines of Hippocrates and Plato*, ed. and transl. by Ph. De Lacy (Corpus Medicorum Graecorum V, 4, 1, 2), Berlin 1978 – 84. vol. 2, p. 369.
16. Strohmaier, in: *Deutsches Dante - Jahrbuch* (see above note 8), p. 198 – 199; cf. also Aristotle. *History of animals* I, 6; 612 a 12 – 15.
17. Al-shifāᵓ, *al-ṭabīᶜīyāt*, 6. *al-nafs*, ed. G. C. Anawati and Saᶜid Zayed. Cairo 1975, p. 221 – 224.
18. Davidson (see above note 12), p. 172 – 175.
19. U. Weisser, Zeugung, Vererbung und pränatale Entwicklung in der *Medizin des arabisch- islamischen Mittelalters*, Erlangen 1983.

until now defied all efforts of the commentators. But a look at the introductory vision in the " Khay ben Mekitz " proves to be helpful.[10] Here Abraham ibn Ezra has not changed very much against Ibn Sīnā. The narrator is walking in the fields together with three unpleasant friends. The first going in front of him is a liar, who mixes the truth with falsehood, nevertheless the narrator is dependent on his informations. The next friend, who goes to the right, is often in anger; the third, who goes to the left, is always greedy. These two are easily to be identified with the lower parts of the soul in Plato's psychology, the so-called spirited part (to thymoeides , *al-ḳūwa al-ghaḍabīya*) and the desiderative part (to epithymetikon, *al-ḳūwa al-shahwānīya*). The narrator himself is the rational part of the soul (to logikon, *al-ḳūwa al-ʿaḳlīya*). But who is the first friend, the liar? He represents the complex of the so-called inner senses (*al-ḥawāss al-bāṭina*) which are located in the ventricles of the brain and which have the task of combining and storing the sense data coming from the sense organs. This doctrine seems to be in this particular form Ibn Sīnā's own invention, and it became so famous that we find it again even in the " Arabian nights " in the words of the learned slave-girl *Tawaddud*.[11] The sense data coming from without are liable to distortion and false combination by the inner senses, therefore this first friend is called a liar. True knowledge comes directly from above, from the active intellect who gives matter its forms and who bestows these same forms directly upon the human intellect. In this way the reliability of human knowledge has its ontological basis.[12] In the field the four friends meet a sheikh with a shining face who greets them kindly. His name is *Ḥayy ibn Yakẓān* and he is the personification of this active intellect. In Ibn Sīnā's version he tells very much about his functions and his knowledge, but he refuses the wish of the narrator to take him with him into the regions of the invisible world. He declares that this is impossible so long as one is in the company of these bad friends, i. e. so long as he is in this life. But in Abraham ibn Ezra the narrator is able to join the active intellect so as to begin a journey with him. Dante follows this pattern, but he has replaced the allegoric figure of *Ḥayy ibn Yakẓān* by the wise Roman poet Virgil and by his beloved Beatrice, whom an Italian commentator of the last century has already identified as being here a symbol of the active intellect.[13] The three bad friends are also present in Dante, but in the disguise of three wild beasts. Here the narrator first passes by a lonza, a female panther, then by a lion, then by a she-wolf, before meeting the spiritual leader. The she-wolf is a symbol of greed, as Dante

10. Ibid., p. 149 – 153 (vv. 12 – 181).

11. Ed. Cairo 1325 A.H., vol. 2, p. 449.

12. A. A. Davidson, Alfarabi and Avicenna on the active intellect. In : *Viator* 3, 1972, p. 154 – 427.

13. Francesco Perez, *La Beatrice svelata*, Palermo 1865.

that Dante revered Ibn Sīnā as one of his philosophic authorities . In Inferno IV, 143 he gives him a place, together with Ibn Rushd, in the family of the ancient philosophers.[6] Ibn Sīnā's allegoric tale, despite its being difficult to understand , was widely known, also in Muslim Spain, and from there came Abraham ibn Ezra (1092 – 1167) , the great herald of Arabic science among European Jewry. who spent some time of his life in Italy. He produced in his language an adaptation under the title *Khay ben Mekitz,* which has the same meaning as *Ḥayy ibn Yakẓān* (" The living one , son of the wakeful one ") .[7] He has introduced some decisive changes into the whole structure of the tale, and it is his version which reveals the most striking parallels with Dante's Comedy, to such an extent that some hitherto obscure passages become clearer.[8]

When climbing the slopes of Mount Purgatorio and coming nearer to the summit where the garden of paradise is situated , Dante or the narrator who speaks in the first person suddenly stands before a wall of fire. He does not dare to cross it, he is full of fear, but Virgil his leader goes first and a voice is heard saying " Come, oh ye blessed of my father " (Matth. 25, 34) , and they come through the formidable heat unharmed. (Purgatory XXVII, 7 – 60) Dante fails to give this fire any spiritual meaning, in the sense of the Catholic doctrine of purgatory, he just describes it as a natural phenomenon. The sense remained obscure. Abraham ibn Ezra has exactly the same scene[9]. It is not found in Ibn Sīnā, i. e. Abraham has added it of his own. Here the narrator together with his leader , who represents the heavenly active intellect, is ascending through the realm of the four elements towards the sphere of the moon . After crossing the air, where the weather is made, they stand before the zone of fire. The narrator , who speaks in the first person, is full of fear, but his leader goes first and says to him "Come, oh ye blessed of the Lord" (Gen. 24,31), and so they come through unharmed. Here the fire is at its right place according to Aristotelian cosmology, but in Dante it is somewhere at the upper rim of a mountain and not close to the sphere of the moon. We cannot avoid the statement that the great poet appears, in this particular instance, as a plagiator, and not even as a very skilful one.

The first canto of the Comedy contains some allegoric mysteries that

6. Cf. also about the quotations in Dante's " Convivio " Munira Shakhidi, Abu Ali ibn Sina-obitatel' limba. In : *Dantovskie chteniya* (Moscow) 1985, p. 151 .

7. German translation in H. Greive, *Studien zum jüdischen Neuplatonismus.* Die Religionsphilosophie des Abraham ibn Ezra, Berlin, New York 1973, p. 149 – 165 .

8. G. Strohmaier, Chaj ben Mekitz – die unbekannte Quelle der Divina Commedia. In : *Deutsches Dante - Jahrbuch* 55 – 56 , 1980 / 81 , p. 191 – 207 ; id. , Avicennas " Ḥayy ibn Yaqẓān " und Dantes " Commedia ". In : *Acta Antiqua Academiae Scientiarum Hungaricae* 29 , 1981 , p. 73–80 .

9. Greive (see above note 7), p. 157 – 158 (vv. 364 – 393) .

Ibn Sīnā's Psychology and Dante's *Divine Comedy*

GOTTHARD STROHMAIER*

In 1919 the Spanish orientalist Miguel Asīn Palacios published his famous book *La escatologīa musulmana en la Divina Comedia*.[1] It became the object of a great strife among European scholars. On the one hand the arabists considering the great impact of Arabic learning on Christian scholasticism found it very plausible that the Italian poet should have borrowed some features of his poem from Arabic literature. On the other side the specialists on the Romance languages in Italy and outside pointed to the fact that similar parallels exist within the Latin literature of the Middle Ages. And how could Dante take notice of the works of Ibn al-ᶜArabī and al-Maᶜarrī's *Risālat* al-*ghufrān*, which were never translated into Latin? The stalemate between the arabists and the Romance scholars seemed to be overcome in 1949 by Enrico Cerulli who discovered that the *miᶜrādj* - legend was, indeed, translated into Latin and was regarded even as an important document of the Muslim creed second after the Qurᵓān.[2] But the great specialists on Dante remained unimpressed, they emphasized that Dante depicted the prophet of Islam in a very unfavourable way (Inferno XXVIII, 31), how should he have followed his footsteps on his journey to the other world?[3]

Unfortunately, a very important remark made by the Russian iranist Evgeniy E. Bertel's[4] in 1938 remained unnoticed in the West. He observed that the introductory vision of Ibn Sīnā's allegoric tale *Ḥayy ibn Yakẓān*[5] resembles to a certain extent the first canto of the *Divine Comedy*. And here we are within the framework of philosophy and not of religion, and we know

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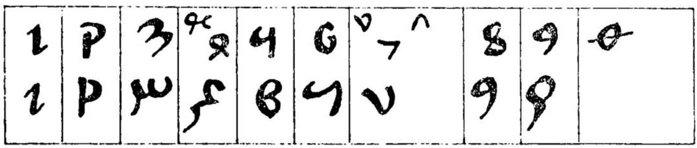
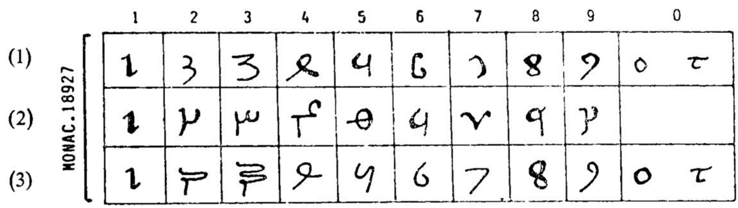
1. 4th ed., Madrid 1984 (Arabic translation by Djalāl Maẓhar, *Āthār al - Islām fī 'l- Kūmīdiyā 'l-Ilāhīya*, Cairo 1980), cf. id., Dante y el Islam, Madrid 1927.
2. Il *Libro della Scala* e la questione delle fonti arabo - spagnole della Divina Commedia, Città del Vaticano 1949.
3. Cf. ' my review of E. Cerulli, Nuove ricerche sul libro della Scala e la conoscenza dell' Islam in Occidente, Città del Vaticano 1972. In : *Deutsches Dante- Jahrbuch* 55/56, 1980/81, p. 337–340.
4. Avicenna i persidskaya literatura. In: *Izvestiya Akademii nauk SSR*, otdelenie obshchestvennykh nauk 1938. p. 80.
5. *Traités mystiques d'Abou Alī al-Hosain b. Abdallah b. Sīnā*, ed. M. A. F. Mehren, 1er fasc. : L'Allégorie mystique Hay ben Yaqzān, Leiden 1889 ; cf. A. M. Goichon, *Le récit de Ḥayy ibn Yaqẓān commenté par des textes d'Avicenne*, Paris 1959.

Reste enfin une dernière comparaison possible qui concerne la graphie des chiffres dans les manuscrits des versions latines dont il a été question. Dans le *Monacensis lat*. 18927 (Ly) et dans le *Vaticanus Palat. lat.* 1393 (LP) apparaissent des chiffres qualifiés d' " indiens " , qui semblent beaucoup plus proches des chiffres arabes originaux que ceux qu'on rencontre dans les manuscrits latins habituellement cités qui contiennent les oeuvres les plus anciennes connues issues de l'arithmétique arabe :[12]



Vatic. Palat. lat. 1393



(1) " Toletane figure "
(2) " Indice figure "
(3) (Tables astronomiques)

On ne peut donc espérer que les textes latins du XIIe siècle suppléent entièrement à la perte du texte arabe d'al-Khwārizmī. Ils en sont cependant indéniablement le reflet . Du point de vue historique, ils sont même irremplaçables dans la mesure même où élaborés en Occident à une époque où la science accusait un retard considérable par rapport aux oeuvres arabes de leur temps, ils témoignent d'un état ancien de la science arabe qui ne peut être révélé autrement .

12. Cfr A. ALLARD, *L'époque d'Adélard et les chiffres arabes dans les manuscrits latins d'arithmétique*, dans *Adelard of Bath, an English scientist and Arabist of the early twelfth century* (ed. c. BURNETT), The Warburg Institute, Surveys and Texts 14. London, 1987, pp. 37 – 43.

entiers .[9] Il en va exactement du contraire pour les fractions et l'extraction de racine carrée. Ainsi, parmi les quelque 25 exemples qui pourraient être cités:

DA LY[3] LA LP : $2^{\circ} \times 2'$
DA LY LA LP : $1\frac{1}{2} \times 1\frac{1}{2}$
DA LY LA LP : $10'' : 5'$
DA LY LA LP : $3/7 \times 4/9$
DA LY LA LP : $3\frac{1}{2} \times 8\ 3/11$
(DA) LY LA LP : $\sqrt{5625}$

On peut croire dès lors que le texte d'al-Khwārizmī ne comportait pas d'exemples pour les nombres entiers , mais en décrivait plusieurs lorsqu'il s'agissait de fractions ou de l'opération d'extraction de racine carrée, plus délicate et utile pour l'astronomie. On remarquera de même qu'aucun texte ne parle de l'extraction de racine cubique, contrairement à ce qu'on trouve, par exemple, dans l'*Arithmétique* d'al-Uqlīdisī .[10]

Nous estimons cependant qu'un moyen révélateur consiste à comparer les procédés eux-mêmes . La duplication des nombres entiers en fournit un exemple probant :[11]

(+ caractéristique présente
- caractéristique absente)

DUPLICATION

1. Poser le nombre à doubler dans l'ordre de ses positions
2. Doubler chacune des positions
3. Poser les unités à la place de chacune des positions et reporter les dizaines à la position suivante
4. Début de l'opération par la droite
5. Début de l'opération par la gauche
6. Procéder par addition
7. Preuve par médiation
8. Preuve par neuf.

	DA	LY^1 LY^2 LY^3	LA	LP
1.	+	-	+	+
2.	+	-	+	+
3.	+	-	+	+
4.	-	-	-	-
5.	+	+	+	+
6.	-	+	-	-
7.	-	-	+	-
8.	+	+	+	-

LY constituant le seul texte où on procède par addition, on peut considérer que l'oeuvre originale procédait, en commençant par la gauche du nombre, de la manière dont on trouve le reflet fidèle dans DA, LA et LP.

9. Le seul exemple commun est celui de 1.800 divisé par 9 (A. ALLARD, *op. cit.* , p. 15 ; 120 – 121). Les exemples sont dans tous les autres cas particuliers à chacune des oeuvres étudiées.
10. A. S. SAIDAN, *op. cit.* , p. 315 – 327 .
11. Cfr A. ALLARD, *A Propos d'un algorisme latin de Frankenthal : une méthode de recherche*, dans *Janus* 65 (1978) , p. 119 – 141 .

d'arithmétique qui leur sont antérieurs , on ne constate aucune correspondance ni dans les textes, ni dans les exemples . Il n'est cependant pas interdit de penser que la publication d'autres arithmétiques arabes des Xe et XIe siècles éclairerait le question d'un jour nouveau. Dans l'état actuel de la question, on peut se livrer à quatre types de comparaisons .

La première comparaison possible vise les textes latins eux - mêmes. On peut l'illustrer dans la multiplication de trois septièmes par quatre neuvièmes où c'est la leçon courte, celle du *Dixit Algorizmi* (DA), qui sans doute est la plus proche de la première traduction latine perdue :[7]

> " Ainsi, si tu voulais multiplier 3 septièmes par quatre neuvièmes, et si ces septièmes et neuvièmes étaient en première position de fractions comme des minutes, tu les multiplierais entre eux, et ils deviendraient dans leur position dans l'espèce des secondes. Lorsque tu veux les élever à un nombre entier, tu les diviseras par l'une et l'autre positions qui sont des septièmes multipliés par des neuvièmes . Si autre chose est divisé et résulte de la division, ce sera un nombre entier, et si on ne peut diviser, ce seront des parties de la même espèce que ce par quoi tu divises. Et trois septièmes par quatre neuvièmes seront 12 parties de 60 trois parties d'un. "

Le même type de réflexion peut être fait à propos de la multiplication de $1\frac{1}{2}$ par $1\frac{1}{2}$, par le biais des fractions sexagésimales ; cette fois, le texte le plus concis, quoique complet, est celui des versions du *Liber Ysagogarum* :[8]

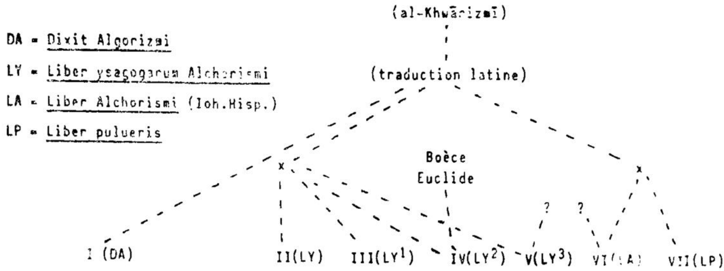
> " Si nous voulons multiplier un et un demi par un et un demi, réduisons un et un demi en minutes, pour faire 90 . Et de même pour l'autre . Multiplions entre elles ces 90 minutes pour faire 8.100 secondes, qu'on divise par 60 pour faire des minutes, et par une deuxième division par 60 on obtient 2 degrés et 15 minutes. "

Il apparaît ainsi dans un premier point que le texte de l'arithmétique arabe d'al-Khwārizmī, comme celui de son *Algèbre* que l'on connaît, devait se limiter à l'énoncé des règles des opérations fondamentales bien connues, telles qu'on les retrouve dans les ouvrages postérieurs tant arabes que latins , mais là sous une forme plus élaborée et illustrée d'exemples .

Si on compare entre eux les exemples donnés par les textes latins, on constate qu'ils ne correspondent pratiquement jamais pour les nombres

7. Quasi uelles multiplicare III septimas in quatuor nouenis, essentque ille septime et nouene in prima differentia fractionum quasi minuta, multiplicaresque eas in inuicem, et fierent in sua differentia ex genere secundorum. Cumque uolueris eas subleuare ad numerum integrum, diuides eas per utrasque differentias que sunt septime in nouenis. Quod si aliud diuisum fuerit et exierit de diuisione, numerus erit integer, et si non poterit diuidi, erunt partes unius eiusdem generis par quod diuisisti. Eruntque tres septime in quatuor nouenis XII partes ex LX tribus partibus unius. Cfr A. ALLARD, *op. cit.* , p. 22.

8. At si unum et dimidium per unum et dimidium multiplicare uoluerimus, unum et dimidium minuta faciamus et erunt 90; similiter de alio. Que inter se multiplicemus eruntque 8100 secunda, que si per 60 diuidantur, ad minuta redibunt; que iterum eadem diuisione 2 gradus et 15 minuta erunt. Cfr A. ALLARD, *op. cit.* , p. 41 .



Il est certain d'abord - on peut regretter le fait, mais il est indéniable- qu'aucune de ces oeuvres ne peut prétendre être une traduction exécutée directement sur le texte arabe d'al-Khwārizmī, pas même le *Dixit Algorizmi*, malgré son *incipit* particulier qui ressemble au mieux à celui des ouvrages arabes :

> " Al- Khwarizmi a dit : rendons à Dieu, notre guide et notre protecteur, de justes hommages qui lui rendent son dû et répandent sa gloire en la faisant s'accroître. . . "[3]

Tous ces ouvrages reflètent au moins une et peut - être plusieurs traductions latines perdues qui leur sont antérieures et qui furent exécutées dans un des centres qui vit naître les premières traductions , soit le sud de l'Italie, soit plus vraisemblablement l'Espagne. Il est d'ailleurs rare qu'en dehors de son titre , une oeuvre se réclame d'al-Khwārizmī . Le fait se présente à deux reprises dans le *Liber Alchorismi* de Jean de Séville, une fois à propos de la division des fractions ordinaires , et une fois à propos de la multiplication des fractions ordinaires, où on trouve explicitement :

> " C'est la même chose que semble dire al-Khwārizmī à propos de la multiplication et de la division des nombres entiers et des fractions, lorsqu'il propose. . . "[4]

On pourrait craindre dès lors que ces versions latines, que trois siècles séparent de leur modèle arabe supposé, soient en fait le reflet d'autres oeuvres arabes rédigées par les successeurs d'al-Khwārizmī. On songe évidemment, par exemple, aux Principes de calcul indien (*Kitāb fi uṣūl ḥisāb al - Hind*) de Kūshyār ibn Labbān[5] , ou à ceux d'al - Uqlīdisī[6] , ou encore à l'oeuvre d'al-Karajī . Si on compare les versions latines du XIIe siècle aux ouvrages arabes

3. Dixit Algorizmi · laudes Deo rectori nostro atque defensori dicamus dignas, que et debitum ei reddant et augendo multiplicent laudem . . . Cfr A. ALLARD, *op. cit.* , p. 1.
4. Hoc idem est illud etiam quod de multiplicatione et diuisione integrorum et fractionum Alchorismus dicere uidetur et si aliter, cum. . . Cfr A. ALLARD, *op. cit.* , p. 163 .
5. M. LEVEY et M. PETRUCK, *Kūshyār ibn Labbān. Principles of Hindu Reckoning*, Madison, 1965.
6. A. S. SAIDAN, *The Arithmetic of Al- Uqlīdisī*, Dordrecht, 1978 .

La Diffusion en Occident des Premières Oeuvres Latines Issues de L'Arithmétiqe Perdue d'Al-Khwārizmī

ANDRE ALLARD*

La diffusion dans l'Occident latin du calcul indien hérité de l'arithmétique arabe et lié par son nom même d'algorisme (*algorismus*) au premier auteur arabe, al-Khwārizmī, qui en écrivit les principes, peut être envisagée sous plusieurs aspects . On peut s'étonner d'abord de la lenteur de cette diffusion, puisque trois siècles séparent la rédaction arabe aujourd'hui perdue des plus anciens témoins latins qui en conservent le reflet. Plusieurs causes peuvent être envisagées. Certainement d'abord une longue tradition médiévale du calcul sur abaque et du calcul digital. Sans doute aussi la difficulté des rapports entre le monde musulman et le monde chrétien. On peut rappeler la phrase fameuse d'Ibn ᶜAbdūn à la fin du XIe siècle à Séville :

> " Il ne faut pas vendre des livres de science aux Juifs et aux chrétiens ... parce qu'ils voudront traduire ces livres de science et les attribuer aux leurs ou à leurs clercs, alors qu'il s'agit en réalité d'ouvrages musulmans. "[1]

Au début du XIIe siècle, et pour le plus grand profit de l'Occident médiéval, la leçon d'Ibn ᶜAbdūn ne fut heureusement pas retenue . Toutefois , la question des origines mêmes de cette connaissance reste complexe. Avant de tenter un rapprochement quelconque avec l'ouvrage perdu d'al-Khwārizmī, il fallait d'abord résoudre les problèmes posés par les manuscrits latins , leurs filiations et leurs rapports .[2] Contrairement à ce qu'on pensait généralement , il existe non pas deux ou trois, mais sept traités latins écrits dans le premier quart du XIIe siècle . Leurs rapports entre eux peuvent être schématisés de la manière suivante :

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1. E. GARCÍA GÓMEZ, *Sevilla a comienzos del siglo XII*, Madrid, 1948, p. 173. Texte cité par M-T. d'ALVERNY, *Translations and Translators* (R. L. BENSON et G. CONSTABLE, *Renaissance and Renewal in the Twelfth Century*) , Oxford, 1982, p. 440, ,n. 79 .
2. Sous réserve d'une découverte, toujours possible, d'une nouvelle oeuvre latine inconnue, l'étude des premiers algorismes latins du début du XIIe siècle est aujourd'hui terminée. Les différentes versions sont en cours de publication · A. ALLARD, *Al-Khwārizmī. Arithmétique. Les versions latines du XIIe siècle*, Louvain- Tunis, 1987 .

It is still necessary to explain why the authors of the *anwā'* genre did not lay claim to their synthesis. Why did they insist on reading back the formal concept of the lunar zodiac into the liminal period before Islam? Despite an intense interest in the philology of the *anwa'* tradition, there was a general reluctance to probe into the origin of the *anwā'*. Abū ᶜUbayd once remarked: " I asked al-Aṣmāᶜī about (the star *mijdāḥ*), but he did not say anything about it and was loathe to see anything good from the *anwā'* system. "[104] Al-Damīrī related a similar tale:[105]

> *ᶜAbd-al-Ḥakam relates that when ᶜUmar b. ᶜAbd-al-ᶜAzīz started from al-Madīnah, there was a man belonging to the tribe of al-Lakhm with him, who related, " I looked up and saw the moon in the Fourth Mansion (i. e., Aldebaran), but did not like to tell him so; so I said to him, "Do not you see how beautiful the moon is to-night!' upon which ᶜUmar looked up at her (sic) and seeing her in the Fourth Mansion replied, ' As if you wanted to tell me that she is in the Fourth Mansion, but we start neither by the sun nor by the moon, but by God the only One, the all-powerful.*

These two anecdotes suggest that the pagan character of the *anwā'* was so well known that Muslims were reluctant to refer to them. Thus, it was necessary in describing the *anwā'* to cleanse the concept of its pagan association in order for the *anwā'* to be a suitable subject for Islamic scholars.

I submit that the *anwā'* were cleansed in two ways. First, the variant star calendars relating to the periods of rain were unified in the neutral frame of a lunar zodiac. Second, it was necessary to assert that the practical element of the *anwā'* as a reckoning system ordained by God existed in pre-Islamic Arabia independent of its use in pagan invocations. The concept was justified as Arab because it was a harmonization of Arab star lore; it became distinctively Islamic because the pagan and magical elements were exorcised. As a result we have only fragmentary information on what stars were in fact *anwā'* and how the system was used before Islam. To the earliest generation of Muslim scholars it was not necessary or expedient to describe the *anwā'* in full. As modern historians of science we are unable to reconstruct the pre-Islamic usage of the *anwā'* with any precision. Yet there is a value in looking beyond the concept to the ways in which it has been formulated and communicated, for this is where the distinction between science and folklore must be drawn.

104. Quoted in al-Marzūqī, 1 : 179.

105. Al-Damīrī, *Ad Damīrī's Ḥayat al-Ḥayawān (A Zoological Lexicon)*, (London, 1906 – 1908), 2 : 248.

It would be tempting to say that the concept of *manāzil al- qamar* was simply borrowed from India and Arabized by incorporating Arabic star names and lore into it. To say that the lunar zodiac, of which there are many variants, is not indigenous to tribal Arabia is not to say that its formal definition in Arab Islamic scholarship was not distinctively Arab and Islamic. The lunar zodiac, like the solar zodiac of twelve signs, spread throughout a number of cultures as a coherent frame for defining the cosmos. The idea of the zodiac was but the skeleton; the features which made the concept distinctive were the flesh and blood of Arab star lore.

The concept of *anwā'* as equivalent to the twenty - eight lunar stations is both Arab and Islamic. As a scientific concept it came into existence only when the variations within the oral lore of Arabia were fused to the unifying frame of a lunar zodiac. The early Islamic scholars, who helped define the direction and components of Islamic science, forged concepts by combining the legacy of previous scholars in other cultures with their own distinctive traditions. The folklore was little more than an undifferentiated mass of information, a universe of particulars with no single, coherent frame of reference. These scholars approached the *anwā'* not as the scientific product of a certain generation, but an evident truth about the cosmos. As part of a cosmic scheme deemed to be basic to Islam, the Muslim scholar would have expected such a concept to be known to earlier scholars and prophets. Ibn Mājid noted that the prophet Daniel was credited with a book on the *manāzil al - qamar* and the *burūj*. Certainly Hermes, the thrice- wise sage of old, or Seth, the patron patriarch of astronomy, would have known such a concept. The fact that information collected from the Bedouins and their poetry was full of contradictions and variant traditions could not invalidate a belief that the lunar stations were ordained by God as a guide for men.

It is not that early Muslim scholars sought to deliberately mislead; rather, they participated in a milieu in which science was concerned with the harmonization of information within an avowedly Islamic framework. In this respect a scholar like Ibn Qutayba, who was not in fact an astronomer, wanted to describe the *anwā'* without reference to the influence of foreign philosophy or scholarly astronomy.[103] His goal was to make sense of what the Bedouin did and this was accomplished not by a critical assessment of the data but by harmonization. It was assumed that the conflicting information was a result of the Bedouins' ignorance in not seeing the lunar stations as part of a cosmic scheme set in motion by God and validated by earlier scholars.

103. Ibn Qutayba, p. 2.

Science and Folklore

The issue of the origin of the *anwā'* in Arab tradition highlights a fundamental problem in reconstructing the history of scientific concepts. When we slide back along the scientific scale to reach the ultimate origin of a concept, eventually we arrive at that liminal and undefined point where science emerges from mere lore. Unfortunately, it is precisely at this point that the evidence usually eludes us. As historians of science we are reliant for the most part on texts. Early Muslim authors provided an analysis of the *anwā'* and in the process preserved samples of pre-Islamic poetry and lore. Yet we know almost nothing about the people who actually used the *anwā'* and only fragmentary glimpses of the use to which they were put.

There is a danger in relying so much on a textual tradition that the " prehistory " of an idea – as it reverberated in men's minds and on their lips – is not only lost but, by definition, insignificant. The history of the concept becomes only the history of what learned men have recorded about it for posterity. Equally , it is unwise to rely too heavily on analogy from contexts we can observe . Ethnographic data on star calendars among Arab tribes can help us understand if a particular calendar is practical or relevant , but we cannot assume it has remained unchanged or is representative for a similar context some fifteen hundred years earlier.

In this study I have attempted to sift through the variety of conflicting information and variant records on the *anwā'* . There is no reason to doubt that a system of stars linked with rain and other phenomena was developed in Arab tradition. However, there is no compelling evidence to think that any specific Arab tribe or community followed a lunar zodiac of twenty - eight asterisms . There is in fact no origin for the *anwā'* no distant Arab tribesman who hit upon the idea on a remote, star - lit night in the desert . There were no doubt many star calendars suited to particular needs, some practical and others magical . It would also appear that the meaning of the *anwā'* was understood as a pagan and unIslamic system, a system that the prophet himself condemned.

The formal scientific concept of the *manāzil al-qamar* can be traced back through the literature , but not to a single, ultimate source . We may be able to discover the first textual reference to the concept , but far too many works have been lost to be definitive . The evidence is clear that certain elements of the Islamic scientific concept of the stations were taken from India and perhaps from other traditions as well , yet we do not know who was the first to combine these elements with the Arab lore .

auspicious of the *anwā'*, yet Aldebaran following it is considered the most detestable. This cannot be explained in terms of the rain being plentiful during the setting of the Pleiades but being absent or harmful during Aldebaran. I would suggest that Aldebaran, referred to as *mijdāḥ* in pre- Islamic usage, may have figured prominently in pagan rites of divining rain. Al - Marzūqī in fact described it as a star associated with rain.[99] ᶜUmar ibn al - Khaṭṭāb once referred to *majādīḥ al - samā'* in a rain invocation (*istisqā'*) .[100] When he was criticized by his fellow Muslims for referring to such a pagan *naw'*, he had to justify the use as appropriate and not legitimizing the divination by the *anwā'*. If it was so necessary to explain his use of the term, it must have been because *mijdāḥ* (*majādīḥ*, plural) was well- known as part of a pagan rite . When the authors of the *anwā'* genre refer to Aldebaran as detestable, they make a conscious statement about the magical uses to which this *naw'* had been put.

Divining the rain and other weather phenomena would clearly have been an important part of pre-Islamic cults. Among the pre-Islamic Bedouins, as among recent Bedouin tribes, knowledge of rain and hence pasture would have been vital for prosperity. Ibn Qutayba quoted verses concerning the most favorable times for rainfall.[101] The most favorable time was said to be at mid-month, i . e. , the full moon; the first night in which the new moon is seen (i. e. , *ghurra*) was also considered favorable for rain . Among some Arabs it was considered to be an inauspicious time to travel when the moon was in Scorpio (*ᶜaqrab*) . This is apparently a reference to the so- called *ᶜaqārib* of winter as determined by the new moon being seen in Scorpio during the cold winter months.[102] While references to fortune and the *anwā'* or *manāzil* are common, it is often difficult to determine what stems from Arab lore and what has been borrowed from India and other cultures.

The conclusion is inescapable that the *anwā'* refer to a system of rain invocation that saw the stars as influential in bringing the rain. It would be wrong to think that all pre-Islamic Arabs followed such a system or were willing to accept it. Yet, it is equally wrong to assume that pre-Islamic Arab tribes so dependent on the rains would have looked to the stars simply as markers of when a rain might occur. The impression given in the *anwā'* genre is that one can isolate a reckoning system based on twenty - eight *anwā'* from a variety of conflicting and often magical lore on the stars. Thus, the origin of the *anwā'* has been filtered for us by a generation of scholars who were wary of the magical and unIslamic use of the stars by their pagan ancestors.

99. Ibn Qutayba, p. 37 , recorded a *ḥadīth* on *mijdāḥ* as a *naw'* for rain.

100. Al-Marzūqī, i : 179 .

101. Ibn Qutayba, pp. 180 – 182 .

102. For this term, see the discussion in my forthcoming *The Medieval Agricultural Almanac*. . .

pagan error along with defamation of ancestry (*ṭaᶜn fī al- ansāb*) and lamentation (*niyāḥa*).[91] The prophet argued that those who said they were rained upon by a certain star were attributing the power over rain to the star and not to God and this had to be condemned in the strongest terms.[92] This echoes a major theme in the Quran that the people of his day had rejected God and ascribed His power to idols and Nature itself.

Abu ᶜUbayd said that the Arabs in the Days of Ignorance (*Jāhilīya*) would attribute rain or wind to the influence of certain stars, saying " *we were rained upon by the naw' of the Pleiades, Aldebaran or simāk.* "[93] In his compendium on religions and sects, Al-Shahrastānī described the *anwā'* as a practice of the pre-Islamic Arabs associated with diviners .[94] Certain idols set up in the *kaᶜba* were in fact prayed to for rain.[95] There is even evidenc of a rain cult associated with the sacred geography of the *kaᶜba* in which the rain reaching a certain door would indicate plentiful rain and fertility for a land associated with the location of that door.[96] We are also told that certain of the stars, including the *manāzil*, were worshipped before Islam.[97] .

The *anwā'* must be understood first and foremost as a system of divining rain. The strong condemnation by the prophet suggests that such a system of rain invocation had become engrained at Mecca and may have centered on sanctuaries such as the *kaᶜba* . Al-Marzūqī remarked that the *anwā'* were also believed to have influence over other aspects of life.[98] Some of the Arabs, he claimed, exceeded proper bounds in their oaths by the *anwā'* and attributed events to their influence until they deluded themselves into thinking that all fortune or misfortune, good or evil, profit or loss was according to the *anwā'*. In responding to their use in divining rain, Muhammad was condemning the wider process of making the stars into " gods" .

The pre - Islamic poetry which has survived does not describe this magical use of the *anwā'* . No doubt such verses would have been deemed offensive to the authors of the *anwā'* genre. Yet, it is clear that some *anwā'* were considered more favorable than others. The Pleiades was considered the most

91. In addition to al-Bukhārī and the standard *ḥadīth* collections, this tradition can be found in Ibn al-Ajdābī, p. 136 , Ibn Qutayba, p. 14 , *Lisān al- ᶜArab* (article *n-w-'*) .
92. See Ibn al-Ajdābī, p. 136; Ibn Qutayba, p. 14 ; Abū Isḥāq al-Zajjāj in *Lisān al-ᶜArab* (article *n-w-'*) .
93. Quoted in *Lisān al-ᶜArab* (article *n-w-'*) .
94. Abū al-Fataḥ Muḥammad al-Shahrastānī, *Kitāb al- Milal wa-al-naḥl*, (Beirut, 1984) , 2 : 241 .
95. Ibn al-Kalbī in Nabih Faris, *The Book of Idols* (New Haven, 1952), p. 7 .
96. Abū Uthmān ᶜUmar al-Jāḥiẓ, *Kitāb al-Ḥayawān*, (Cairo, 1968) , 3 : 43 .
97. Al-Qalqashandī, p. 452. Cf. the discussion in al-Shahrastānī.
98. Al-Marzūqī, i : 178 .

system of agricultural marker stars (*maᶜālim al - zirāᶜa*) which parallels arbitrarily the twenty - eight lunar stations.[89] Evidence for this calendar is quite recent, yet certain stars were chosen as markers as early as the 9th century. The Yemeni sultan, al-Malik al-Ashraf ᶜUmar ibn Yūsuf, writing in the 13th century observed that the *anwā'* in Yemen were different from those of Syria and other areas because the timing of the rains varied accross the general region .[90] My ethnographic research in a central highland valley showed that while most Yemeni farmers know about a few major stars, only a few claim to know the system as a whole. In the valley where I lived there was in fact no division of the year into discrete units, but rather stars were chosen to mark only seasons of rain and major agricultural activities. A system of twenty-eight *anwā'* or a lunar zodiac would have been irrelevant to the needs of the farmers.

Much of the discussion on the *anwā'* has assumed that the system of twenty-eight lunar stations was a practical calendar for pastoralists or farmers. To my knowledge the division of an entire year into discrete (and often equal) units is arbitrary and unrelated to a practical context. For most communities it was only necessary to mark periods of local importance. Even so, most people probably could recognize only a few stars, with certain individuals having expert knowledge. It is not that pre-Islamic Arab tribesmen were too ignorant to comprehend a system of twenty- eight *anwā'* or *manāzil*; it would simply not have been relevant. While certain stars, such as the Pleiades , Canopus or Sirius, would have been useful markers to a bread spectrum of groups, I would argue that a variety of star calendars was to be found .

Rain, Fortune and the Anwā'

The *anwā'* genre portrays a star calendar of twenty-eight lunar stations as a basic feature of pre-Islamic tradition. Based on the available literary evidence and by analogy to ethnographic examples, it must be concluded that the *anwā'*, as a system of stars linked with periods of rain, were not simply an Arab variant of the lunar zodiac. In trying to reconstruct the nature of the *anwā'* before Islam it is important to set aside the claims made by scholars of the genre and focus on the few fragments of documentation available.

The primary evidence for the interpretation of the *anwā'* comes from the tradition literature of the prophet Muhammad. Although there is no reference to the *anwā'* in the Quran, Muhammad bitterly criticized the *anwā'* as a

89. D. M. Varisco, *The Adaptive Dynamics of Water Allocation in al- Ahjur, Yemen Arab Republic*, (Ph. D. dissertation, University of Pennsylvania, 1982), pp. 554 – 576 .

90. I discuss this in my forthcoming , *The Medieval Agricultural Almanac of a Yemeni Sultan*, (Cambridge) .

The range of pre-Islamic star calendars recorded in the *anwā'* genre shows that no one system of twenty - eight *anwā'* was universally recognized. Furthermore, the seemingly arbitrary fit between the stations and seasons or rain periods suggests that the Arab tribes were not aware of the full contingent of lunar stations. While reference is made to the conjunction of the moon and the Pleiades, there is no reference in the poetry or sayings to the general stationing of the moon in a different asterism each night. Finally, it is clear that both the settings and risings of certain stars , not always of the lunar stations, were cited as markers.

The textual evidence is too fragmentary to reconstruct an actual star calendar of a given tribe. The early authors of the *anwā'* genre were not ethnographers faithfully documenting a tradition of lore and its variants. It is useful, therefore, to look at the types of star calendars actually used by contemporary Arab tribes. It should be noted that in some cases the tribesmen may have absorbed elements of the formal concept of *manāzil*, but such sophistication is rarely encountered.

Information on the stars linked with rain periods among the Rwala Bedouins was collected early in the century by Alois Musil.[87] Musil recorded that the Bedouins began their year with the rains associated with the rising of Canopus in October. This was the season of *ṣafarī* and the rain was called *wasm*. This is remarkably similar to the Canopus calendar recorded by Ibn Qutayba. After forty nights the Rwala observed the evening rising of the Pleiades, followed by the rising of *jawzā'* (Orion or Gemeni). Both of these stars were said to reign for twenty-five days each. Winter (*shitā'*) was heralded by the evening rising of Sirius and lasted for forty nights. *Simāk* was the star associated with the next fifty days, followed by the spring (*ṣayfī*) rains in mid - April. The four hot months of summer were referred to as *qayẓ* and included no rain.

The Rwala calendar, which is similar in many respects to that of the Sinai Bedouins,[88] shows that both morning and evening risings of stars were cited as markers. The stars used as markers were not limited to the formal lunar stations but were chosen because they coincided with the general limits of each season . As the rains were not of the same duration or timing every year, nor over a wide area, the seasons and rain periods represented a general sequence and not a calendar fixing the same date year after year.

In highland Yemen the tribal farmers have looked to the stars for centuries in marking rain periods and agricultural activities. One finds today a

87. Alois Musil, *The Manners and Customs of the Rwala Bedouins*, (New York, 1928) .

88. Clinton Bailey, "Bedouin star- lore in Sinai and the Negev, " *B. S. O. A. S.* , 1974, 37 : 580 – 596 .

when these two conjuncted on the fifth day after the *hilāl*.[81] This Pleiades calendar has survived among tribal groups in Palestine,[82] Yemen[83] and Afghanistan.[84] In Yemen a period of nine months is said to commence when the moon and the Pleiades are linked at the nineteenth day after the new moon in autumn until the Pleiades is said to disappear in April. These months were referred to by an odd number representing the days elapsed between the new moon and conjunction in each of them. Although admittedly an approximate system, the number - months thus formed served to time agricultural activities and describe the weather.

Finally, a star calendar oriented toward the pastoral cycle was formulated from the later summer rising of Canopus (*suhayl*). As described by Ibn Qutayba, the Bedouins first trekked to pasture in August with the dawn rising of Canopus.[85] Al - Marzūqī quoted a similar calendar in which this season is called *ṣafarīya*.[86] By the setting of *al - fargh al-mu'akhkhar* (≈ 27) in September most of the herders had left for the pasture. In general the winter rains and pasture thus produced allowed the Bedouins to remain in the more arid areas until April and the rising of *sharaṭayn* (≈ 1) . At the dawn rising of the Pleaides in May most had returned and the last were said to come into the settlements by June. Al-Marzūqī presented a variant of this calendar according to five seasons of rain :

Season or Rain	Stations
qayẓ (summer)	rising of the Pleiades to rising of Canopus
ṣafarīya (autumn)	rising of Canopus to rising of *simāk*
shitā' (winter)	rising of *simāk* to setting (*wuqū*^{c}) of *jabha*
dafa'ī	setting of *jabha* to setting of *ṣarfa*
ṣayf (spring)	setting of Spica to setting of Arcturus (ca. forty nights)

The variant recorded by al-Marzūqī combines risings and settings of stars, only some of which are among the twenty eight *anwā'* .

81. Ibn Qutayba, p. 87

82. Gustav Dalman, *Arbeit und Sitte in Palästina* (Gütersloh, 1928) , 1 : 23 .

83. Eduard Glaser, " Der Sternkunde der Südarabischen Kabylen, " *Sitz. d. Akad. d. Wissenschaften d. Wien*, 1885, 91 : 89 – 99 .

84. Alessandro Bausani , " Osservazioni sul sistema calendariale degli Hazāra di Afghanistan . " *Oriente Moderno*, 1974, 54 : 341 – 354 .

85. Ibn Qutayba, p. 96.

86. al- Marzūqī, 1 : 199 .

The system described here is clearly not a reference to the lunar stations, but one does find those stars which are cited in the pre-Islamic poetry.

I suggest that the *anwā'* system of the Qushayriyīn represents a variant of actual tribal usage and that this system was modified by early Islamic authors to fit the formal system of a lunar zodiac. The basic reference point in this and the other variants is the start of the *wasmī* rains at the *naw'* or setting of two stars in Pegasus commonly referred to as *al-fargh al-mu'akhkhar*, *fargh al- dalw al- suflā* or *al-ᶜarquwatān al- mu'akhkharatān*. The stars referred to are either clearly visible or associated in their risings and settings with an important part of the seasonal cycle. As such these *anwā'* were not used to delineate the year in discrete calendrical units, but rather to mark only those seasonal phenomena of relevance.

The sources indicate that certain stars or asterisms were far more important than others. No star is more famous than the Pleiades (*thurayyā*), which was even called *najm* because it was the star par excellence.[77] According to Ibn Qutayba the Bedouins divided the year according to the November setting and May rising of the Pleiades.[78] The setting of the Pleiades marked the time of the *wasmī* rain . At the rising of the Pleiades the hot *bāriḥ* wind blew and dried up pasture. This was the time when the Bedouins had to return from herding in the desert to settlements with water.

In addition to its rising and setting, the Arabs also noted the timing of the moon's conjunction or stationing in the Pleiades. Once a year the new moon (*hilāl*) was seen to conjunct with the Pleiades; this was in April just before it disappeared from view for about 40 – 50 days. The disappearance of the Pleiades from view due to effacement from the rays of the sun was generally considered a bad omen. Indeed the rising and setting of this star is commonly associated with diseases in traditional Arab medicine.[79] The conjunction of the moon and the Pleiades was taken as an auspicious sign, especially that with the new moon.[80]

The conjunction (from *qarana* rather than *nazala*) of the moon and the Pleiades was used as a marker of time by counting the number of days elapsed between the first of the lunar month (i. e. the *hilal* of the moon) and the conjunction. Ibn Qutayba quoted a verse that referred to the arrival of winter

77. Ibn Qutayba, p. 23 ; Ibn Sīda, 9 : 9 ; al-Marzūqī, 1 : 185 .*Al-Najm* in the sense of the Pleiades is the title of a surah in the Holy Quran.

78. Ibn Qutayba, pp. 30 , 96 .

79. Al-Suyūṭī in A. M. Heinen, *The Place of al-Suyūṭī's al-Ḥay'at al-Sanīya fī al-Ḥay'at al-Sunnīya in the History of Arabic Science.* (Ph. D. dissertation, Harvard University, 1978) , p. 590 .

80. Ibn Mājid, p. 85 .

This system appears to be a variant of one attributed to Mālik ibn Anis,[75] who began the year with the *wasmī season* at one - third of station ≈ 28 , a reference to the setting rather than the rising .

All of the variants described above, to which numerous examples could be offered for later periods, involve the linkage of seasons with the twenty-eight *anwā'*. The system described by Ibn Kunāsa and Abū Ḥanīfa al-Dīnawarī, however, must be based on a smaller number of *anwā'* stars. Such a system was ascribed to the Qushayriyīn by Abū Zayd and Quṭrub , two of the earliest authors of the *anwā'* genre.[76] This system mentions about 13 asterisms, some of which are not part of the lunar stations, as the signs for six main periods of rain throughout the year. Furthermore, some of the names could further be combined to form more common names for the groupings :

Rain Period	Anwā'	Comments
wasmī	*al-ᶜarquwatān al-mu'akhkharatān*	15 days for each star period at *wasmī*; this asterism is part of *dalw*
	sharaṭ	
	thurayyā	
shatawī	*jawzā'*	
	dhirāᶜān or *dhirāᶜ*	
	nathra	
dafa'ī	*jabha*	also part of *shatawī* and some say part of *ṣayfī*
	ᶜawwā	not mentioned by some
	ṣarfa	not mentioned by some or perhaps a separate Season
ṣayfī	*simākān*	40 day period
ḥamīm	*dabarān*	20 day period, but said to be no *naw'* at this time; some combine *ḥamīm* with *kharīf*
kharīfī	*nasrān akhḍar*	Altair and Vega
	al-ᶜarquwatān al-ūlayān	

75. Quoted in Ibn al-Ajdābī, pp. 98 – 99 .

76. The system of Abū Zayd is cited in al-Marzūqī, 1 : 198 – 199 and E. W. Lane, 2 : 2861 – 2862. That of Quṭrub can be found in al-Marzūqī, 1 : 198 . A similar calendar attributed to Abū Manṣūr is mentioned in *Lisān al-ᶜArab* (article *n-w-'*) .

Another attempt to relate the twenty - eight *anwā'* to a sequence of seasons is recorded by al-Alūsī,[73] although this would appear to be more recent than those mentioned in the early *anwā'* literature. Once again the calendar begins in autumn, although this time with the setting of ≈ 26, and the seasons are of irregular length .

Season	Anwā'	Starting Date
badrī	26 – 28	IX : 8
wasmī	1 – 4	X : 17
walī	5 – 14	XII : 9
ghamīr or *mudd*	15 – 18	IV : 18
busrī or *nuffākh* (?)	19 – 20	VI : 9
qayẓ	21 – 23	VII : 5
iḥrāq al- *hawā*	24 – 25	VIII : 13

The fit here is clearly arbitrary and appears to be adapted for the cultivation of dates in Iraq. While this is clearly not a pre-Islamic calendar, it shows the tendency of scholars to fit indigenous systems into a common model .

Some variants seek to link the *anwā'* with the months . Al - Marzabānī (?)[74] divided the year into six seasons of two months each. This forces the *anwā'* periods to be divided into four and two- thirds stations per season. It is hard to imagine the start of *ḥamīn*, for example, in the autumn at two-thirds of the length of station ≈ 3 (the Pleiades) , especially when the Pleiades is always associated with the later period of the *wasmī* rain :

Season	Stations (dawn risings)
wasmī	13 – 1/3 of 17
shitā'	2/3 of 17 – 1/3 of 22
*rabī*ᶜ	2/3 of 22 – 26
ṣayf	27 – 1 / 3 of 3
ḥamīm	2/3 of 3 – 1/3 of 8
kharīf	2/3 of 8 – 12

73. Al- Alūsī, 3 : 235 .

74. Al-Alūsī, 3 : 244 . The same system was quoted by al-Qalqashandī, 2 : 415 – 416 .

seasons as defined by the equinoces and solstices were of unequal length; most were unaware of precession of the equinoces.[70]

Another way of dividing the year into seasons without having to fraction the periods of the *anwā'* is to have seasons determined primarily by the weather rather than an equinox or solstice. One variant of this system was provided by Ibn Kunāsa, who claimed it was used by the Banī Māwiya of the tribe Kalb and the Banī Murra of the Banī Shaybān.[71] The year is divided into a number of rainy seasons with certain *anwā'* apparently added only to fill in gaps :

Rain or Season	Anwā'	Comments
wasmī	26 – 3	26 and 27 mentioned only as *dalw*; 28 said to be not used because of importance of *dalw* ; 1 referred to as *sharaṭ*; 2 referred to as *baṭn* or *buṭayn*
walī (?)[72]	4 – 5	4 is said to be hated as a *naw'* and 5 is mentioned only as part of *jawzā'* (Orion)
shatīya	6 – 9	6 is said to be not mentioned; 9 mentioned as part of *asad* (Leo)
dafi'iya	10 – 11	10 is famous and 11 seldom mentioned in this form
	12	overshadowed by importance of *asad*
ṣayf	13 – 17	15 – 17 not mentioned as *anwā'*
ḥamīm	18 – 19	not mentioned as *anwa'*
kharīf or *qayẓ*	20 – 26	20 – 25 not mentioned as *anwā'*: 20–24 considered as rain called *shamsīya*, while 25 – 26 considered *kharīfīya*

The sequence of rain periods parallels much of the information on pre-Islamic designation of seasons for rain. The comments of Ibn Kunāsa and his transmitters, however, show conclusively that the fit with the twenty-eight *anwā'* is contrived. The sequence of rain periods associated with certain stars could have been that of a particular tribe, but the link to the lunar stations certainly was not. Virtually the same correlation, albeit with minor variations, was given by Abū Ḥanīfa al-Dīnawarī .

70. Ibn Mājid, p. 160, wrote : " The people who make tables and almanacs take this into account, but ignorant navigators, sailors and bedouin persist in the traditional error and they all reason to this day that the first of *al-Sharaṭān* is the first of Aries. "

71. Quoted in al-Marzūqī, 1 : 199 – 200 .

72. This rain is not mentioned in the passage in al-Marzūqī, but it is in a similar calendar attributed to Abū Ḥanīfa al-Dīnawarī in Ibn Sīda, 9 : 80 – 81 .

Season	Stations	Starting Date
*rabi*ᶜ (spring)	1 – 7	III : 20 (equinox)
ṣayf (summer)	8 – 14	VI : 23 (solstice)
kharīf (autumn)	15 – 21	IX : 24 (equinox)
shitā' (winter)	16 – 28	XII : 22 (solstice)

As Ibn Qutayba observed, this reckoning based on the course of the sun through the zodiac was not practiced by the Arab tribes. The association of station ≈ 1 as the beginning of spring refers to its conjoining with the sun (i. e., *ḥalūl al- shams*) ; the *naw'* at this time would be ≈ 13 .

Having acknowledged that such a model was not indigenous to the Arab tribes, some authors still proceeded to state an Arab version of this model. Al-Qalqashandī recorded a variant of the four season model adapted to the Arab practice of beginning the year with the *wasmi* rain in autumn. In this each season is arbitarily assigned an equal number of days and linked with seven *anwā'* :[69]

Season	Anwā'	Comments
ṣafarīya (autumn)	27 – 5	contains *wasmī* rain; some call this season *rabī*ᶜ
shitā' (winter)	6 – 12	
ṣayf (spring)	13 – 19	
qayẓ (summer)	20 – 26	

Abu Isḥāq al-Zajjāj mentioned this system of dividing the year into four quarters, but he preferred to begin it at III : 20 (i. e. , the vernal equinox) rather than in autumn. The major problem with this method is the arbitary fit which would have been of no practical use to any herding or farming community. A number of the authors in the *anwā'* genre ignored the fact that the

69. This is attributed to Abū Ḥanīfa al-Dīnawarī by Ibn Sīda, 9 : 80 .

stars in Orion, a distinction not mentioned in the pre-Islamic poetry, again parallels the identification of the fifth station in the Indian system. The astrological prognostications based on the stationing of the moon in each station are also taken from India, a fact at times noted by the Islamic authors.

There can be no doubt that the Islamic concept of the *manāzil* consists of foreign elements, yet a conscious attempt was made to Arabize the system and to see it as an indigenous tradition of the Arabs. The fact that borrowing of certain elements to refine the concept has occurred does not rule out the possibility that a lunar zodiac was used by the pre-Islamic Arabs. However, the evidence for such a zodiac cannot be found in the very literature cited by early Islamic scholars to prove the linkage of the *manāzil* with the *anwā'*. The numerous disagreements and conflicting information show that the concept of *anwā'* is not to be understood as equivalent to the formal astronomical system of the *manāzil*. The question then arises : what can we learn about the *anwā'* from the literary evidence and star lore ? Setting aside the interpretations provided by the compilers of the genre, what aspects of the *anwā'* as a practical star calendar emerge ?

Pre- Islamic Star Calendars

It has been assumed by most Muslim scholars that the pre - Islamic Arabs developed one major system of the *anwā'*, which are seen as nearly identical with the *manāzil al-qamar*. This assumption is unwarranted based on the available literary evidence and ethnographic information on star calendars among contemporary Bedouin and other Arab tribes. In examining the *anwā'* genre and related sources it becomes clear that a number of variant systems were in use. While many authors tried to harmonize these systems with the model of twenty-eight lunar stations , the resulting number of major disagreements indicates many Arabs followed alternative models. It may not be possible to determine the precise star calendars used in pre-Islamic Arabia, but one can distinguish between those calendars related to the twenty-eight *anwā'*, the *anwā'* system of the Qushayriyīn, the Pleiades calendar and the Canopus calendar.

If one examines the star calendars linked to twenty-eight *anwā'* according to the number and sequence of seasons or rain periods, it is evident that a number of variants are referred to. The classical model of the four seasons as expressed in the astronomical literature would associate each station with seven *anwā'* , as noted by Ibn Qutayba :[68]

68. Ibn Qutayba, pp. 100 ff.

its rain. The presence of these more limited numbers suggests that the duration of a *naw* ' as thirteen days is an arbitrary fit rather than a reflection of pre-Islamic usage.

Another point which calls into question the association of the *anwā'* with the *manāzil* is the lack of references in the poetry and sayings to conjunctions of the moon and the stations with the notable exception of the Pleiades. As will be discussed below, the stationing of the moon in the Pleiades (*thurayyā* , ≈ 3) was part of a seasonal calendar in pre-Islamic Arabia and one which has survived among contemporary Arab tribespeople. If the *manāzil* constituted an important calendar for the Arabs before Muhammad and at his time, why are there so few references in the poetry and other lore to the moon stationing in these *manāzil* ? The literature primarily reflects the risings and settings of the *anwā'* at dawn or twilight and not in terms of a lunar zodiac.

Finally, there is no doubt that certain elements of the Islamic concept of the *manāzil* were borrowed from the Hindu concept of the lunar zodiac.[66] Knowledge of the lunar zodiac may easily have penetrated the peninsula in the century or so before the prophet Muhammad, since the Sassanians had earlier adopted the Indian lunar zodiac. During the period of conquests, Arab scholars came into contact with the scientific tradition of India. By the 2 nd / 8 th century the Hindu Siddhanta, which describes the lunar zodiac, had been translated into Arabic. It was not long after this that the earliest texts in the *anwā'* genre began to be compiled . The earliest Islamic astronomers, such as al-Farghānī and al-Battānī, include the lunar stations in their discussions of Islamic astronomy. Abū Maᶜshar would have been aware of the hemerological use of the stations in Indian astrology.[67]

A comparison of the *manāzil al- qamar* with the Indian lunar zodiac, usually referred to as a system of *nakṣatras*, does not show a simple one- to-one correspondence. The main element borrowed from the Indians was the division of the *manāzil* into equal units of arc; thus, the stations became a scientific coordinate system rather than marking the locations of actual stars. The choice of *sharaṭayn* clearly parallels the start of the Indian system with *asvini*, the identical asterism. The distinction of *haqᶜa* as three specific

66. Cf. Colebrooke; Jean Filliozat, " L'Inde et les échanges scientifiques dans l'antiquité. " *Cahiers d'Histoire Mondiale*, 1953, 1 : 1 : 357 ; Nallino, 5 : 180 - 181 ; Pellat, p. 523 ; Louis Pierre Sedillot, *Matériaux pour servir à l'histoire comparée des sciences mathématiques chez les Grecs et les Orientaux*, (Paris, 1849) , 2 : 475 .

67. Abu Maᶜshar is attributed with an *anwā'* text which was translated into Latin. Cf. R. Y. Ebied and M. J. L. Young, " A Treatise on hemerology ascribed to Ǧaᶜfar al-Ṣādiq, " *Arabica*, 1976, 23 : 298 .

and al-Qādirī mentioned a *nawʾ* of the shepherd (*rāʿī*);[62] both of these are said to be known to sailors, but the reference is clearly much later than the pre-Islamic usage.

The idea of the lunar zodiac as formalized in the *manāzil al-qamar* presupposes knowledge of the solar zodiac. Al-Ṣūfī argued that the Arabs did not use the twelve signs of the zodiac, although they did have the lunar zodiac.[63] The system of *manāzil*, however, assumes that the first station begins at the start of the Ram and the vernal equinox. Indeed, one of the reasons cited for the meaning of *sharaṭayn* ($\approx$ 1) is that it was the first of the stations and thus a sign or marker (*sharaṭ*) . Yet, the Arabs did not begin the year according to the equinox or solstice, but with the start of the rains in autumn (*rabīʿ*), particularly the *wasmī* rain which was considered the first rain of the year in many sources.[64] The astronomical concept of the *manāzil* thus is linked to the solar zodiac, which is clearly not an indigenous concept on the peninsula .

The classical model of the four seasons, where each season is defined according to the solar zodiac, is also linked to the stations, but the fit is arbitrary. Only in the case of *sharaṭayn* does the beginning of a season coincide with the start of the thirteen - day period represented by a lunar station. For the astronomers, however, each season was linked with seven stations, although the seasons themselves were not of equal length. Since the pre - Islamic Arabs did not use the four - season model articulated in Islamic science, the fit of the *manāzil* to these stations necessarily involves a tampering with the concept of *anwāʾ* as employed by earlier Arabs.

In describing the system of *anwāʾ*, there is a disagreement over the number of days attributed to a star's *nawʾ* .[65] Some assumed that the *nawʾ* referred to the entire period of thirteen days. The major *anwāʾ* texts, however, also record the length of each *nawʾ* between 1 – 7 days in the sense that this represented the time of its influence. The latter usage associates the *nawʾ* not with the simple process of a star's setting, but rather with a more limited time of the influence of such a setting. These lengths can hardly refer only to rain, since for several of the *anwāʾ* there could not possibly be rain. No satisfactory reason is given for the limited number of days assigned to each *nawʾ*. A higher number is not necessarily associated with a *nawʾ* famous for

62. Al-Qādirī, f. 10 r.
63. Al-Ṣūfī, p. 11.
64. Ibn al-Ajdābī, p. 100 ; Ibn Qutayba, pp. 103, 121 ; al-Marzūqī, 1 : 186 ; Shāriḥa ibn al-Sayyid in al-Alūsī, 3 : 244. For a discussion of the *wasmī* rain and other pre-Islamic rain periods, see my " The Rain periods in pre-Islamic Arabia, " *Arabica*, (forthcoming) .
65. Ibn Qutayba, p. 9 ; Ibn al-Ajdābī, p. 136 .

eavesdropped on the conversation of angels.[54] yet another interpretation was given by Ibn Mājid, who claimed the phrase was only used for *sharaṭayn* since from this first station the longitude of other stars was measured.[55] While the first explanation seems the most plausible, it hardly proves that a full lunar zodiac of twenty-eight asterisms was referred to.

In examining the literary evidence recorded in the *anwā'* genre, one does not find a single reference to a system of twenty-eight lunar stations. Indeed, the authors of the *anwā'* genre admitted that a number of the lunar stations were not mentioned in the poetry or only mentioned as part of a larger asterism. In his discussion of each of the lunar stations, Ibn Qutayba found that several stations (≈ 2, 4 , 13 , 20) were not mentioned in the older poetry, several were only mentioned as part of a larger grouping of stars (≈ 5 , 6 , 7 , 11 , 12) and for some (≈ 15 , 21 , 23 , 28) no poetry is in fact cited . Ibn Kunāsa argued that some stations, such as *baṭn al-ḥūt* (≈ 28) , were not mentioned because they were overcome by the importance of a station preceding or following.[56] Ibn Sīda noted that *zubānā, iklīl, qalb* and *shawla* (≈ 16 , 17 , 18 , 19) were usually referred to simply as *ᶜaqrab* of which they were a part.[57] Similarly, *haqᶜa* and *hanᶜa* were known as *jawzā'* (Orion and part of Gemeni) in the poetry. Ibn Mājid quoted a line of poetry on the fame of the Pleiades, Orion, Spica and Arcturus (*simākān*) and Sirius (*mirzam*); the other stars, he explained, were of little use[58].

While not all of the so-called *anwā'* are to be found in the pre-Islamic poetry, some stars which are not part of the lunar zodiac are mentioned as *anwā'*. Some of these are asterisms in which the moon is said to periodically station when it deviates from the usual course , suche as *khibā'* instead of *al-simāk al-aᶜzal* (≈ 14) or Spica. Ibn Qutayba quoted a verse in which *shiᶜrā* is referrred to as a *naw'* .[59] *Shiᶜrā* is commonly used as the term for Sirius, the brightest star in the sky, but Ibn Qutayba rejected this identification in this case because Sirius is not one of the lunar stations. However, he noted that the *naw'* could be attributed to Sirius in conjunction with one of the lunar stations. The rising of Sirius in summer was in fact associated with a *bāriḥ* wind and the coming of the heat. Although Canopus (*suhayl*) is not identified as a *naw'*, its rising in late summer is marked in many areas as a time of rain .[60] Ibn al-Ajdābī noted a *naw'* of the forty witnesses (*arbaᶜīn shāhid*)[61]

54. Ibn Qutayba, p. 5; E. W. Lane. 1 : 30 .
55. Ibn Mājid, p. 80 .
56. Quoted in al-Marzūqī, 1 · 199 .
57. Ibn Sīda, 9 : 14 .
58. Ibn Mājid, p. 85 .
59. Ibn Qutayba, p. 91 .
60. Cf. Ibn al-Ajdābī, p. 173. In Yemen Canopus is a marker of the summer rains.
61. Ibn al-Ajdābī, p. 152 .

which has been interpreted as follows : *He it is Who has made the sun a source of light and the moon shedding lustre, and ordained for it stages, that you might learn the method of calculating the years and determining time.*[50] .

The second reference is in surah *Yāsīn* (36 : 39) : *We have appointed stages for the moon, till it wanes into the shape of an old dry branch of a palm tree.* Most of the authors of the *anwā'* genre, as well as Quranic commentators, take the reference to *manāzil* (translated here as stages) as meaning the twenty-eight lunar stations.[51] Al - Zamakhsharī, for example, provides the meaning as the *manāzil al-qamar* which are said to be equivalent to the *anwā'* of the Arabs.

A closer reading of the two passages, however, brings into question the identification with the formal lunar zodiac. Ibn Kathīr in his commentary preferred to define *manāzil* as referring to the phases of the moon in its waxing and waning.[52] The passage in surah Yāsīn is clearly concerned with the moon's phases in describing the moon as reaching the stage of an old palm branch (*ᶜurjūn*). The idea of phases also makes more sense because these determined the lunar month so important in Islamic timekeeping. Observation of the moon entering the stations did not in fact define the time of the month, since the new moon would appear in a different station each month. While the lunar stations could be used for reckoning the year vis-à-vis their risings or settings with the sun, the sidereal circuit of the moon in some twenty-seven and one-third days was not a basis for the calendar in Islam. This Quranic usage should be seen as an echo of the biblical tradition, where God is said to have appointed the moon and sun for marking seasons (e. g. , Genesis 1 : 14 , Psalm 104 : 19). In Hebrew as well as Islamic cosmology the phases of the moon were the basis of the calendar, not the lunar zodiac.

A second line of evidence is lexical. One finds in some of the pre-Islamic poetry the phrase *nujūm al-akhdh*, which is defined as the moon taking up (*akhadha fī*) its place in a station.[53] Abū ᶜAmr and al - Shaybānī explained the use of *akhdh* here as the stationing of the moon in one of its stations (nuzūl *al - qamar manzilih*). There is, however, disagreement on this usage. Some have mentioned this as a reference to certain stars cast at devils who

50. *The Koran* (New York. 1971), Muhammad Zafrulla Khan. translator. *Manāzil* is also translated as " stages " by N. I. Dawood (Middlesex, Penguin Books, 1968) . Arberry translates the term as " stations "

51. Among the authors who interpret this as a reference to the lunar stations are : Abū Ḥanīfa al-Dīnawarī in Ibn Sīda, 9 : 79 ; Ibn Qutayba, pp, 16 – 17 ; al-Marzūqī, 1 : 184 – 185; al-Qalqashandī, 2 : 372; Shamr in *Lisān al-ᶜArab* (article *n-w-'*); al-Zamakhsharī, *al-Kashshāf*, 2 : 225, 3 : 323.

52. Ibn Kathīr, *Mukhtaṣar tafsīr Ibn Kathīr*, (Beirut, A.H. 1399) , 2 : 184 , 3 : 123.

53. Abū ᶜUbayda in al-Marzūqī, 1 : 185 .

Ibn Qutayba explained the meaning of the saying in terms of the season in the pastoral cycle. This station rises at the beginning of May as pasture begins to dry up and the nomads are forced to return to permanent water sources and larger encampments. As the smaller herding units come together it is a time to meet obligations, such as the paying of debts. They dress in finery because they are meeting old friends. Similarly, it is the time to wear perfume and to seek out smiths to restore implements used during the year. Abū Isḥāq al- zajjāj in his *anwā'* text noted that pasture dries up because of the end of the spring rains. At this time the barley harvest was over and the wheat harvest commences in Iraq.

When one examines the collection of sayings as a whole it becomes clear that it is not relevant to a particular tribal group practicing pastoralism or agriculture. Rather, the references seem to sum up a variety of economic and ecological contexts on the peninsula . If one looks only at the poetry relating to the *anwā'*, the focus is almost entirely on rainfall associated with their risings and settings. At the very least the literary evidence assembled in the *anwā'* genre is ambiguous. All of this prompts one to question whether Arab tribesmen used a lunar zodiac as defined for the twenty-eight *anwā'* or if the nature of the *anwā'* must be found in an indigenous calendar relating to the risings and settings of certain stars ?

Anwā' as *Manāzil al-Qamar* : the Evidence

The belief that the formal set of twenty- eight lunar stations was part of indigenous Arab star lore is held by virtually all of the early authors on the *anwā'* genre. It must be remembered that this was a time when concepts of a given time were often seen as universal truths evident since the beginning of creation. It is not surprising that a work on the lunar stations is attributed to the prophet Daniel[49] of Israel and knowledge of this system is ascribed to the legendary sage Hermes. Sincere Muslims at this time would have had no problem in associating a concept such as the zodiac with Adam's son Seth, the patriarchal patron of star-gazing, nor to Adam himself.

Apart from the belief in the general validity of cosmic truths, one of which the lunar zodiac would have been, these early scholars collected poetry, sayings and lexical information which they saw as supporting their views. What then is the major evidence in support of pre-Islamic usage of the lunar zodiac in Arab tradition ?

The chief support comes from two references to *manāzil* in Quranic passages describing the moon. The first reference is in surah Yūnus (10 : 6),

49. Ibn Mājid, p. 73 .

the north side of the *kaᶜba*, thus linking it to the sacred geography of Islamic belief in the *kaᶜba* as the center of the cosmos. Ibn Sīda added that it could have been named because it picks up dust as it blows.[46] If *bāriḥ* originally meant the wind appearing at the rising of certain stars, then by analogy rain may have originally meant the rain appearing at the setting of certain stars.

According to the *anwāʾ* texts, each *nawʾ* came to be associated with a thirteen- day period that occurred the same time each year in relation to the seasons. In this sense the *anwāʾ* served as a kind of almanac in which each period of a *nawʾ* would be known for certain meteorological phenomena, pastoral or agricultural activities and events in nature. The primary literary source for information on this almanac lore is the collection of rhymed sayings for each of the twenty-eight stations, as well as a few other important stars such as Sirius and Canopus. These sayings, which invariably begin with the word *idhā*, were interpreted by Fahd as parallel to an Akkadian form in Assyro - Babylonian presages.[47] The implication is that this type of saying has a long and widespread history in the region. While it is usually assumed that the sayings are part of an earlier pre-Islamic Arab tradition, there is no evidence that the sayings for all twenty-eight *anwāʾ* were in fact pre-Islamic. It would have been relatively easy to copy the form in order to arrive at a saying for the full complement of *manāzil al-qamar*. One finds a number of variations in the texts as well as numerous errors which were introduced by later copyists and authors.

An example of the kind of information provided in these sayings can be taken for the rising of *buṭayn* (station ≈ 2), as related by Ibn Qutayba:[48]

When *buṭayn* rises,
debts are paid,
finery appears,
the perfumer and the smith are pursued.
(*idhā ṭalaᶜa al-buṭayn*
uqtuḍiyu al-dayn
wa-ẓahara al-zayn
wa-uqtufī bi-al-ᶜaṭṭār wa-al-qayn)

46. Ibn Sīda, 9 · 13 .

47. Toufic Fahd, *La Divination Arabe*, (Paris, 1966), p. 413.

48. Ibn Qutayba, p. 21.

early Islamic poetry.[39] A verse quoted by Ibn Qutayba refers to the *naw'* of *rabī^c*, clearly a reference to the *rabī^c* rain in the wider context of the verse.[40] The sense of rain is further implied in the form *istan'awā al-wasmī* (they expected the *wasmī-rain*) . The use of *naw'* for rain is common in a number of dialects for the Arabian Peninsula and North Africa.[41] The lexical sources also indicate that *naw'* could refer to the herbage produced by rain.

The linkage between *naw'* and rain is clear, despite the debate over the origin of the term. Ibn al-A^crābī said that it cannot be a *naw'* unless there is rain with it; if there is no rain with it, it is not a *naw'* (*lā yakūn naw' ḥattā yakūn ma^cah maṭar wa-illā fa-la naw'*).[42] Shamr observed that the Arabs did not expect rain at the risings or settings of all stars, but only with the *anwā'*.[43] Further, the reference to the *anwā'* in the tradition literature clearly associates these with rain in a magical sense. Al-Zamakhsharī even noted that the pre-Islamic goddess Manāt, mentioned in surah al-najm (53 : 21), may be derived from people who sought rain from her while looking for her blessing ; *manā't* being in this case the *maf^cala* form of *naw'*[44].

It is possible that the term *naw'* was not originally related to the sense of *nā'a* as recorded in the lexicons. While there is no evidence of the term *naw'* in the pre-Islamic dialects of Arabic or earlier Semitic usage, it may have been associated with rain as part of an earlier magical rite of rain invocation or simply as a term for rain. In this respect it is interesting to note the usage of *naw'* and *bāriḥ* in the formal system of *manāzil al-qamar* as representing the dawn setting and dawn rising respectively of a star. Ibn Qutayba mentioned that rain and cold were associated with the settings of certain stars, while heat and wind were linked to the risings of certain stars.[45] Thus, in the poetry we find that at the setting of *jawzā'* (Orion) comes the winter rain and at its rising six months later comes the summer heat. The term *bāriḥ*, which came to be associated with the rising of a station , was originally a term for wind, particularly the hot summer wind . One of the possible derivations of this meaning is that this wind comes from (*tabraḥu*)

39. Landberg, 3 : 2830 ; Nallino, 5 : 189
40. Ibn Qutayba, p. 111.
41. For Dathīna in Ḥaḍramawt . see Landberg, 3 : 2830 ; for Dhofar . see T . H. Johnstone *Jibbali Lexicon* (Oxford, 1981) , p. 198 where *naw'* is referred to as a dark raincloud; for North Africa, see Mohamed Ben Hadji Serradj, '' L'Automne et l'hiver chez les fellahs Azailis, *Institut des Belles- Lettres Arabes* (Tunis), 1953, 16 : 311 , and H. P. J. Renaud, *Le Calendrier d'Ibn al-Bannā' de Marrakech*, (Paris,1948), p. 4. note 2. C. Pellat, *Anwā'*. p.523 claimed that the sense of rain was a later usage, but it is attested in the earliest sources.
42. Quoted in *Lisān al- ^cArab* (article *n-w-'*) .
43. Quoted in *Lisān al-^cArab* (article *n-w-'*) .
44. al-Zamakhsharī, *Al-Kashshāf*, 4 : 30 .
45. Ibn Qutayba, pp. 88 – 89 .

discussion of the term. Ibn Manẓūr recorded that *naw'* was so-called because it referred to the star rising in the east and then noted that others linked it to the setting.[31]

A number of scholars offered ingenious solutions to the controversy, but these appear to be contrived. Ibn Kunāsa said that the *naw'* appeared or rose up as the star itself set.[32] In this case the *naw'* does not refer to the movement of the star but rather to its influence. Abū Isḥāq al-Zajjāj claimed that the verb *nā'a* referred to rising with difficulty as though it was inclined to set.[33] The key to this explanation is the sense of *nā'a bī al-ḥiml*. explained by al-Zamakhsharī as *māla bī ilā al-suqūṭ* (it inclined me to a setting).[34] An example of this is a woman with buttocks so large that they cause her to rise with great difficulty as though she would sit down at any moment. In this sense it is a rising constrained to go down again. This fits the sense of *yanū'u* used in surah al-qaṣaṣ (28 : 76) as *to be a heavy burden* so that something is so burdened that it is inclined downward (*idhā athqalah ḥattā amālah*).[35] Lane has suggested an interesting figurative use of the term here as rising and setting stars which appear to have been nearly overcome by the glimmer of dawn.[36] One could perhaps speculate that the light was seen as burdening the movement of the star, but such a view cannot be documented in the lexical sources.

It is important to stress the fact that these early compilers of lexical works , who had far more information on dialect usage than we can reconstruct today, were not in agreement on the origin of the term. This confusion is also evident in later sources. Ibn Mājid, for example, wrote that :[37] " *Some say naw' was its culmination, some its middle position, some its most easterly position, some its most westerly position, some make it a rising position. Some say it is when it appears at dawn and some when it appears in the twilight*".

In a variant interpretation, Mu'arrij claimed that *naw'* referred to the rain at the setting of a star because the rain " rose " (*nahaḍa*) as the star set, but that by extension *naw'* came to mean the setting star itself .[38] The identification of *naw'* as rain or a time of rain is found in the pre-Islamic and

31. *Lisān al-ᶜArab* (article *n-w-'*) .
32. Quoted in Ibn Qutayba, p. 9.
33. See my forthcoming " The *Anwā'* stars. . . "
34. al-Zamakhsharī, *Asās*, p. 475.
35. al-Zamakhsharī, *Al-Kashshāf*, (Beirut, N. D.) , 3 . 190 .
36. E. W. Lane, 2 : 2861 .
37. Ibn Mājid, p. 79 .
38. Quoted in al-Marzūqī, 1 : 184 .

Anwā'

The term *anwā'* (*naw'*, singular) is well attested in the earliest lexical sources, although there are significant differences of opinion on its meaning.[25] The primary sense advocated by the authors of the *anwā'* genre is an astronomical definition of *naw'* as the cosmical setting of one of the twenty - eight *manāzil al-qamar*. One finds a number of variations of this definition, which Ibn Qutayba expressed as follows:[26] the setting of an asterism from the lunar stations to the west at dawn and simultaneous rising of another (asterism) opposite it to the east (*suqūt al - najm minhā fī al - maghrib maᶜa al - fajr wa - ṭulūᶜ ākhar yuqābiluh min sāᶜatih fī al - mashriq*) . It is important to stress that although the *naw'* is attributed to the setting star, this is invariably placed in opposition to an opposite star rising at the same time. The term *naw'* is never used for the setting of a star per se, but is restricted to a certain set of stars centering on the *manāzil al-qamar*.

Abū Ḥanīfa further refined the meaning of *naw'* as the first setting attained in the early morning before the stars are lost from view in the light of dawn (*awwal suqūṭ yadrukuh fī al - afaq bi - al - ghadāt qabl inmiḥāq al-kawākib bi - ḍaw' al- ṣubḥ*).[27] Thus, the *naw'* refers to the interval of time in the early morning between the dawn (*fajr*) and the sun's actual rising (*ṭulūᶜ*).

As the lexicographers themselves noted, the sense of *naw'* as a setting appears to contradict the more common usage stemming from the root *n-w-'* as a rising (*nuhūḍ* or *ṭulūᶜ*). Abū ᶜUbayd argued that the meaning of setting was only applied to *naw'* in reference to the lunar stations.[28] Several scholars suggested that in fact the original sense of *naw'* was for the rising, but it was later changed by the Arabs to refer to the setting.[29] Ibn Qutayba recognized that both senses were to be found in the lore, although he thought the idea of setting to be more common and justified by the usage of the verbal form in the Quran (surah al-qaṣaṣ 28 : 27).[30] At one point in his extended

25. For lexical discussions of the term *anwā'* , see : Carlo Landberg, *Glossaire Datinois* (Leiden, 1942), 3 : 2829 – 2830 ; Carlo Nallino, *Raccolta di Scritti Editi e Inediti*. (Rome, 1944), 5 : 184 – 186 ; E. W. Lane, 2 : 2860 – 2861. C. Pellat, *Anwā'*, *The Encyclopaedia of Islam* (Leiden, 1960), new edition, 1: 523 errs in defining the *naw'* as an acronychal setting, which would refer to the evening setting, rather than a cosmical setting.

26. Ibn Qutayba, p. 6.

27. Quoted in *Lisān al-ᶜArab* (article *n-w-'*) , Ibn Sīda, 9 : 13, and Abū ᶜAlī Aḥmad al-Marzūqī, *Kitāb al-Azmina wa-al-amkina*, (Hyderabad, 1914), 1 180 .

28. Quoted in *Lisān al-ᶜArab* (article *n-w-'*) .

29. Mubarrad in Maḥmūd Shūkrī al-Alūsī, *Bulūgh al-arab fī aḥwāl al-ᶜArab*, (Baghdad, 1882) 3 : 270, and Ibn al-Ajdābī, p. 134.

30. Ibn Qutayba, pp. 7 – 8 .

through Latin translations of Arabic texts into the West.[19] In addition to this prognosticative aspect, the form of each station in an arrangement of dots was adopted into geomantic magic.[20]

As many of the Muslim authors have noted, there is a compelling magical aura about the number of stations in the context of Islamic cosmology. The most obvious connection is with the twenty-eight letters of the Arabic alphabet. As the letters are distinguished as light (*nūr*), for the fourteen which begin surahs in the Quran, and dark (*ẓulma*), for the letters which do not, so there are fourteen visible and fourteen hidden stations.[21] Similarly, fourteen letters are formed with dots (i. e., *manqūṭ*) and associated with inauspicious stations, while fourteen are formed without dots and are associated with the auspicious stations.[22] The number 28 happens to be a perfect number in the Pythagorean sense, i. e., it is equal to the sum of its parts (28 = 14 or a half + 7 or a fourth + 4 or a seventh + 2 or a fourteenth + 1 or a twenty – eighth)[23]. It also equals the cosmic sum of the 7 planets, 9 spheres (*aflāk*) and 12 zodiacal houses (*burūj*) or the product of the four elements (earth, wind, water, fire) and the seven planets. Not least, 28 is an important sum in Jabir's magic square of the nine primary numbers.

In sum, the *manāzil al - qamar* represented for the Muslim both a practical astronomical concept for time reckoning and establishing coordinates for navigation, and a magical astrological concept for divining the fates in a cosmic order perceived to be set in motion by God Himself. One finds innumerable charts and discussions in manuscripts, including references to the risings and settings in Arab almanacs. When the Arabic concept diffused into medieval Europe, it was only the astrological use which persisted.[24] References to the lunar stations, usually hopelessly garbled, are even found in the occult literature of the present day. Some believe, despite the lack of historical evidence, that the concept of the lunar stations was shared by a wide range of early civilizations and extended back into the hoary mists of man's earliest history.

19. See Hellmut Ritter and Martin Plessner, " *Picatrix.* " *Das Zeil des Weisen von Pseudo-Mağrīṭī*, (London, 1962)

20. Savage-Smith, Emilie and M. B. Smith, *Islamic Geomancy and a Thirteenth-Century Divinatory Device*, (Malibu, Calif,. 1980) , pp. 32 – 33.

21. Dāwūd ibn ʿUmar al-Anṭākī, *Tadhkirat ūlī al-albāb*, (Beirut, 1952) , 2 : 97

22. ʿAbd al-Qādir ibn Maḥmūd al-Nabatītī al-Qādirī, *Risāla fī tawqīʿāt ayyām al-sana al-Suryānīya*, (ms. Muṣṭafā Fādil Mīqāt, 108, Dār al-Kutub, Cairo, ca. 1640 A. D.) , f. 2v.

23. The numerical significance of the stations is discussed by the Ikhwān al-Ṣafā.

24. Cf. Lynn Thorndike, *History of Magic and Experimental Science*, (New York, 1923), 1 : 712 – 171, 2 : 112 – 115 .

longer period of time, moreover, more days would be lost due to precession of the equinoces. It is also true that the timing of risings will differ for different regions, as noted by early Islamic scholars such as Ibn Qutayba.[15] As an approximate seasonal reckoning system, as opposed to a long - term calendar, the thirteen-day periods represented by the stations could serve for fixing the timing of meteorological phenomena, pastoral movements, cycles of plants and animals, and agricultural activities. It is in fact this sense of the stations as a seasonal almanac that was associated by Muslim scholars with the *anwā'* of pre-Islamic Arabia.

As a system of coordinates the lunar stations appear to have been important to navigators. Many of the twenty-eight stations, however, were too small or insignificant to bother observing. Thus, it was the coordinate as a segment of arc that was valued. The author of one of the major medieval navigational treatises, Ibn Mājid, described the relevance of the lunar stations as determinants for sailing.[16] The concept of the twenty - eight stations was combined with a system of 32 rhumbs commonly employed on ships sailing the Indian ocean. The stations would also be located on the astrolabe. Once again the approximate nature of the stations as coordinates must be stressed. As Ibn Mājid versified[17]

These stars and rhumbs with the Arabs

Are only approximate . Oh my captain

If you set course exactly on them

in a narrow place , then you will have difficulty.

In addition to the astronomical use of the stations as coordinates for time reckoning or navigation, the *manāzil al-qamar* were of great importance in the astrological literature. One finds hemerological references to auspicious or inauspicious times for events or tasks when the moon enters a specific station.[18] When the moon stations in the Pleiades, for example, it is appropriate to travel, to enter into the presence of rulers with petitions, for purchase of slave girls, for commerce and a vâriety of other activities. A woman who becomes pregnant at this time will have a boy who will be good looking, tall in stature, with wide shoulders, brave, generous and one who likes people. This tradition was borrowed from India and was transmitted

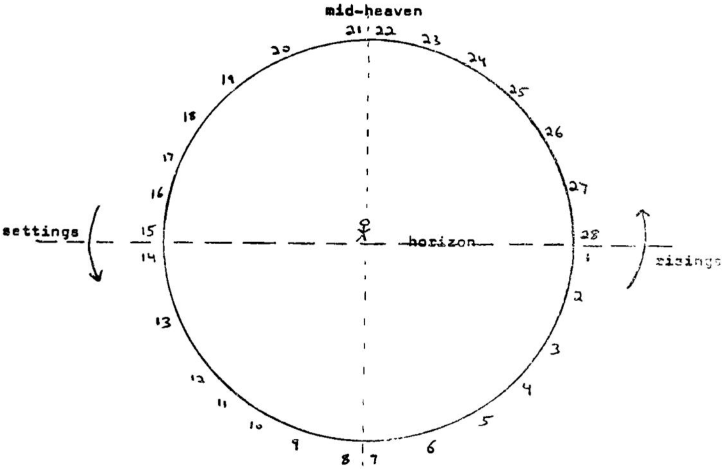
15. Ibn Qutayba, p. 9 – 11 .

16. Aḥmad ibn Mājid, *Kitāb al-Fawā'id fī uṣūl al-baḥr wa-al-qawā'id* , translated by G. R. Tibbetts, *Arab Navigation in the Indian Ocean before the Coming of the Portuguese* (London, 1971) , pp. 79 – 120 .

17. Ibn Mājid, p. 75.

18. For divining by the stations, see Ikhwān al-Ṣafā, *Rasā'il Ikhwān al- Ṣafā*, (Beirut, 1957), 4 : 427 ff.

Figure 1. Observations of the *Manāzil*



will be the first station seen to set in the evening. Thus the main coordinates in the system are fixed at the beginning of daytime and the beginning of nighttime.

Referring again to figure 1, it is possible to see how the risings and settings of the stations can be used as a reckoning system for time at night. If one observes the station rising at the beginning of the evening, it is obvious that it will reach mid-heaven in six hours and set in twelve hours. To be more exact in an approximate system , one and one-sixth stations will rise every hour of the night, or a new station will rise every 6/7 of an hour. In this manner, weather permitting, the stations can represent a sky clock once a reference point has been established. As the astronomers noted, this is only an approximate system, but it could serve well in an age before our modern clock.

The twenty-eight stations can also be viewed as a seasonal reckoning system when plotted against the rising of the sun. Each station was said to rise at dawn for a period of thirteen days, with the exception of one period of fourteen days in order to round out a year of 365 days (27 stations × 13 days + 14 days). Once again one finds an approximate system, since a day will be lost every four years due to ignoring the leap year. Over a much

Table 1. The Arabic *Manāzil al-Qamar*[14]

Number	Name	Identification	Date of Setting
1	*sharaṭayn*	βϒ Arietis	X : 19
2	*buṭayn*	εδπ Arietis	X : 31
3	*thurayyā*	Pleiades	XI : 11
4	*dabarān*	α Taurus	XI : 24
5	*haqᶜa*	λΦ′φ‵ Orionis	XII : 7
6	*hanᶜa*	γξ Geminorum	XII : 20
7	*dhirāᶜ*	αβ Geminorum	I : 2
8	*nathra*	εγδ Cancri	I : 15
9	*ṭarf*	κ Cancri , λ Leonis	I : 28
10	*jabha*	ζγηα Leonis	II : 10
11	zubra	δθ Leonis	II : 23
12	*ṣarfa*	β Leonis	III : 7
13	*ᶜawwā*	βηγδε Virginis	III : 20
14	*simāk*	α Virginis	IV : 3
15	*ghafr*	ικλ Virginis	IV : 17
16	*zubānā*	αβ Librae	IV : 30
17	*iklīl*	βδπ Scorpii	V : 13
18	*qalb*	α Scorpii	V : 26
19	*shawla*	λγ Scorpii	VI : 9
20	*naᶜā'im*	σφτζγδεη Sagittarii	VI : 23
21	*balda*	(vacant space)	VII : 6
22	*saᶜd al-dhābiḥ*	αβ Capricorni	VII : 19
23	*saᶜd bulaᶜ*	με Aquarii	VIII : 1
24	*saᶜd al-suᶜūd*	ς′ Capricorni, βξ Aquarii	VIII : 14
25	*saᶜd al-akhbīya*	γπζη Aquarii	VIII : 27
26	*al-fargh al-muqaddam*	αβ Pegasi	IX : 10
27	*al-fargh al-mu'akhkhar*	δγ Pegasi	IX : 23
28	*baṭn al-ḥūt*	β Andromedae	X : 6

14. The identification is taken from P. Kunitzsch, *Unter-suchungen zur Sternnomenklatur der Araber*, (Wiesbaden, 1961). The dates are taken from the *anwā'* text of Abū Isḥāq al-Zajjāj. The numbering here is the standard order of the stations and will serve as a reference for further discussion in this paper.

of the solar zodiac. For the astronomer each zodiacal sign covered two and one - third stations, commencing with *sharaṭayn*, the so-called two horns of the Ram (*ḥamal*) . The choice of *sharaṭayn* as the first of the stations, as noted by the astronomer ᶜAbd al-Raḥmān al-Ṣūfī, was due to the Ram being the traditional starting point of the zodiacal year .[13] In fact the correspondence between the stations and each zodiacal sign is not exact, even though the general sequence is similar. The second station, *buṭayn*, is indeed part of the Ram, while the third station, the Pleiades (*thurayyā*), is not part of the zodiac although it is in the vicinity of the Bull (*thaur*) . The fourth station , Aldebaran, is part of the Bull, but the following station is actually in Orion . The further correlation between the stations and the zodiacal signs can be seen in table 1, where the stations are identified.

Some astronomers sought to delineate the precise amount of space occupied by each asterism, but this results in a series of stations of unequal lengths. The most common division paralleled the system of the solar zodiac in which each station was defined as an equal amount of arc along the moon's course. Thus, starting from the first of the Ram each of the twenty-eight stations comprised 12° 51′ (i. e., 360° ÷ 28) . As a system of equal units the twenty-eight stations resulted in a coordinate system useful for time reckoning and in navigation. Some Islamic scholars noted that the position of the station as a coordinate could be helpful in determining the *qibla*, although practical examples of this are limited.

The concept of the lunar zodiac implies that on any given night the moon will appear to station or conjoin with one of the twenty-eight stations. Regardless of the position of the moon, however, observation of the risings and settings of the stations at night focused on certain key positions in their use as a coordinate system. This can best be illustrated by reference to the ideal horizon shown in figure 1. By definition, fourteen or half of the twenty-eight lunar stations would be visible at any given time at night. Those visible were often referred to as *ẓāhira* , while the stations beneath the horizon were known as *jāfīya* . If station ≈ 1 in the figure represents the station which rises at dawn (i. e. , *manzila al-fajr* or *ṭāliᶜ al- fajr*), this would represent the last station visible before the sun appears above the horizon. Stations ≈ 2 and ≈ 3 will be obscured by the sun as they rise in turn; ≈ 3 is referred to as *manzila al-shams* because it is in this station that the sun arrives (i. e., *ḥalūl al-shams*) at dawn . Assuming an ideal twelve-hour day , the station which will rise at the beginning of evening (*ṭāliᶜ auwal al-layl*) is ≈ 15 ; this is the same station which sets at dawn as ≈ 1 rises at dawn. The station located at mid -heaven at the beginning of evening will be ≈ 8 , while ≈ 1

13. Abū al-Ḥusayn ᶜAbd al-Raḥmān al-Ṣūfī, *Kitāb Ṣuwar al-kawākib*, (Hyderabad, 1954), p. 142 .

the firmament (*falak*).[8] While the lexical sources include much information on the stars identified as *manāzil*, there is no precise explanation for the origin of the term. One can surmise that the sense of *manzil* or *manzila* refers literally to a place of alighting (*mawdi*ᶜ *al-nuzūl*) in the course of a journey.[9] As the *manzil* is where a man and his mount stop for the night, so it is where the moon comes to rest at night. Translation of the Arabic term *manzil* should be as " station " or " stage " in English, as suggested long ago by Sir William Jones.[10] The term " mansion " , which is commonly found in the literature,[11] is misleading and reflects a later Arabic usage of *manzil* as a dwelling. Perhaps the tendency to see the *manzil* as a mansion is due to the translation of *burj* (in reference to the solar zodiac) as a house.[12] If indeed the system of *manāzil al- qamar* is to be associated with tribesmen, the original sense must have been that of where the moon alights. The verbal form *yanzilu* in this context can best be translated as "to station " . This is evidenced by the common expression *yaḥullu al-qamar bi-al-manzil* (the moon arrives at the station).

The fully developed system of *manāzil al-qamar* in Islamic astronomy refers to a lunar zodiac, although it closely parallels the solar zodiac of twelve signs. On any given night, regardless of the moon's phase, it appears to station (*yanzilu*) in the area of the sky occupied by a star or group of stars. After its revolution of about twenty- seven and one- third days, the moon more or less follows the same course again. Thus, the choice of twenty- eight stations represented by stars is a result of repeated observations of the moon's circuit. It is not an arbitrary or fanciful division of the heavens . Such a system is admittedly approximate, since the stars are not evenly spaced and at times the moon alters course. As a practical star calendar the lunar zodiac could have been developed by any culture, yet it is clear that not every culture found it useful or significant.

Although not all of the asterisms recognized as lunar stations were from zodiacal constellations, they represent to a large extent an expansion

8. Al- zamakhsharī, *Asās al-balāgha* (Beirut, 1982), p. 453. Cf. E. W. Lane, *An Arabic- English Lexicon* , (Cambridge, 1984), 1 : 1289 .

9. Ibn Sīda as quoted in *Lisān al-*ᶜ*Arab* (article *n-z-l*). The definition of *manāzil* as the lunar stations is not in fact discussed by the author of *Lisān al-* ᶜ*Arab* under the article. While *manzil* is the common singular form, the form *manzila* is also found.

10. William Jones, p. 304. In German this would be Mondstationen (plural) and in Italian stazioni lunare .

11. In German the plural is Mondhauser; in French, mansions lunaires; in Latin, mansiones lunae. W. M. O'Neil, *Time and the Calendar* (Sydney, 1975), p. 53 mistakingly calls these " the inns of the moon. " .

12. The parallel meaning of *burj* and *manzil* was pointed out by al-Qalqashandī, *Ṣubḥ* al-*a*ᶜ*shā fī ṣinā*ᶜ*at al-inshā'* (Cairo, 1913 ff) , 2 : 372 .

Manāzil al-Qamar[5]

Islamic astronomy dealt with the theoretical and the practical. It is the theoretical focus that engages the attention of most historians of science, particularly those interested in the relation of the Arabic sciences to the scientific traditions of neighboring cultures. Yet it is the practical side of astronomy, as well as astrology, that appears over and over again in the bulk of surviving manuscripts. While a few scholars pondered astronomy for its own sake , most were more concerned with practical matters of time reckoning, determining coordinates in navigation, fixing the location of the *qibla* and deciphering one's fate. In this sense the heavens were approached as a map, a guide for accomplishing given tasks, rather than an object of scientific curiosity .

One of the more practical concepts in Islamic astronomy and astrology is the idea of the zodiac. The solar zodiac , with the sun coursing through the twelve signs, had become almost a universal frame of reference by the beginning of the Islamic era. Many of the same stars in the zodiacal constellations could also be plotted along the monthly course of the moon. Thus, the system of lunar stations (*manāzil al-qamar*) comprised the round of stars in which the moon stationed each night of its sidereal revolution of about twenty-seven and one-third days. It is important to remember that the concept of a lunar zodiac refers only to the revolution of the moon vis-à-vis the sky and has no direct relation to the phases from new moon to new moon.[6] It was the latter which was the basis for the lunar calendar elaborated in Islam.

The origin of the term *manāzil* in reference to stars along the moon's course is obscure .[7] Many commentators have argued that this usage is intended in the Quranic passages of surah yāsīn (36 : 39) and surah Yūnus (10 : 5). In these passages *manāzil* refers to the place through which the moon glides (*yasbaḥu*), just as one finds reference to the sun gliding or passing along

5. There is no complete, up-to-date study of the *manāzil al-qamar*. The discussion by J. Ruska in *The Encyclopaedia of Islam* (first edition, Leiden, 1936) , 5 : 232 is inadequate . For example, *al-ᶜawwā'* is misspelled as *al-sawwā'*. I am at present compiling a survey of the stations in a work to be entitled : *Anwā' and Manāzil. The Lunar Stations in Arab Tradition.*

6. Paul Kunitzsch, *Arabische Sternnamen in Europa* (Wiesbaden, 1959), p. 33, erred in noting that the lunar stations pertain to the synoptic month based on the phases.

7. Fritz Hommel, ''Uber den Ursprung und das Alter der arabischen Sternnamen und insbesondere der Mondstationen, '' *Z. D. M. G.* , 1891, 45 : 608 claimed that the term *manzil* was derived from the Akkadian and was in use by the pre-Islamic Arabs. However, the line of poetry he quotes to prove his point refers to *nazil*, a term for abundant rain and not for the stations. Hommel and others also related *manzil* to the Hebrew *muzzaloth* or *mazzaroth* in Job. I have not encountered use of the term *manzil* to refer to a star or asterism in the pre-Islamic poetry.

a practice condemned by the prophet Muhammad as pagan. The stars associated with periods of rain came to be known as *anwā'* (*naw'* , singular). During the first three centuries of the Islamic era a literary genre on the *anwā'* flourished.[3] This genre described the pre-Islamic folklore about the stars as reflected in the poetry and rhymed sayings of the Arabs. Although different beliefs and usages were noted, the scholarly consensus held that the formal *manāzil al-qamar* were equivalent to the *anwā'* of tribal Arabia[4].

In this paper I assess the evidence for and against the identification of the *anwā'* as equivalent to the *manāzil al- qamar* or lunar zodiac. The bulk of the evidence, primarily that selected by authors of the *anwā'* genre, is literary and lexical. There is also a matter of exegesis, since the term *manāzil* occurs in the Holy Quran and the term *naw'* in the traditions of the prophet Muhammad. The solution to the problem, however, cannot be drawn from the textual evidence alone. It is necessary to show how certain Arab tribes use star calendars as described in the ethnographic literature. Regardless of what is claimed for the pre-Islamic Arabs , is it reasonable to consider the lunar zodiac as a practical star calendar for Arab tribesmen ?

In seeking to determine the origin of the *anwā'* it is important to distinguish between the various interpretations reflected in the folklore and the scientific concept adopted for Islamic astronomy and astrology. This raises a methodological problem for reconstructing the history of scientific concepts. How do we recognize the point at which an idea from the vast array of a culture's accumulated lore becomes scientific ? Perhaps it is more accurate to ask : At what point are we willing to recognize an idea as being scientific? This problem is even more acute in approaching the Islamic sciences, because most historians approach the subject from an admittedly biased, Western viewpoint. In looking at the ways in which early Muslim scholars dealt with the *anwā'*, I argue that the equation of the *anwā'* with the lunar zodiac was a decidedly Arab and Islamic act of scholarship. The earliest Muslim scholars were not simply describing a system of reckoning found in their folklore. They in fact created the concept by placing a myriad of conflicting information into a legitimate, coherent frame .

3. The *anwā'* texts are listed by Fuat Sezgin, *Geschichte der Arabischen Schrifttums*, (Leiden, 1979) , 7 : 322 – 370. Among the major published texts are; Ibn Qutayba, *Kitāb al- Anwā'* , (Hyderabad, 1956); Ibn al- Ajdābī, *Kitāb al-Azmina wa-al-anwā'* , (Damascus, 1964) ; Abū Isḥāq al-Zajjāj, *Kitāb al-Anwā'* , abridged in Abū Manṣūr Mawhūb al-Jawālīqī, *Sharḥ adab al-kātib*, (Cairo, 1350), pp. 175 181, and translated in D. M. Varisco, " The *Anwā'* stars according to Abū Isḥāq al-Zajjāj, " forthcoming.

4. Almost all the authors make this link. Cf. Abū ʿUbayd and Shamr in *Lisān al-ʿArab* (article *n-w-'*); Abū Ḥanīfa al-Dīnawarī in Ibn Sīda, *kitāb al- Mukhaṣṣas*, (Beirut, 1965), 9 : 79 ; Ibn al- Ajdābī, p. 134 ; Ibn Qutayba, p. 16.

The Origin of the ANWĀ' in Arab Tradition
On the distinction between science And folklore

DANIEL MARTIN VARISCO*

One of the standard modes in Islamic astronomy for dividing the heavens into discrete reckoning units is the concept of twenty-eight lunar stations (*manāzil al-qamar*), which constitute a lunar zodiac. The origin of the lunar zodiac, which was present in both India and China as early as the second millennium B. C. E., has not been determined despite a spirited debate among scholars in the 19th and early 20th centuries.[1] It is clear that the lunar zodiac was not part of Babylonian, Assyrian or Greek science; nor is it found in the early Hermetic sources. While Ptolemy, for example, was well versed in the twelve signs of the solar zodiac, he did not mention the lunar stations. Similarly, there is no reference to the lunar zodiac in the biblical narratives or ancient Hebrew cosmology.

The earliest evidence for the system of twenty-eight lunar stations in Semitic tradition comes from early Muslim scholars, such as Ibn Qutayba, who claimed that this system was part of the meteorological lore of pre-Islamic, tribal Arabia. The pre-Islamic Arabs regarded certain stars or asterisms[2] as seasonal markers of rain, wind, heat or cold. Some went so far as to attribute the power over rain and similar phenomena to the stars,

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1. The debate was mainly directed at whether the Chinese or Indian system was oldest. A review of many of the ideas proposed can be found in Friedrich Karl Ginzel, *Handbuch der Mathematischen und Technischen Chronologie* (Leipzig, 1906), 1 : 70 – 77, and William Whitney, " On the views of Biot and Weber respecting the relations of the Hindu and Chinese systems of asterisms," *J. A. O. S.*, 1864, 8 : 1 – 94. See also the arguments made by William Jones, " On the antiquity of the Indian zodiack, " *Asiatic Researches*, 1790, 2 : 239 – 306 ; H. T. Colebrooke, 1807, " On the Indian and Arabian divisions of the zodiac, " *Asiatic Researches*, 1807, 9 : 323 – 376, Max Müller, *On Ancient Hindu Astronomy and Chronology* (Oxford, 1862); Jean - Baptiste Biot, *Études sur l'astronomie Indienne et sur l'astronomie Chinois*, (Paris, 1862); Leopold de Saussure, " La symétrie du zodiaque lunaire asiatique, " *J. A.*, 1919, 11th series, 14 : 141 – 148.
2. The term asterism is more appropriate than star or constellation, since most of the stations are pairs or small groups of stars. Cf. W. D. Whitney, " Reply to the strictures of Prof. Weber upon an essay respecting the asterismal system of the Hindus, Arabs, and Chinese, " *J. A. O. S.*, 1865, 9 : 388.

[illegible] writing and [illegible] "[illegible]", Eulers and [illegible] Trigonometria [illegible] [illegible] means the different problems for the general spherical triangle. Below we check the results, given between brackets, only using the cosine rule and [illegible] HP34C. Though hardly any [ ]-value is correct [illegible] the sums, which theoretically must be 180° [illegible] for the simple HP34C no deviations, up to the 10-th digits.

I $a = 99°$ $b = 127°45' = 127°,750$ $c = 70°13' = 70°,21666667$

$\cos\alpha = (\cos a - \cos b\cos c)/\sin b\sin c = 0.06824951 7$ $\alpha = 86°,08 [illegible] = 86°.5'.11.34.27$ [86°5'14"]

$\cos\beta = (\cos b - \cos a\cos c)/\sin c\sin a = -0,601757341$ $\beta = 126°,[illegible] = 126°.52'.45.6.9$ [126°54'44"]

$\cos\gamma = (\cos c - \cos a\cos b)/\sin a\sin b = 0,310763500$ $\gamma = 71°,8947[illegible] = 71°.53'.41.[illegible]$ [71°[illegible]'42"]

I' $\alpha = 81°$ $\beta = 52°15' = 52°,25$ $\gamma = 109°47' = 109°,78333333$

$\cos a = (\cos\alpha + \cos\beta\cos\gamma)/\sin\beta\sin\gamma = -0,068249517$ $a = 93°,9134[illegible] = 93°[illegible]'40.[illegible]$ [93°[illegible]'46"]

$\cos b = (\cos\beta + \cos\gamma\cos\alpha)/\sin\gamma\sin\alpha = +0,601757341$ $b = 53°,04[illegible] = 53°[illegible]'14.[illegible]$ [[illegible]]

$\cos c = (\cos\gamma + \cos\alpha\cos\beta)/\sin\alpha\sin\beta = -0,310763500$ $c = 108°,10515222 = 108°6.[illegible]$ [[illegible]°[illegible]'10"]

II $a = 132°50' = 132°,8333333$ $b = 112°42' = 112°,700$ $\gamma = 14°30' = 14°,500$

$\cos c = \cos a\cos b + \sin a\sin b\cos\gamma = 0,917345116$ $c = 23,4[illegible]098 = 23°.27'.32.28[illegible]$ [23°2[illegible]'3[illegible]"]

Method I $\cot\alpha = -0,0072800735$ $\alpha = 152°,53260942 = 152°32'[illegible].30.2$ [152°[illegible]'2"]

$\cos\beta = +0,814453274$ $\beta = 35°,46666134 = 35°.27'.59.[illegible]$ [35°2[illegible]'[illegible]"]

II' $\alpha = 47°10' = 47°,16666667$ $\beta = 67°18' = 67°,300$ $c = 165°30' = 165°,500$

$\cos\gamma = -\cos\alpha\cos\beta + \sin\alpha\sin\beta\cos c = -0,917345116$ $\gamma = 156°,5409[illegible] = 156°32'[illegible].[illegible]$ [156°32'[illegible]"]

Method II' $\cos a = 0,0072800735$ $a = 27°,4666490[illegible] = 27°27'59.91.5[illegible]$ [[illegible]°[illegible]'50"]

$\cos b = -0,814453273$ $b = 144°,53323[illegible] = 144°32'0.1.0$ [144°32'2"]

III $a = 103°10' = 103°,16666667$ $b = 120°12' = 120°,200$, $\beta = 131°10' = 131°,166[illegible]$

$\cos b = \cos a\cos c + \sin a\sin c\cos\beta \longrightarrow -0,5030[illegible] = -0,22778442[illegible]\cos c + 0,64731[illegible]\sin c$

$\tan\varphi = \frac{0,22778442[illegible]}{0,64731941[illegible]} = 0,35[illegible] = \tan 19°,3062960[illegible]$

$\sin(\varphi + c) = 0,5030[illegible] / \sqrt{0,227784427^2 + 0,64731941[illegible]^2} = 0,73302[illegible]$ $\varphi + c = \begin{matrix}47°,[illegible] \\ 132°,[illegible]\end{matrix}$

$c_1 = 27°,[illegible] = 27°40'[illegible] * [27°40'15"]$, $c_2 = 113°,[illegible] = 113°[illegible] * [113°2[illegible]'[illegible]"]$

Method I $\cos\alpha_1 = 0,540077304$ $\alpha_1 = 57°,3110[illegible] = 57°.10'.[illegible]$ [57°10'4[illegible]"]

$\cos\gamma_1 = 0,9104196[illegible]$ $\gamma_1 = 23°,7346[illegible] = 23°44'.[illegible]$ [23°44'6"]

$\cos\alpha_2 = -0,540077304$ $\alpha_2 = 122°,6889[illegible] = 122°41'.[illegible].3.26$ [122°41'17"]

$\cos\gamma_2 = -0,6094606[illegible]$ $\gamma_2 = 127°,5510[illegible] = 127°33'[illegible]$ [127°32'1[illegible]"]

III' $\alpha' = 76°50' = 76°,83333333$ $\beta' = 59°48' = 59°,800$ $b' = [illegible]$

$\cos\beta' = -\cos\alpha'\cos\gamma' + \sin\alpha'\cos b'\sin\gamma' \longrightarrow 0,50301994[illegible] = -0,22[illegible]\cos\gamma' + 0,64731[illegible]\sin\gamma'$

$\tan\varphi = 19°,3062960[illegible]$ and $\sin(\gamma' - \varphi) = 47°,1403[illegible]$ or $132°,[illegible]$

$\gamma_1' = 66°,526[illegible] = 66°31'.36.17.32 * [66°31'42"]$, $\gamma_2' = 152°,2460[illegible] = 152°14'[illegible] * [152°14'40"]$

Method I' $\cos a_1' = 0,540077304$ $a_1' = 57°,3110[illegible] = 57°10'.39.[illegible]$ [57°10'43"]

$\cos c_1' = 0,6094606[illegible]$ $c_1' = 52°,44[illegible] = 52°.26'.[illegible]$ [52°27'4"]

$\cos a_2' = -0,540077304$ $a_2' = 122°,68890[illegible] = 122°41'.20.3.26$ [122°41'17"]

$\cos c_2' = -0,9104196[illegible]$ $c_2' = 156°,2653[illegible] = 156°,15'.[illegible].23.44$ [156°15'54"]

We have systems of mutual polar triangles. For I, I', II, II' it is evident that cosines have opposite signs, the results are supplements. For III, III' we see

$\alpha_1 + a_2' = \alpha_2 + a_1' = c_1 + \gamma_2' = c_2 + \gamma_1' = \gamma_1 + c_2' = \gamma_2 + c_1' = 180°,000000$ [illegible] $[illegible]°[illegible]$

and for 10 digits exact no difference [illegible]!

Third Method

$$\left[\sin(G-M) - (1-\cos t)\cos M \sin G\right]^2 + (\sin t \cos M)^2 = \sin^2 u$$
$$\sin Q = \sin t \cos M / \sin u$$

The values $a = \sin t \cos M$ and $\bar{G} = (1-\cos t)\cos M$ were taken by al-Bīrūnī from the results obtained in the Second Method.

$\bar{G}$	0.104059530	6.243571722	6.14.36 51.30	6.14 36	6.14.40	
$\sin G$	0.553149239	33.18895433	33.11 20 14.0	33.11.20	33.11.20	
×	—	207.2176104	207.13 3 25.34	207.12.38 100	207.14.46 13.19	
:60	0.057560450	3.45362693	3.27.13.3 25	3.27 12	3.27.15	
$\sin \bar{M}$	0.79351187	47.61067119	47 36 30.21 50	47.36 38	47.36.35	
+	0.851071637	51.06427016	51.3.51.20.21	51.3.50	51.3.5[illegible]	
$T=h$	0.140920364	8.935707104	8.56 8.31.50	8.56 10	8 56 6	
h^2	0.022179658	79.84676637	79.50 40.21 32	7[illegible]	79.5[illegible] 16	
a^2	0.182508546	657.3115668	657.10.41 30 25	657.10 35.36 51	657.[illegible] 36 51	
+	0.204766204	737.1500332	737.9.27.59.[illegible]	737.9.50 10 5[illegible]	737.[illegible] 27	
$\sqrt{}$	0.452510999	27.15065990	27.9.2 22 32	27.9.2	27.9	27.9.41
$a:\sqrt{}$	0.944209609	56.65730127	56.39 26.34 21	56 39.27	56 39.27	56 40.11
Q	70.78490394	70 78490394	70.47.0.34.15	70 47 7	70 47.13	70 49.17

Instead of $\sin(G-M)$ directly — perhaps to reduce the number of subtractions — al-Bīrūnī computes

$$\sin \text{vers}(90 - \overline{G-M}) = 1 - \sin(G-M),$$

and subtracts from the sinus totus 1, leading to $\sin(G-M)$.

Second Method.

$$\left\{\left[\cos(k-M)/\cos k - (1-\cos t)\cos M\right]\sin k - \sin M/\cos k\right\}^2 + (\sin t \cos M)^2 = \sin^2 u$$

$$\sin k - \sin t \cos M / \sin u$$

sin 78°5'	0.978440761	58.70693768	58.42.24.58.32	58.42.25	
60×	—	3522.416261	3522.24.58.32.[illegible]	3522.25.0	
cos k	0.833002101	49.98493004	49.59.5.45.3	49.59.5	
:(d)	1.174092726	70.44556356	70.28.10.25.43	70.28.12	
sin t	0.459706527	27.58219161	27.35.13.53.23	27.35.14	
1−cos t	0.111970524	6.71823145 0	6.43.5.37.59	6.43.[illegible]	
cos M	0.929347524	55.76085145	55.45.39.5.54	55.45.39	
sin k	—	1538.20593	1538.17.7.3.17	1538.17.11.21	
:(a)	0.427301470	25.63800822	25.38.17.7.3	25.38.17	
(1−cos t)	—	374.61430 63	374.36.51.30.9	374.37.50.47.51	
:(c)	0.104059550	6.24357172	6.14.36.51.30	6.14.56	6.14.20
d−c	1.070433196	64.22599176	64.13.33.34.13	64.13.34	64.13.[illegible]
tan k	0.553149239	33.18895433	33.11.20.14.8	33.11.20	33.11.20
×	—	2131.593508	2131.35.36.37.43	2131.35.30	[illegible].34.24
:(b)	0.592109308	35.52655847	35.31.35.36.37	35.31.35	35.31.34
sin M	0.369206147	22.15236884	22.9.8.31.40	22.9.8	22.9.8
60×	—	1329.142131	1329.8.31.40.17	1329.8.0	1329.8.0
cos k	0.833002101	49.98493004	49.59.5.45.3	49.59.6	49.59.6
:(g)	0.443180944	26.59085664	26.35.27.5.2	26.35.27	26.35.27
1−sin k	0.148920364	8.935701830	8.56.8.31.35	8.56.8	8.56.7
h^2	0.022179658	79.84676719	79.50.48.21.42	79.50.38.57.4	79.50.21.4.49
a^2	0.182506546	657.3115676	657.18.41.30.36	657.18.5.36.52	657.18.3.36.52
+	0.204766204	737.1503350	737.9.30.0.21	737.9.14.23.56	737.8.56.41.4
√	0.452510999	27.15065994	27.9.2.22.32	27.9.2	27.9.1
u:√	0.944209689	56.65738132	56.39.26.34.21	56.39.27	56.39.29
arc sin	70.70490394	70.70490394	70.47.5.39.14	70.47.8	70.47.13

First Method.

$\sin h = \cos \ell \sin t$, $\sin \ell / \cos h = \cos p$, $q = 90 - M - p$, $\cos u = \cos h \cos q$

$\cos M \sin t / \sin u = \sin \varphi$

cos ℓ	0.8330821181	49.98493084	49.59.5.45.3	49.59.5	49.98472222
sin t	0.4597806527	27.58719161	27.35.13.53.23	27.35.14	27.587[illegible]22
×	—	1378.943865	1378.56.37.54.50	1378.56.22.41.1	1378.98963[illegible]
60:	0.3830399962	22.98239775	22.58.56.37.54	22.58.56	22.98222222
arc sin	22.52211252	22.52211252	22.31.19.36.18	22.31.19	22.52194444
90 −	—	67.47788748	67.28.40.[illegible].41	67.28.41	67.47805556
cos h	0.923731773	55.42390634	55.25.26.3.46	55.25.26	55.4238[illegible]
sin ℓ	0.5531492239	33.18895433	33.11.20.14.8	33.11.20	33.18[illegible]
×60	—	1991.337260	1991.20.14.8.9	1991.20	1991.333333
sin ℓ/cos h	0.598820194	35.92921163	35.55.45.9.42	33.55.45	35.929[illegible]
arc sin	36.70544690	36.70544690	36.47.7.36.31	36.47.7	36.7052[illegible]
				36.47.7	36.[illegible]
90−M−p	15.118780822	15.118780823	15.7.7.36.31	15.7.7	15.6.48
compl	—	74.88121917	74.52.52.23.29	74.52.53	74.53.12
sin	0.9653887192	57.92323150	57.55.23.38.0	57.55.24	57.55.29
60×	—	3210.331758	3210.19.54.19.43	3210.20.11.0.27	3210.24.[illegible].27
cos h×	0.8917508822	53.50552930	53.30.19.54.19	53.30.20	53.30.25
arc sin	63.09504853	63.09509849	63.5.42.21.16	63.5.42	63.5.54
u	26.90490147	26.90490151	26.54.17.38.43	26.54.17	26.54.6
sin u	0.452510999	27.15065992	27.9.2.22.32	27.9.2	27.8.51
cos M	0.929347524	55.76005145	55.45.39.3.54	55.45.39	55.45.39
sin t	0.4597806527	27.58719161	27.35.13.53.23	27.35.14	27.35.14
×	—	1538.2085293	1538.17.7.3.17	1538.17.11.24.0	1538.17.11.24.0
:60	0.427301470	25.63800822	25.38.17.7.3	25.38.17	25.38.17
: sin u	0.9442089609	56.65738135	56.39.26.34.23	56.39.27	56.39.50
φ	70.78490394	70.78490398	70.47.5.39.15	70.47.6	70.48.14

cotg 70° 45′ = 0.349216 ; cotg 71° = 0.344328 ;

arc cotg 0.348504 being 70°47.11.6.

These values are very near to the results given by al-Bîrûnî .

A table with an interval of 1′ yields

tg 70° 47′ = 2.86891 ; tg 70° 48′ = 2.87161 ; arc tg 2.86940 = 70°.47.10.41 cotg 70° 47′ = 0.348563 ; cotg 70° 48′ = 0.348237 and then arc cotg 0.348504 is 70° 47. 10. 40, and we see that both values should again lead to the **eleven** seconds .

The final results of al-Bîrûnî computing with tg and cotg show definitely **the use of a table with an interval of 15′** , a " ptolemaic table " . The great difference then found in 70°.47.9 and 70°.47.12 is **then** in accordance with the given results, which al-Bîrûnî could never have obtained from a table with a smaller interval.

By this analysis we have shown that the use of the tangens function **causes difficulties**, because of the not being allowed of linear interpolation with tables of an interval of 15′. The conclusion must be that sticking to the sine values and not using tables of tangents has NOT been a drawback for the Greeks, and that people like al-Bîrûnî , computing really very accurately, met indeed with this difficulty in having **different** results . . linear interpolation **not** being allowed. . in certain intervals.

Al- Bîrûnî obtained the best results possible with the tools he had available – just the ptolemaic tools in trigonometry . . , and that the " efforts in trigonometry " were in the " Islamic Period " not concerned with " theoretical problems " but only with the numerical precision, the search for computational schemes **causing** the least possible error . In fact al-Bîrûnî obtained the same accuracy as **still** about 1900 AD in the then used text books could be arrived at. Only the modern simple electronic pocket computer working at 10 decimal places eliminates all these "ptolemaic–islamic" problems . **This** caused the disappearance of trigonometry – plane as well as spherical – but for one simple relation, a cosine rule.

For people like al-Bîrûnî holds true Schiaparelli's statement, that the greatest praise a scientist can obtain is that with the tools available in **his** period he obtained the best possible results. His first method for the qibla can be simplified from numerical degree 17 to degree 7. . . but even modern mathematicians did not yet see that D. A. King's quoted scheme can still **numerically** be simplified from degree 9 to degree 7.

and his rounding off leads to tg $Q = 172.9.50 = 60$ times 2.869398148

His value for the cotangens follows from

$$\text{cotg } Q = 536.6.0 \ / \ 25.38.17 = 60 \ . \ (8.56.6 \ / \ 25.38.17) =$$
$$= 20.91032211 = 60 \text{ times } 0.348505369$$

The rounded value 20.54.37 is 60 times 0.348504630
The more precisely taken values for the quotients, which should in their product evidently lead to 3600 are

172.9.49.35.29 and 20.54.37.9.34, product 3599.999999 in decimals. Al-Bîrûnî's rounded off values give 3599.994741 and divided by 60 the value 0.999998539, instead of the evident 1.000000000. There remains an accuracy of at most six decimal places.

The quantity 8.56.6 should be at least 8.56.8. the ten place decimal values lead then to

$$\text{tg Q} = 2.869217857 = \text{tg } 70^{\circ}.78517274$$

$$\text{cotg } Q = 0.348537038 = \text{cotg } 70^{\circ}.\ 78517271$$

the product of the two values being 1.000000000, and in sexagesimal degrees

$$Q = 70^{\circ}\ 46'\ 6''\ 37'''\ 18''''$$

The round values obtained by al-Bîrûnî lead to

$$\text{tg } Q = 172.9.50 \ / \ 60 = 2.86938148 =$$
$$= \text{tg } 70^{\circ} \ . \ 78629155 = \text{tg } 70^{\circ} \ . \ 47' \ . \ 10'' \ . \ 38'''$$

$$\text{cotg } Q = 20.54.36 \ / \ 60 = 0.348504630 =$$
$$= \text{cotg } 70^{\circ} \ . \ 78631755 \ \tfrac{1}{2} \text{ cotg } 70^{\circ} \ . \ 47' \ . \ 10'' \ . \ 44'''$$

which results should both be $70^{\circ}\ 47'\ 11''$ at two sexagesimal fractional parts, equal to al-Bîrunî's result for the cotg, but more than the $70^{\circ}.47.9$ obtained from the tangent .

If, however, we use a " ptolemaic table". with an interval of $15'$ we would find at five decimal places by division

$$\text{tg } 70^{\circ}\ 45' = 2.86356 \ ; \ \text{tg } 71^{\circ} = 2.90421 \ ;$$

$$\text{arc tg } 2.86940 = 70^{\circ} \ . \ 47.9.17$$

and

We showed above that by introducing ω by tg $M = \sin \omega$ the degree of numerical difficulty can be reduced to 7.

§ 5. *Analysis of the numerical computation by al - Bîrûnî*

In the Appendices I, II, III we show the computations according to the first, second and third method.

To the **first** method we remark that suddenly a discrepancy between the two place values and the value of al - Bîrûnî occurs : 36.46.48 instead of 36.47.7. This caused **instead of a hightly correct result,** which only differs in 0°.0.0.20.45 from the ten place value in decimals al-Bîrûnî's result of 70° 48.14, somewhat more than 1′ too great. In **order to show the influence** of the rounding off's to two sexagesimal parts we computed in the last column also the decimal value of the rounded off values.

To the **second** method we have in the first four columns the ten place decimal, four place sexagesimal and the two place rounded off values, parallel to al-Bîrûnî's data given. Again here a suddenly arising discrepancy 6.14.40 instead of 6.14.36. Not a very great discrepancy seemingly , but having its repercussions. The rounded value would have led to 70°. 47.7 , and the last columns, giving al-Bîrûnî's result shows 70°.47.13, about 8″ too great. In the line with the quantity $h = r - g$ we see the value 8.56.8 coming to 8.56.6 with al-Bîrûnî.

To the **third** method the table makes clear how al-Bîrûnî carried over the too great result 6.14.40 from the second method's computation, and also that instead of the more precise value 8.56.8 he gives his former value 8.56.6. In the fifth column till the third values from below everything is then correctly computed. , and then suddenly the suqare root is given as 27.8.41. What was caused by the transfer of the deviating values would have led to the final result of 70°.47.13 , as with the second method. The last three values in the most right column below the wrong square root 27.8.41 lead to the result then obtained 70°.49.14, a deviation of **more than two minutes.**

§ 6. *The tangens and cotangens with al-Bîrûnî*

A few remarks on al-Bîrûnî's results in the application of the tg and cotg. He computes the tangent of the qibla from

$$\text{tg } Q = 1538.17 \,/\, 8.56.6 = 60 \,.\, (25.38 \,.\, 17 \,/\, 8.56.6\,) =$$

$$= 172.1637754 = 60 \text{ times } 2.869396257\ ,$$

The third formula used (G. M indicating the latitudes of Ghazna and Mecca and the difference in longitude) reads – leaving out the unnecessary " detour " $\{ 1 - \sin \text{vers} (90^o - G + M) \} = \sin (G - M) -$

$$\{ \sin (G - M) - (1 - \cos t) \cos M . \sin G \}^2 + (\sin t . \cos M)^2$$

which is the same value as

$$\{ \cos t . \cos M . \sin G - \cos G . \sin M \}^2 + (\cos M)^2 - (\cos t . \cos M)^2 =$$

$$(\cos t . \cos M . \sin G)^2 + (\cos G . \sin M)^2 - 2 \cos t . \cos M . \sin M. \cos G . \sin G$$

$$+ (\cos M)^2 - (\cos t . \cos M)^2 =$$

$$= 1 - (\sin M . \sin G + \cos M . \cos G . \cot t)^2 = 1 - (\cos u)^2 = (\sin u)^2.$$

The second formula reads

$$[\{\cos (G - M) / \cos G - (1 - \cos t) \cos M \} \sin G - \sin M / \cos G]^2$$
$$+ (\sin t . \cos M)^2$$

which makes evident, that for complete equivalence one should have

$$[\cos (G - M) - (1 - \cos t) \cos M \cos G] \sin G - \sin M =$$

$$= [\sin (G - M) - (1 - \cos t) \cos M \sin G] \cos G.$$

Here the terms with $1 - \cos t$ cancel and there remains the evident

$$\cos (G - M) . \sin G - \sin (G - M) . \cos G = \sin M .$$

The three different formulas are by simple goniometric relations shown to be equivalent, and leading to the first $\cos u$. The only difference is the **degree of numerical difficulty** .

The first used relation can be derived by

$$\text{cotg } Q = \sin q / \text{tg } h = \sin (p - G) / \text{tg } t . \sin p =$$

$$= (\sin p . \cos G - \cos p . \sin G) / \text{tg } t \sin p$$

which is

$$(\cos G . \cos t - \text{cotg } p . \sin G . \cos t) / \sin t ,$$

and leads to

$$(\cos G . \cos t - \text{tg } M . \sin G) / \sin t ,$$

which is the relation used by D. A. King , as stated above . The degree of numerical difficulty in this way is 9.

He did not consider both, supplementary, values of h possible. Perhaps al-Bîrûnî knew that t acute requires h acute in an **orthogonal** triangle. Then

$$\cos p = \cos a \ / \cos h$$

gives p uniquely and thus $q = p - b$ is determined. Finally

$$\cos u = \cos h \cos q$$

provides the distance Ghazna - Mecca, and from that by the sine rule

$$\sin Q = \sin t \ . \cos \mathrm{M} \ / \sin u$$

yields the value of Q. This computational scheme has a degree of difficulty 17.

Using only uniquely determining relations – the computation of h is then not necessary – gives **less sources of errors**

$\mathrm{tg}\, p = \cos t.\ \mathrm{tg}\, a$ yields directly p, then $q = p - b$, and finally $\cos q \ . \cos a \ / \cos p = \cos u$. A scheme of degree of difficulty 12.

Next to this al-Bîrûni gives two other methods, only operating with sine functions and **at last** applies also tg and cotg relations. He obtained in this way from the **same data** five different final values :

$70^{\circ}48'\,15''$; $70^{\circ}\,47'\,13''$; $70^{\circ}\,49'\,16''$; $70^{\circ}\,47'\,9''$; $70^{\circ}\,47'\,11''$.

In fact $1''$ is in " time difference " one fifteenth of a second, 1 / 54000 of an hour. Again, a qibla for religious purposes has no need of a precision better than $10'$, Ptolemy's limit for measurement of angles, corresponding to 40 sec. of time.

The problem is **purely geographical,** and al-Bîrûnî gave first the systematical spherical trigonometrical solution. Then he derives two other relations, and refers to analoguous relations as " the triangle of time ", the "arc of daylight". . which do NOT mean that astronomy is involved by any phenomenon. The fact that al- Bîrûnî computed $\sin Q$ for the qibla from a rectangled triangle . . of which tg Q and cot Q could be obtained directly, without computation of the hypotenusa, by **one division**, makes it plausible that **at first** al - Bîr*ûni* wished to avoid the tangents and considers the last two functions more as a check for the tangens and cotangens function.

He leaves out the proof that these latter two formulas obtained are **equivalent** with the first one. We add here the simple proof for that!

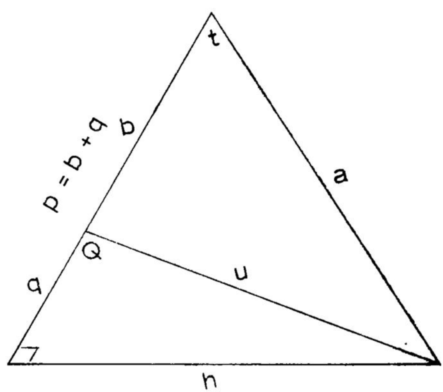
For further reference we compute the qibla of Ghazna, mention made of the fact that taking M as **exactly** $21^\circ\ 40'$ the decimal value of $= 23^\circ.470790951$ and the value for the difference in longitude of Mecca and Ghazna as $27^\circ\ 24'\ 22''$

$$
\begin{array}{lrlcccc}
G & = 33^\circ\ 35' & = 33.58333333 & & & & \\
t & = 27^\circ\ 22'\ 24'' & = \underline{27.37333333} & & & & \\
 & & 60.95666666 & + & \sin & + & 0.874252791 \\
 & & 6.21000000 & - & \sin & + & 0.108172866 \\
 & G & = 33.58333333 & & & & \\
 & & = \underline{23.40790950} & & & & \\
 & & 10.17542383 & - & \sin & + & 0.176662568 \\
 & & 56.99124283 & + & \sin & - & \underline{0.838587315} \\
 & & & & & & 0.320500910 \quad + \\
 & & & 2 \sin t & = & & \underline{0.919573054} \quad : \\
 & & & \cot Q & = & & 0.348532298 \\
 & & & Q & = & & 70^\circ.78490394 \quad = \\
(\sin Q = 0.944289689) & & & & & & 70^\circ 47' 5'' 39''' 15''''
\end{array}
$$

§ 4. *The qibla computations of al-Bîrûnî*

In a first and direct method al-Bîrûnî computes[8] (fig. 7)

$$\sin h = \sin a \ . \ \sin t$$



8. Jamil Ali, *Al- Bîrûnî's Tahdîd al-Amâkin*, Beirut, 1957; E. S. Kennedy .

There is, having at disposal Ptolemy's reduction in the *Almagest* I, 13 – 16 NO THEORETICAL PROBLEM in spherical trigonometry. The only problem which remains is TO OVERCOME NUMERICAL DIFFICULTIES in solving problems. THESE were leading to the " jungle of formulas" and still about 1900 AD- as can easily be shown checking results given in former textbooks, where problems to elucidate the situations are solved leading to errors of 5″ and more in results which were estimated as exact to the seconds. These difficulties were not mastered until the small electronic desk computers arose : no difficulty any more in multiplication, division, having logarithms or exponentials, sines . . at ten places exact. . . just by pushing a button. One must be still careful for the last digits: the rounding off at ten places might even affect the result of *a. b. c.* when calculated by *a. c. b.* For the difficult tangens function one can obtain different first and last numbers in $a \to \text{tg}\, a \to \text{arc tg}\, a$.

Remains to remark that even the sailors, having to compute their first " course " used – a ready for logarithmic computation formula – :

$$\text{cotg}\, C = \text{tg}\, b_2 \,.\, \cos b_1 \, \text{cosec}\, L - \sin b_1 \,.\, \text{cotg}\, L$$

where b_1 and b_2 are the latitudes of the place of depart and the destination and L is the difference in longitude. This asks to look for five values of logarithms (adding and subtracting are not counted !) – three multiplications for non- logarithmic schemes coming to these – and two antilogarithms to have the value of cotg C, which being found from a table of cotg gives numerical difficulty 8, and if one works via logcotg a numerical difficulty 9.

If one substitutes cosec $L = 1/\sin L$, cotg $L = \cos L/\sin L$ one comes to take the denominator sin L and the formula for the supplement of the course, the QIBLA , becomes taking $b_1 = G$, $b_2 = M$ and $L = t$,

$$\text{cotg}\, Q = (\sin G.\, \cos t - \text{tg}\, M \cos G\,)\, /\, \sin t\,.$$

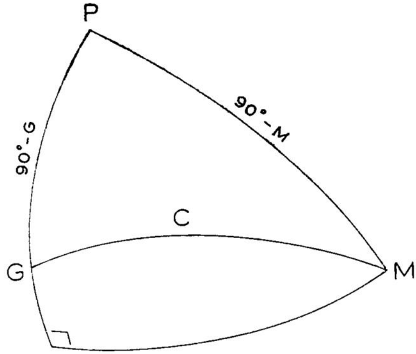
This is the same formula as used by D. A. King, loc, cit. in the *Encyclopaedia of Islam.* We have here a numerical difficulty 9, as above. Observing that the latitude of Mecca is a " world constant " one can reduce the numerical difficulty by introducing an angle ω such that

$$\text{tg}\, M = \sin \omega\,.$$

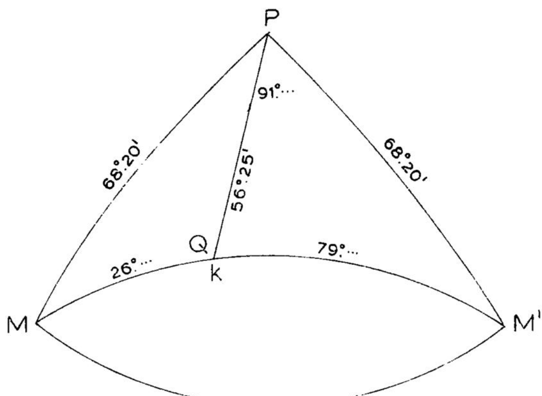
The reduction to

$$\text{cotg}\, Q = \sin (G + t) + \sin (G - t) + \sin (G - \omega) - \sin (G + \omega)\, /\, 2 \sin t$$

is then possible and makes the degree of numerical difficulty 7 .



i. e. the place at distance c_1 to the west of Ghazna's meridian or the place at distance c_2 to the east, and at the same latitude of Mecca, 21° 40′. NOTHING of the former checking of " possible or inadmissible " results remains in this way[7]. (fig. 6.).



7. Q in fig. 6 is the supplement of the qibla of Ghazna. The " paradoxal result " is caused by the fact that a place can be reached on the sphere travelling a distance $a°$ forwards or $306°-a°$ backwards. Taking the qibla of Ghazna $180°-Q$ for M one reaches M after having travelled a distance of 26° . . , and M' at distance 280° . . , i. e. travelling backwards with qibla Q over 79° . . . The **conventions** on spherical triangles eliminate a negative angle or side, as well as an angle or side greater than 180°. The traveller shall reject to go more than half of a great circle of the earth for his destination. This last is, however, an extra condition, which does not follow from the definiton of the qibla. The choice is then be made by the acceptance of the difference in longitude!

and substitute (6) into (7) . Then reducing by a factor $\sin a \neq 0$ is possible and we arrive at

$$\sin a \, . \sin b = \sin c \, . \cos \beta + \sin b \, . \cos a \, . \cos \gamma \, .$$

Applying the sine rule and interchanging, a, b and α , β leads to

$$\sin \alpha \, . \cos b = \sin \gamma \, . \cos \beta + \sin \beta \, . \cos \gamma \, . \cos a \qquad (8)$$

$$\sin \beta \, . \cos a = \sin \gamma \, . \cos \alpha + \sin \alpha \, . \sin \gamma \, . \cos b \qquad (9)$$

and substituting (8) into (9), a division by $\sin \gamma \neq 0$ is possible and leads to

$$\sin \beta \, . \sin \gamma \, . \cos a - \cos \beta \, . \cos \gamma = \cos \alpha \, .$$

§ 3. *Numerical considerations*

The cases I, I′ , II , II′ are solved by the cosine rules : three sides lead directly to the cosines of the three angles; two sides and an angle, to a third side, and mutatis mutandis two angles and one side to a third angle in the cases II , II′ . . . and thus reduce all problems to I , I′ . In fact there remained three types. . and the sets III , III′ are , using the sine rule equivalent to two sets of the type (a , b , α , β) .

In the last period of spherical trigonometry this case was solved by considering many possibilities, having used a sine rule. All these troubles can be avoided by solving one goniometric equation for the third side , or the third angle! As this remark is not to be found in many of the formerly used text-books; we give an example. It reduces the problem of the sailor who wished to determine his destination from the course given at the harbour of depart for an other. . . which is the reverse of the problem of the qibla! . . . In order to treat case III we ask for the possible positions of Mecca, latitude 21° 40′ if the qibla is (decimally) 70°. 78490394 and the latitude of Ghazna is 33° 35′. We have (fig. 5)

$$\sin M = \sin G \, . \cos c - \cos G \, . \sin c \, . \cos Q, \text{ or}$$

$$0.369206147 = 0.553149239 \cos c - 0.274180233 \sin c$$

$$\mathrm{tg}\varphi = 0.553149239 \,/\, 0.274180223 = 2.017465859 = \mathrm{tg}\ 63^\circ, 63370345$$

$$\sin(\varphi - c) = 0.369206147 \,/\, (0.553149239^2 + 0.274180223^2)^{1/2} =$$

$$= 0.598028115 = \sin 36^\circ.72880193 = \sin 143^\circ.27119807$$

and thus

$$c_1 = 26^\circ.90490152 \quad , \quad c_2 = -79^\circ.63749455$$

a. A plane perpendicular to OC at C makes the angle γ visible , according to Euclid's definition 6 in Book XII. Then we have by plane geometry

$$AB^2 = OA^2 + OB^2 - 2\,OA\,.\,OB\,.\cos c = AC^2 + BC^2 - 2\,AC\,.\,BC\,.\cos\gamma,$$

and replacing in Euclid II, 12, 13 the " rectangles to be added or subtracted" using the cosine for the projection we apply the theorem of Pythagoras to

$$OC^2 + AC\,.\,BC\,.\cos\gamma = OA\,.\,OB\,.\cos c$$

yielding $\cos c = \cos a\,.\cos b + \sin a\,.\sin b\,.\cos\gamma\,.$

b. If one makes visible the **three** angles, again using Euclids definition 6, Book XII one **has** to take a point inside all **dihedral** angles given, P, and to fall the perpendiculars on the sides of the trihedral, say $O.\,ABC$. Then it is evident that the sides of the trihedral $P.\,A'\,B'\,C'$ are the supplements of the angles of $O.\,ABC$, and the angles are the supplements of the sides of $O.\,ABC$. The " polar trihedral " is a mere **evidence.** The Arabs caused[6] themselves great troubles in working ON the sphere and not using ONLY the last two points *a, b*. The reducing of one type of the cosine rules to the other consists in merely changing the signs of the cos, and keeping the sines with the same sign.

For sake of completeness we add that from **one set** of cosine rules – just as in plane trigonometry – **all other relations follow merely algebraically.** After having seen what was obtained in the section a.. there is no need to consider the " polar trihedral ", nor polar triangles .

A. $\cos a = \cos b\,.\cos c + \sin b\,.\sin c\,.\cos\gamma$, thus

$$(\sin a\,.\sin b\,.\cos\gamma)^2 = (\sin a\,.\sin b)^2 - (\cos a - \cos b\,.\cos c)^2 = S^2\,.$$

Here $S^2 = 1 - (\cos a)^2 - (\cos b)^2 - (\cos c)^2 + 2\cos a\,.\cos b.\cos\,.\,c,$

and this is **invariant** under permutation of a , b , c . Thus, as in the square root we have to take always the positive sign, as all sines are positive :

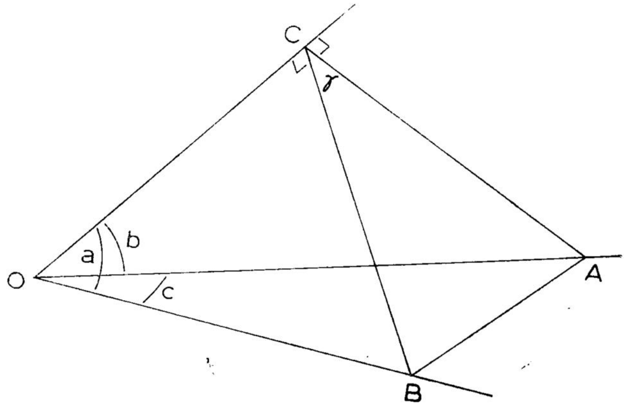
$\sin\alpha\,/\sin a = \sin\beta\,/\sin b = \sin\gamma\,/\sin c$; *SINE - rule.*

B. We take two out of the three cosine rules

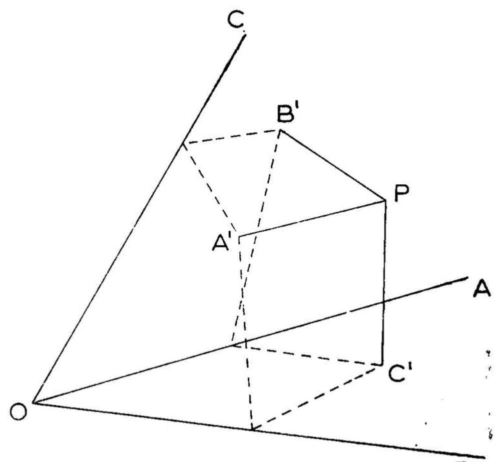
$$\cos a = \cos b\,.\cos c\,. + \sin b\,.\sin c\,.\cos\alpha \qquad (6)$$

$$\cos b = \cos c\,.\cos a + \sin c\,.\sin a\,.\cos\beta \qquad (7)$$

6. vide N. G. Khayretdinova, Ist. mat. issl. , 28, 154 – 159 .



(a)



(b)

$$c = p + q$$

or eventually a difference. Then

$$\cos a \,/\, \cos p = \cos h = \cos b \,/\, \cos q \,,$$

and immediately follows

$$\cos a\,(\cos c \cdot \cos p - \sin c \,.\, \sin p) = \cos b \cdot \cos p \,,$$

an equation for p leading to

$$\cos b - \cos a \,.\, \cos c = \cos a \,.\, \sin c \,.\, \mathrm{tg}\, p.$$

Here the right hand side is equal to $\sin a \,.\, \sin c \,.\, \cos \beta$, and we arrive at the three cosine rules of the first type

$$\cos b = \cos a \,.\, \cos c + \sin a \,.\, \sin c \,.\, \cos \beta \,.$$

It is not necessary to compute the value of h!

I′ . The angle is decomposed by the altitude from C into two parts, P. Q leading to

$$= P + Q$$

whereas $\cos \alpha = \sin P \,.\, \cos h$, $\cos \beta = \sin Q \,.\, \cos h$, or

$$\cos \beta \sin P = \cos \alpha\,(\cos \gamma \,.\, \cos P - \sin \gamma \,.\, \sin P)$$

$$\cos \beta + \cos \alpha \,.\, \cos \gamma = \cos\alpha \,.\, \cos\gamma \,.\, \mathrm{cotg}\, P = \sin\alpha \,.\, \sin\gamma \,.\, \cos b$$

leading to the three cosine rules of the second type

$$\cos \beta = -\cos \alpha \,.\, \cos \gamma + \sin \alpha \,.\, \sin \gamma \,.\, \cos \mathrm{b} \,.$$

We followed exactly the rules as applied also in Arabic Science. The Arabs systematically first consider the problem on the sphere, which caused them many difficulties. Though the systems I and I' automatically lead to the two types of cosine rules a **strict** " euclidean solid geometry " in the trihedral leads **directly** to one of the types of cosine rules AND to the so called " polar triangle " which allows to reduce the second type cosine rule from the first, and vice versa. We give the few lines necessary for that here explicitely (fig. 4) .

3. (a , β) $\operatorname{tg} c = \operatorname{tg} a \,/\, \cos \beta$; $\operatorname{tg} b = \sin a \,.\, \operatorname{tg} \beta$: $\cos \alpha = \sin \beta \,.\, \cos a$

4. (c , α) $\operatorname{cotg} \beta = \cos c \,.\, \operatorname{tg} \alpha$; $\operatorname{tg} b = \cos \alpha \,.\, \operatorname{tg} c$; $\operatorname{tg} a = \cos\beta \,.\, \operatorname{tg} c$

5. (α , β) $\cos c = \operatorname{cotg}\alpha \,.\, \operatorname{cotg}\beta$; $\cos a = \cos\alpha \,/\, \sin\beta \,.\, \cos b = \cos\beta \,/\, \sin\alpha$

whereas (a , α) leads to $\sin a = \sin c \sin \alpha$ .There is none, one or a pair of solutions corresponding to the condition $\sin a \leqslant \sin \alpha$. The datum $\sin a = \sin\alpha$ leads to $c = 90^{\circ}$.

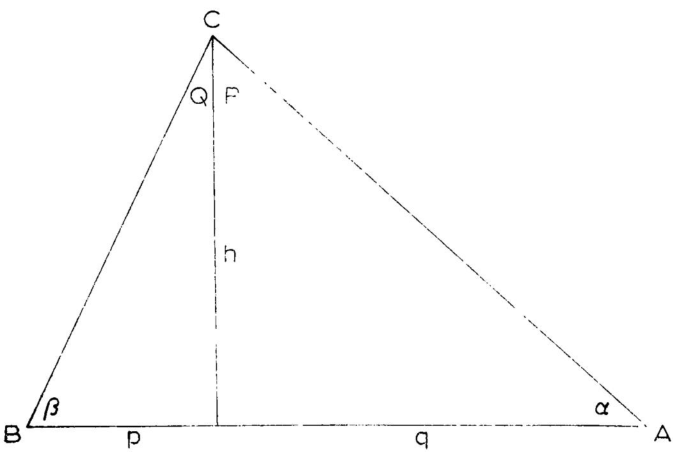
If now we go over to general triangles we have the " example " of plane geometry – known from the Old Babylonian Period – that any triangle can be decomposed into two orthogonal ones.

The " very many different cases " for three data on a spherical triangle are **not** different from one of the six cases :

I (a , b , c)	I′ $(\alpha , \beta , \gamma)$
II (a , b , γ)	II′ (α , β , c)
III (a , b , α)	III′ (α , β , a)

The **simplest** cases are I and I′ :

I. If the side c is decomposed by the altitude from C into two segments p , q we have (fig. 3)



No side, neither an angle, of a general spherical triangle needs to be greater than 180° in problems. If so the problem to be solved can be treated using " an adjacent triangle ". The Greeks, just as in plane geometry, did not allow angles greater than 180°. If an angle would turn out " greater than 180° " in modern terminology the " gauge " was observed and the angle was measured at the other side of one of the legs .

A direct consideration of the *orthogonal* triangle shows, and we have as sin b is positive that tg α and tg a have the same sign, and thus that a side and its opposite angle are either both acute or both obtuse. We don't know of a statement of this fact before " modern times " .

Not knowing negative numbers one can go over to " positive values only " taking the **halves** of angles and sides . This led in later times to a " jungle of relations between halves and quarters of angles and sides " . The relations, present in the *Almagest* for the following first two relations, from which the third follows immediately :

$$\sin (a \pm b) = \sin a . \cos b \pm \cos a . \sin b$$

$$\cos (a \pm b) = \cos a . \cos b \mp \sin a . \sin b$$

$$\mathrm{tg} (a \pm b) = (\mathrm{tg}\, a \pm \mathrm{tg}\, b) / (1 \mp \mathrm{tg}\, a . \mathrm{tg}\, b)$$

can be checked easily in Manitius, 1962,[5] vol I, 10. I, pages 28,29. They allow also values $a + b$ exceeding 180° to be reduced to angles smaller than 90°, in the goniometric computations.

Finally we have - see Manitius , I. 10. II. page 30 -

$$2 (\sin \tfrac{1}{2} a)^2 = 1 - \cos a .$$

These last sets of relations do refute S.H. Nasr's statements, quoted § 1, sub *d*.

The sine value being given one has always two angles , smaller than 180°, for any positive value. This makes the **arc sine to be avoided** as much as possible. On the other hand cos a (and tg a) determine an angle **uniquely** in the given interval, and thus in numerical work one has to prefer the cosine (and the tangens) . Except for the combination (a , α) , and its analogue we have for all combinations of two elements for an orthogonal triangle a **unique** solution. We specify:

1. (a , b) $\cos c = \cos a . \cos b$; $\mathrm{tg}\, \alpha = \mathrm{tg}\, a / \sin b$; $\mathrm{tg}\, \beta = \mathrm{tg}\, b / \sin a$

2. (a , c) $\cos b = \cos c / \cos a$; $\cos \beta = \mathrm{tg}\, a / \mathrm{tg}\, c$; $\mathrm{tg}\, \alpha = \mathrm{tg}\, a / \sin b$

5. K. Manitius, *Ptolemäus, Handbuch der Astronomy*, I, II, Leipzig, 1963.

which using the tangens function is

$$\cos \alpha = \operatorname{tg} b \;/\; \operatorname{tg} c \tag{3}$$

and here applying (2) reducing by (1)

$$\cos \alpha = \sin \beta \;.\; \cos a \tag{3'}$$

Finally $PQC \;/\; RAB$ gives $PB \,.\, QR \,.\, CA = PR \,.\, QA \,.\, CB$ or

$$\cos a \;.\; \sin \alpha \;.\; \sin b = \cos \alpha \;.\; \sin a$$

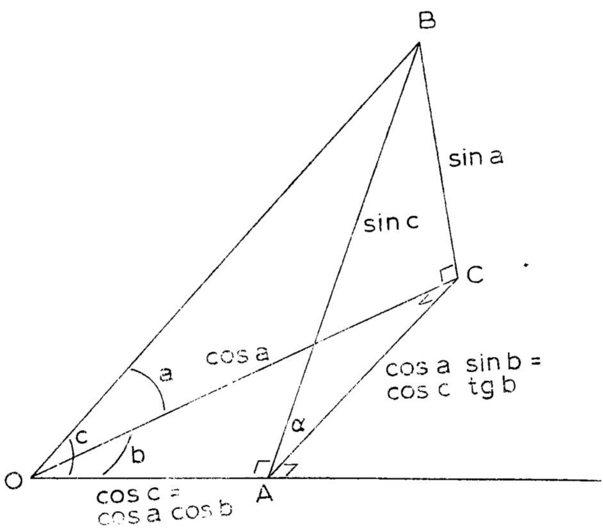
and with the tangent function

$$\operatorname{tg} \alpha = \operatorname{tg} a \;/\; \sin b \tag{4}$$

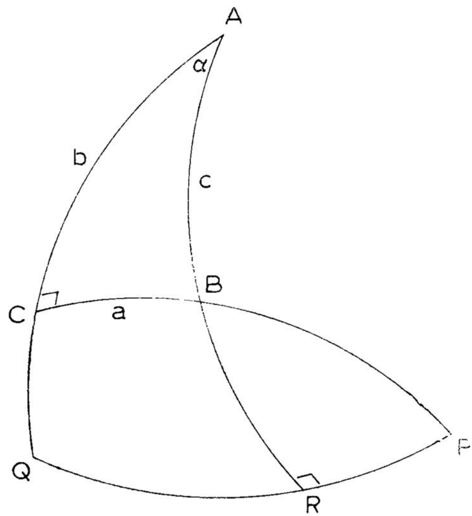
Immediately follows from (4)

$$\operatorname{cotg} \alpha \;.\; \operatorname{cotg} \beta = \cos a \;.\; \cos b = \cos c \tag{5}$$

In this way we have all relations for the **orthogonal** triangle, which all can be read **immediately** from the orthogonal trihedral angle, (fig. 2), as a mere **evidence** .



the six segments as a ratio of two being equal to the product of two other ratios. This is equivalent with the equality of the products of three segments to the product of three other segments : (fig. 1).



If the triangle ABC has the points on the transversal P (on BC), Q (on CA), R (on AB) we indicate this by ABC/RPQ. We have then just to permute P, Q, R cyclically to obtain the uniquely possible equality.

$$AR \,.\, BP \,.\, CQ = AQ \,.\, BR \,.\, CP$$

or $$1 \,.\, \cos a \,.\, \cos b = 1 \,.\, \cos c \,.\, 1,$$

as here $PC = PQ = AR = AQ$ are 90°, and for the orthogonal triangle we have demonstrated the " spherical pythagoras "

$$\cos c = \cos a \,.\, \cos b \qquad (1)$$

Again

$PRB \,/\, QAC$ leads to $PC \,.\, RQ \,.\, BA = PQ \,.\, RA \,.\, BC$ or

$$\sin \alpha \,.\, \sin c = \sin a \qquad (2)$$

Then

$ARQ \,/\, BPC$ yields $AC \,.\, RB \,.\, QP = AB \,.\, RP \,.\, QC$ or

$$\cos b \,.\, \cos c = \sin c \,.\, \cos \alpha \,.\, \cos b$$

The computational technique with " Muslim Scientists " is in no way different from that of Ptolemy, even carrying on the " sinus totus " as we already mentioned. . . removing that in the same way as Ptolemy did.

The **aim** of the present essay is to show this and by that to come to the **reason** for the sudden disappearance of " trigonometry " . The accuracy of the tables, available up till very recently, was not allowing great accuracies, using only one basis- relation. The simple relation can, however, be used **directly** due to the great accuracy of the small electronic desk computers. We shall discuss in detail al-Bîrûnî's methods for the qibla of Ghazna, and elucidate the difficulties he met with. ONLY the organising of computational schemes in such a way that with the available tables the error was not too much increased led to the " jungle of formulas in plane and spherical trigonometry " .

2. *Ptolemy's trigonometries*

In Book I, 10,11 of the *Almagest* Ptolemy describes a **method** for composing a table of lenghts of chords, and gives such a table, corresponding to 120sin $\frac{1}{2}x$ for $0^{\circ} < x \leqslant 180^{\circ}$; at an interval of $\frac{1}{2}^{\circ}$, which is $15'$ for the half of the central angle.

In I, 13,1 he first proves the " Theorem of Menelaos ", the relation between six segments on the sides and the productions of the sides, intersected by a transversal of a triangle, in **plane** geometry. In I, 13,2 he shows, using a trihedral angle at the centre of a sphere, that the same relations hold true if one substitutes for " lengths" the " chords ", i. e. sine functions. He distinguishes neatly between two cases of the triangle with respect to the transversal :

A. the transversal meets only two of the sides,

B. the transversal meets all sides on the productions.

In I. 14 and I,16 he immediately applies this for the relations between declination δ , rectascension a , longitude λ and inclination of the ecliptic ε (leaving out factors 60 here) .

$\sin\delta = \sin\varepsilon \,.\, \sin\lambda$; $\cos\varepsilon \,.\, \sin\lambda \,.\, \cos a = \sin a \,.\, \cos\lambda$, which last relation is the same as

$$\cos\varepsilon = \mathrm{tg}\ a \,/\, \mathrm{tg}\ \lambda$$

The scheme of the four lines of a triangle and one transversal can be considered in **four** ways as such a scheme. Ptolemy writes the relation between ting the integral part into a sexagesimal " rest ", when dividing by the " sinus totus". We shall illustrate that in particular below.

Ptolemy had **all the tools**, and **all the numerical material** available and near at hand, used it in **exactly the same** way as later mathematicians, e. g. in the Arab World. He **sticked** to the use of the sine function **only**, and chord $x = 120 \sin \frac{1}{2} x$. Ptolemy mostly had the vertex of an angle **on** the circle and thus he used – in fact – chord $= 2R \sin x$, when x is the angle at the perimeter, corresponding to $\frac{1}{2}x$ measured in the " angle at the centre ".

Ptolemy not only developed the " by priests and philosophers " prescribed system of epicycles in a unique way- having celestial bodies moving of perfect curves, circles, with the most beautiful motion, at uniform speed, but in his *Almagest*, Book X, 6, states that one can *also* subtract the anomaly for the outer planets from the sun's longitude in stead of adding it to a centre of an epicycle where there is nothing. This corresponds to an interchange of deferent and epicycle for the outer planets and yields exactly *Tycho Brahés* system : all planets in perfect circles around the sun and that system as a whole in circles about the earth, which is placed excentrically.

ad c. Here we have to refute Neugebauer's statement on the tangens function. The trouble with the " table of tg *a* " is – *and this was felt*! – that linear interpolation is not possible, preserving the wished accuracy in a considerable part of the interval 0° – 90° .

In 1896 L. Schröne in his 7 – place tables saw no other possibility than to give special formulas for the computation of " logtga " in the interval 0° – 3° , and for the interval 3° – 10° taking the interval at 10 seconds corrected. In order to guarantee 5 places exact the Dutch " Wiskundige tafels in 5 decimalen " – about 1960 AD – departed from that system , and gave values for cotg a increasing a by one second in the interval 0° – 3° , and increasing by ten seconds in the interval 3° – 10° , and by one minute onwards. If one computes, as Ptolemy easily could have done, a table of quotients. . leading to a table of tg *a* at an interval of 15′ then *a* very great part of the table **does not permit linear interpolation.** Below we shall indicate that al-Bîrûni was aware of this fact, and computed from $\operatorname{cotg} Q = A / B$ first $\sin Q$ in order to **safely** interpolate.

Rightly Ptolemy sticked to the relation of the " six segments" which gave in sine functions **all relations needed,** as we shall show below. It was, indeed, very prudent to use the values of " only one table of sines" , and **not** to compose a table of tg *a*, from that.

First we quote some authors on the subject of *Islamic Science.*

a. A. I. Sabra wrote in the *Encyclopaedia of Islam* :

" The mathematics needed for solving problems in spherical astronomy even for the simple geocentric system without circles and epicycles is a laborious business, and it is difficult for the modern mind to understand how a scientist such as Ptolemy could have constructed and analysed such an elaborate system without the benefit of place number numerals, decimals or a fully developed trigonometry (not to mention logarithms and other techniques). Place number arithmetic entered the Muslim world from Indis in the ninth century and came into general use in Islam in the tenth. "[2]

b. D. E. Pingree, in the same *Encyclopaedia* stated :

" The Muslims basing their work on Indian ideas also developed trigonometry – plane and spherical – into something approximating its modern form "[3] .

c. O. Neugebauer, at various occasions, emphasised that the Greeks had not the tangesn function, which was used in the *Islamic Period*, and that this absence must have caused drawbacks for the Greeks.[4]

d. S. H. Nasr, quoting here his *Islamic Science*, published for the World of Islam Festival, London, 1976 – page 184, gives :

" Although Greek mathematicians, especially Hipparchus, had calculated a table of chords, trigonometry - both plane and solid and based on the relation of the sides and angles of a right triangle - was invented by Muslims. "

Some remarks must be made to these statements.

ad a. Ptolemy had at his disposal the sexagesimal fraction, used for the fractional positional part – not a decimal system ! – and the place value symbols 0 – 59 , including the zero , were represented in tenbundles – the normal Greek numbers, – writing the integral part in the same ten bundles. A. I. Sabra – e. g. *The World of Islam* , London 1976 , page 185 – speaking about a " mixed system " in which a non place value decimal (sic !) system was used for the integers and a place value sexagesimal (positional) for the fractions, " missed the point completely . On the contrary: Ptolemy's system is purely sexagesimal positional for the fractional part. . . and **is in no way** different from what " Islam Scientists " used in goniometrical computations. In any positional system with basis A we need A symbols to specify the place values . . . and for these one used the " numerals " of the tenbundles .

Also, with Islamic Scientists Ptolemy's $R = 60$ was continuously carried on – and dividing is just a shift of the sexagesimal , eventually split-

2. A. I. Sabra, Enc. Isl. 3, 1138 – 1141.
3. D. Pingree, Enc. Isl. 3. 1135 – 1138 .
4. O. Neugebauer, e. g. *The exact Sciences in Antiquity*, Providence, 1957[2], 209 : " The only real inconvenience lies in the lack of tables for the ratios corresponding to tan α." This is, decidedly, numerically incorrect.

Ptolemaic and Islamic Trigonometry, The Problem of the Qibla

EVERT M. BRUINS*

1. *Introduction*

About 2000 BC in Mesopotamia the problem of the chords in a circle was attacked, and - as we know from the Susa texts[1], Tablet III, and the related drawings on the tablets I, II - the sides of the regular n – gon with n = 2, 3, 4, 5, 6, 7, 10, 12, 24 were computed. For the square, in particular, the sexagesimal value of the diagonal 1.24.51.10. . . – decimally 1. 414212963 ..., a difference with the more precise value 1.41421356 ... of 6×10^{-7} – was obtained. This value is the same as that given by Ptolemy 84; 51.10 if the radius is 60, just – still as in Arabic mathematics – writing the integral part in tenbundles. Though in later times tables of chords were computed, – according to tradition by Hipparchos – only the table of chords in Ptolemy's *Almagest*, giving the lengths of chords in a circle with radius 60, subtending an arc of x^{0} seen from the centre of the circle, up to two sexagesimal fractional parts, is preserved from the " Greek Period ". The table has **not** been computed as Ptolemy **says** he did, because following the indication for the 30 – th parts of the increase in the lengths of subsequent chords, in his table with an interval of $\frac{1}{2}^{0}$, would lead to results with an **even** last sexagesimal – (as a / 30 = 2a / 60, a being the **integer** of the difference) – and it turns out that one half of the results per " sixtieth degree" does end **odd**. Again his tentative trisection of the arc of $1\frac{1}{2}^{0}$ is theoretically exact, but numerically using too great values for the bounds not leading to the right result. The exact value of chord 1^{0} is lying **outside** the interval, correctly computing the bounds indicated by Ptolemy. The rounded off value, at two sexagesimals, is correct. . . but **cannot** be used to compute the table itself. It would have been easy to derive – from the isosceles trapezium relation – a cubic equation for the trisection !

About 2000 AD trigonometry, plane as well as spherical, has been removed from mathematical instruction! What did happen ?

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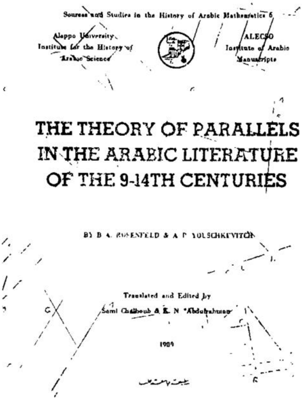
1. E. M. Bruins and M. Rutten, *Textes mathématiques de Suse*, Paris, 1961.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THE THEORY OF PARALLELS
IN THE ARABIC LITERATURE
OF THE 9-14TH CENTURIES

BY B. A. ROSENFELD & A. P. YOUSCHKEVITCH

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66 2/3 miles or even the Syrian 75 miles per degree which seems to have been used by al-Idrīsī,[25] the difference as compared to 14°S in al - Khorezmi is dramatic and Suhrāb, whose texts (as indicated above) do not contain mile measurement which otherwise might allow a comparison with or verification of al-Battānī's figures. Al-Idrīsī, on the other hand, cites distances in cubits, miles and *farsakhs* (unit equalling 3 miles) but has no corresponding figures in degrees. Although citing Ptolemy for his description of the seas, he quotes no dimensions for the whole of the Indian Ocean (the length of the Red Sea is estimated by him at 1,400 miles) .[26]

While this limited evidence is inconclusive, it would be difficult to dismiss al-Battānī's figures altogether: the numbers, however round and therefore easily suspect, are carefully written in words and thus cannot be explained away by corruption of the digits. Although the dimensions as found tend to contradict al-Battānī himself as discussed in (9), it is important to admit that Greek-Arabic geography may have allowed for a more realistic conceptualization of the Indian Ocean, however imperfectly measured and visualized cartographically.

(11) To limit the discussion of Ptolemy's influence on Arab geographers to three early works may seem to constrict the pool of data unnecessarily. However, the sources we have chosen represent not only the most complete and faithful exposition of Ptolemy's information in Arabic, but also are among the most carefully edited and extensively examined pieces in all of medieval Arabic geographic writing. Not only the later Muslim authors but also those of medieval Europe, especially in the case of Al-Battānī,[27] drew on the tables and descriptions they had provided. Under the name *Kitāb rasm al - rub^c al - ma^{c}mūr* (" Design of the Inhabited Quarter ") al-Khorezmi's *Kitāb ṣurat al-arḍ* (" Geography ", or " Image of the Earth ") is quoted in the 14th century by Abu 'l - Fidā' who also cites al-Khorezmi's coordinates anonymously.[28] However, by that time the toponyms known to the Arabs in East Africa are no longer those transcribed or translated from Ptolemy. The coordinates, when provided, are attached to new and different names; the continuity is broken. The cartographic tradition, although forever inclined to imitate old authorities, undergoes a dramatic transformation at the hands of al-Idrīsī and it is he who is imitated from then on by descriptive geographers. Although in the wider context of Islamic geography new translations of Ptolemy are made in the late 15th century, these are occasioned by the new Turkish access to Greek manuscripts and bypass the medieval Arabic tradition.

25. Al-Idrīsī, *Opus geographicum sive " Liber ad forum delectationem qui terras peragrare studeant "*, *fasc.* 1 (Naples - Rome, 1970), p. 8.
26. Ibid. , p. 10 .
27. Krachkovskii, pp. 100 – 101 .
28. Ibid. , p. 93

of an Africa distorted eastward did exist. In fact, the case would be more doubtful if the Arabic text did not base itself on a map: in the awkward phrasing of al-Khorezmi it is easy to loose track of the correct noun, and then one might read the above as a description of the sea, rather than the coast, reaching to 112° E. There are two considerations against this possibility. First, the reiteration of 14° latitude at both " ends " of the coastline suggests that *a line* was indeed drawn on the map being described between the cited meridians. Second, later works belonging to the al-Idrīsī school of geography- such as the authoritative Ibn Saᶜīd al-Maghribī - return to the use of coordinates which, when superimposed on the African coast, seem to reconfirm Ptolemaic notions at a time when Arab navigation to East Africa flourished. True, Ibn Saᶜīd who wrote in the latter part of the 13th century, no longer includes the Greek toponyms, but he willingly, recognizes his theoretical source in Ptolemy.

(9) The very different narrative of al-Battānī focusing on the seas and the equator, rather than continents or the coastline, also suggests a system where the Asian landmass north of the equator is symmetrically faced across the sea by another landmass south of the equator, and that this landmass is Africa :

...وذكروا ان خط الاستواء من الأرض يقطع من المشرق إلى المغرب فيما بين الهند والحبش ...[22]

" It is claimed that the equator crosses east to west the space between India and Ethiopia... "

Al - Battānī gives the Indian Ocean an elongated contour, citing a length west to east of 8,000 miles and a width of 2,700 miles.

(10) Nevertheless, al-Battānī also includes statements which imply a much greater southward extent of the Indian Ocean than either Ptolemy or other Greek-Arabic geographers indicate:

... وقدروا بحر الهند وقالوا ان ... يجاوز من جزيرة استواء الليل والنهار إلى ناحية الجنوب الفا وتسعمائة ميل ...[23]

" They have measured Baḥr al-Hind and stated that it. . . stretches beyond the island where night equals day (i. e., beyond the equator) in the direction of the south for one thousand and nine hundred miles. . . "

If measured in degrees at the so-called al-Ma'mun equivalent of $1^{\circ} = 56\ 2/3$ miles,[24] this would allow a southward depth of the ocean to the latitude approximating 34°. Even if other equivalents are used (Ptolemy's

22. Kubbel' and Matveev, p. 296 .
23. Ibid.
24. Krachkovskii, p. 84 .

ning with al-Istakhri's (early fourth / tenth century) were not of the Greek school. From al-Khorezmi, Greek-Arabic cartography takes a leap to al-Idrīsī (mid - twelfth century) whose most detailed maps show the African mainland extended east, with the Indian Ocean open to the Surrounding Ocean (*al-Muḥīt*) to the extent of its full " width " from north to south. If, therefore, the European historians of science were to look toward Arabic sources for confirmation of the " open-sea thesis ", it may be adequately substantiated with narrative and illustrative Islamic data, both Ptolemaic and originating elsewhere .

(8) The cartographic reconstruction of the East African coastline, attempted before,[19] is difficult and involves a great deal of guesswork. However, the eastward curve of the littoral may be guessed at from al-Khorezmi's narrative. To repeat, the text represents a description of a map bearing placenames and the markings for degrees and minutes of longitude and latitude.

... حد ... يمر إلى اسفل مدينة رافاطا عند طول سو o والعرض زل خلف
الاستوى ويمر إلى طول سح o والعرض يج o وهذه العروض التي نذكرها
هي خلف خط الاستوى إلى ان تجوره فنذكر ذلك يمر إلى طول عب o والعرض
يد o يمر إلى طول قيب o والعرض يد o ..[20]

The coastline . . . passes below the city of Rāfāṭā at 66° 00′ longitude and 7° 30′ latitude beyond the equator, reaching to the longitude of 68° 00′ and the latitude of 13° 00′. The latitudes we refer to are beyond (i. e. south of) the equator, and if (the coastline) recrosses (the equator) we shall point that out. (The coastline then proceeds) to the longitude of 72° 00′ and the latitude of 14° 00′ and reaches the longitude of 112° 00′ and latitude of 14° 00′ . . . "

Suhrāb's text is nearly identical, differing only in slight omissions and the variation in coordinates from 00′ to 05′ as discussed above. Characteristically, nothing is described and no locations are listed for the longitudes between 72° and 112°. Thus the mainland's location so far east is implied rather than stated or substantiated.

It has been argued that Ptolemy did not make it his business to describe *unknown* places and therefore, whatever his ideas of continental contours, he was unlikely to create a visual representation of a southern *Terra Incognita*[21]. The Arabic versions seem to suggest that a Ptolemaic representation

19. By both Honigman and Mžik, 1916. See also Gabriel Ferrand, *Relations de voyages et textes géographiques arabes, persans et turks relatifs à l'Extrème- Orient du XIII - e au XVIII - e siècles*, vol. II (Paris, 1916), pp. 590 – 595.
20. Mžik, 1926, p. 75 .
21. Washburn, pp. 3 – 4 .

(6) There are no maps of East Africa by the three authors. The sole existing manuscript of Al-Khorezmi contains four maps of which only one refers to Africa (the Nile) ; there is no world map. The precise nature of the map which the texts of al - Khorezmi and Suhrāb seem to be describing has not been established, nor its exact provenance. The theoretical discussion of the seas, continents and measurements found in Ptolemy is missing in both. The close paraphrasing of al- Khorezmi by Suhrāb suggests a possibility that his book merely repeats al-Khorezmi's description of the lost map rather than describes another map similar or identical to the former.

As distinct from these two authors, al-Battānī does include a description of the earth and particularly the seas. Although also organized as *zīj*, this work follows *Geography's* structure somewhat more faithfully, incorporating Ptolemy's system of listing the 94 inhabited areas in Bk. VIII which is missing in al-Khorezmi and Suhrāb. The text of the geographical introduction does not suggest that a related map ever existed but offers systematic comments on the location and size of the seas, division of the continents, and possibilities of navigation .

(7) In the history of European cartography a controversy arose over whether Ptolemy in fact mapped the east coast of Africa as reaching far to the east opposite Asia, as late medieval maps show, and whether he conceived of the Indian Ocean as an open or closed sea. The text and tables of *Geography* do not answer these questions. On the one hand, Ptolemy's description of Ethiopia limits the extent of Barbaria to the east by the Bay of Arabia, the Red Sea and the Barbaricus Sea (IV,7). On the other hand, the land mass of Ethiopia bounded by the Great Bay of the Outer Sea is also said to be " terminated. . . by the unknown land toward the west and the south " (IV , 8).

The controversy over the closed contour of the Indian Ocean does not apply to Arab geography since neither texts nor maps currently in existence, of whatever school of thought in Islamic scholarship, ever suggested that the waters of the Indian Ocean did not communicate with the mass of the ocean. Furthermore, the suggestion that printing and color confusion may have played a role in the proliferation of European maps of the " closed - sea " pattern[17] has no bearing on Arab cartography, as the Arab medieval tradition preceded the revival of Ptolemy in Europe; the earliest extant world maps, which are first to show the Indian Ocean, or *Baḥr al-Hind*[18] begin-

17. Wilcomb E. Washburn, " A proposed explanation of the Closed Indian Ocean on some Ptolemaic Maps of the Twelfth - Fifteenth Centuries, " *Revista da Universidade de Coimbra*, vol. XXXIII, (1985), esp. pp. 435 – 437 .

18. *Encyclopaedia of Islam* (2nd ed.), s.v. " Baḥr al- Hind, " by D. M. Dunlop and " Djughrafiya", by S. Maqbul Ahmad.

17° 05′ يز ه in Suhrāb's table.[16] Since Suhrāb's text mentions the integer 17° يز with no reference to minutes, it may be suggested that here, again, no intended correction of data took place but rather that a mistake occurred in the process of transmitting astronomical data through alphabetic notation. The special culprit here is the " cipher, " easily confused in its medieval full-round form with the letter *ha* ه (= 5) in its unattached or final scripted form. There are no locations listed with the latitude or longitude of 0° , so confusion between the " cipher " and whole - degree coordinates is much less likely to occur and in fact, has not been observed (the tens and hundreds up to and including one thousand all require a single character) .

The above also confirms that al - Battānī and Suhrāb were editing, copying or otherwise revising Ptolemaic data from the Arabic, rather than the Greek or Syriac, since the nature of digital corruption is tied so closely to the particular script used. There is no reason to challenge the accepted view that al-Khorezmi's *Ṣurat al- arḍ* served as the source to both the authors. Moreover , the mistakes in the minute component of the coordinates were unlikely to originate in the process of translation from the Greek since Ptolemy's tables do not mark 00′ on the one hand, and on the other hand frequently use fraction designations inapplicable to the Arabic version : ½° for 30′, ¼° for 15′ and ½° + ¼° for 45′ .

(5) The sequencing of toponyms in the text and tables plays an important role in controlling the precision of transmission. The regional divisions of Africa adhered to by Ptolemy were known to his Arab editors but, as was indicated earlier, their texts seem to follow a map rather than a systematic narrative. Their tables also differ in content organization, both from Ptolemy and among each other. The most significant distinction is in the sequencing of the placenames in the tables by clime, the unit first used by Eratosthenes; it is not used by Ptolemy in the existing version of *Geography*. In this system, locations in the First Clime are generally listed beginning from the south, in the order of increasing longitude; the latitudes for the most part, but not consistently, increase as well. The lists pertaining to the Second Clime restart in the west and south and proceed toward east and north, and so on. Since al - Khorezmi's, the earliest Arabic , version offers a fully integrated and competent handling of the clime system in all three formats - texts, tables, and maps, and since the early European Ptolemaic maps retain it as well, it may be assumed that a version of Ptolemy's *Geography* incorporating the clime grid had existed prior to the ninth century and was available to early Arab scholars.

16. Mžik, 1926, p. 9; Kubbel' and Matveev , p. 302 .

with characters marked with diacritical dots underneath, and it seems legitimate to see in al-Khorezmi's published figure another instance of scribal corruption of the digit.

The discussion here is limited to the relevant group of toponyms but further examples of similar nature may be found among both Ptolemaic and non - Ptolemaic data, whether relating to Africa or elsewhere. The point is that what seems to be a mathematical discrepancy may in fact be no more than scribal error; even if the extant manuscript copies from which published editions were prepared are carefully written and appear legible with confidence,[15] the mistake may have occurred at an intermediate stage. This should be considered an important factor in the evaluation and interpretation of geographic and astronomic data, especially those derived from the same original source or, in E. S. Kennedy's words , " families of sources ". Most importantly, this is a factor operating indiscriminately in the records of latitude as well as longitude. Therefore our awareness of it should serve to temper the willingness to explain away mistakes in longitude by divorcing the numerical content from the system of notation .

(4) It will have been noticed above that the minute component of the coordinates is subject to variation and corruption no less frequently than the degree numbers. There is, however, one pattern of variation which occurs in the minute component at the rate suggesting a special vulnerability. Three types of numbers of involved: no minutes (i. e. , 00′) , tens of minutes and fractions ending in 5. Again, this discussion needs to be divorced from the modern Arabic - numeral notation and focused on sexagecimal Arabic characters. The " no minutes " notation, absent in Ptolemy, uses the Indian zero while the tens are all transcribed with a single character; therefore the mistake, if such is the cause of variation, might involve graphic confusion between the " cipher " and six numerical characters sufficient for expressing the above group of fractions.

For the most part these are easily distinguishable even in handwriting. Reviewing our selected examples, however, it will be noticed that the variation even within this limited pool of numbers is not between the " no minutes " and " tens of minutes " components but rather from " no minutes " to " n + 5 minutes " and from " tens of minutes " to " n + 5 minutes " (or vice versa) . Compare 20′ / 45′ ك / مه for Qanānā, 00′ / 05′ o / ه for Rāfātā among the Ptolemy derived data and 00′ / 15′ / 30′ o / يه / ل for Dunqula from the non - Ptolemaic. The apparently Greek-derived Ptolemaic city of Tiyas (?) on the Red Sea has a latitude varying from 17° يز in al - Khorezmi to

15. This writer was unable to inspect manuscript versions of the texts under discussion here.

it becomes possible to treat the disagreement between al-Khorezmi's and al-Battānī's longitude for al-Ṭīb / Aromata as a graphic mistake confusing the sources that were originally coherent with each other and with Ptolemy.

(3) Once the intrusion of the " prime meridian factor " into Greek-Arabic coordinates is eliminated, or at least suspended for sources under discussion, it becomes possible to view in the same light the disparate degrees of latitude cited for identical locations.

To offer an example of the origination of digit confusion, the letters *jīm* ج and *ḥa* ح have the same body and are distinguished only by the presence or absence of a dot ; in the sexagecimal system confusing the two means variation from 3 to 8 . Occasions have been recorded when *jīm* was scripted without a dot and moreover, with its tail left off to prevent its confusion with *ḥa*.[14] This, however, could open further possibilities of confusing the truncated, dotless *jīm* with other characters - and apparently did.

An instance of inconsistent latitude citations concerns Qanānā : al-Khorezmi gives 2° 45′ , Suhrāb's table 3° 45′ and Suhrāb's text 2° 20′ (Ptolemy's Opone is at 4° 15′) . It may be observed that the first and second measurements differ by the magnitude of 1° , the first and third differ in minutes, and the second and third in both the degree and minute components. Both the letters *ba* ب for 2 and *jīm* for 3 are normally scripted with a diacritical dot underneath, and may be corrupted or confused if carelessly written. It is more difficult to explain in graphic terms the transformation of 45′ into 20′ (*mīm – ha / kāf* ك / مه) but it may be observed that, although separately , both the degree and minute components of all - Khorezmi's figure reappear in Suhrāb. Therefore the difference among the coordinates as cited may not be regarded as an intended correction but rather a corruption.

Support for this conclusion may be found again if we cast the net wider among non - Ptolemaic toponyms related to Eastern Africa. The capital of Nubia Dunqula has the following listings of latitude : 2° (*ba*) in al-Khorezmi, 14° 15′ (*yā - dāl yā - hā* يه يد) in al-Battānī, 14° 05′ (*ya - dāl hā* ه يد) in Surhrāb's text, 14° 30′ (*yā-dāl lām* ل يد) in Suhrāb's table. Since al - Khorezmi's and Suhrāb's coordinates for Aswān coincide completely (55° 30′ longitude, 22° 30′ latitude), the discrepancies again do not seem intended . The latitude of 2° N is inconsistent not only with the other authors' but also with al - Khorezmi's own data for other locations as well as the place of Dunqula in the sequence of listed toponyms (generally moving north from the equator). Both numbers are commonly transcribed

14. Rida A. K. Irani, " A Sexagecimal Multiplication Table in the Arabic Alphabetical System, " *Studies in the Islamic Exact Sciences* (Beirut, 1983), pp. 511 – 512 .

(2) It has long been observed that the greatest discrepancies among the Arabic coordinates, whether Ptolemaic in origin or not, occur in the longitudes. The discrepancies usually noted are of two kinds: one reflects the random variation in magnitude explained as mistakes occasioned by the difficulty of establishing the longitude in pre-modern times; the other originates in the differenc of 10° built into the practice of placing the prime meridian at the Canary Islands versus the western-most point of Africa. Mistakes also occur in latitude data but are usually less disparate.[11]

As Table 1 shows, in our case variations occur both in longitude and in latitude. Taking the longitude first, as the Arabs did after Ptolemy, it may appear that al-Battānī follows the prime meridian chosen by Ptolemy while al-Khorezmi's prime meridian differs from both by close to 10°; the latter manner is also seemingly adopted by Suhrāb. However, in a wider context it turns out that al-Khorezmi and al-Battānī do not diverge consistently. In fact, *Kush al - dākhila* (Ethiopia Interior) has the identical 50° longitude in both the sources. Another example from Eastern Africa (not found in Ptolemy) is *Dunqula* (Dongola), the capital of Nubia. While al - Khorezmi gives 53° longitude, al-Battānī cites 93°.[12] Similarly, for Āswān; also not in Ptolemy, the longitude is 55° 30′ and 95°, respectively.[13] Clearly, a mistake of 40° by the author or even translator is doubtful. In surveying the sources it became apparent that in each case the discrepancy seemed significant due to positional mathematical value of the disparate decimal components; an explanation was then sought in the numerical notation used in Arabic sources.

The Islamic system for marking the numbers originating in sexagecimal computation, such as the 360° of the circle, uses Arabic characters assigned numerical value in an antiquated order which made transcribing Greek alphanumeric data both easy and convenient. However, a carelessly scripted character could be misread and incorrectly copied by another scribe; considering the graphic specificity of Arabic characters, the resulting mistake in this system could range from 1 to 59. The important point to keep in mind is that such a mistake would have nothing to do with (mis) calculation or fundamental differences in method: its origin would lie in the confusion of handwritten character contours. Once such a possibility is accepted,

11. For a concise summary of variation patterns in astronomic coordinates see Mary H. Regier, "Kennedy's Geographical Tables of Medieval Islam : An Exploratory Statistical Analysis," *From Deferent to Equant : a Volume of Studies in the History of Science in the Ancient and Medieval Near East in Honor of E. S. Kennedy* (New York: New York Academy of Sciences, 1987), pp. 357 - 372.
12. Mžik, 1926, p. 4 ; Kubbel' and Matveev, p. 297.
13. Mžik, 1926, p. 108 ; Kubbel' and Matveev, p. 297.

The boundary of the Green Sea. . . passes under a city at 69° 30′ longitude and 6° 10′ latitude. Then it curves like a pot near (the place) below the city of al-Ṭīb and adjoins (the place) under the city of Qanānā at 72° 30′ longitude and 2° 20′ latitude . It passes under the city of Rāfāṭā at 66° 00′ longitude and 7° 30′ latitude beyond the equator . . . "

Although the seeming graphic approximation might excuse the inconsistency in the coordinates, the problem deserves further attention. To begin with, the coordinates contained in the quotation above, as well as the much longer text of nearly uniform nature from which it is excerpted, are very closely followed in Suhrāb's version. In fact, despite the distancing effect that time, editing a new version, and copying may have had on the original data, the narrative parts of al-Khorezmi's and Suhrāb's works are closer to each other than the text data of al - Khorezmi to his own tables. This kind of discrepancy has not been noted in the literature and, since it obviously does not originate in Ptolemy, requires an explanation which will take into account the nature of Arabic geographic works. It would be desirable to inquire as well into the transmission process, examining the transfer of data via different languages and numerical systems; unfortunately however, although we are fully aware that many Arabic - Greek texts were translated via Syriac or Hebrew, such intermediary versions are not extant.[9] The following comments therefore treat the data as if they were. indeed, a straightforward translation from Ptolemy; the coordinates are compared within the source, among the sources of the selected group, and between these sources and Ptolemy. The value of the coordinates, the manner and format of their presentation, and the implications of these for Greek - Arabic geographical theory and cartography as well as manuscript - derived numerical data are elaborated in the following discussion.

(1) Regarding the differences between the coordinates cited by Ptolemy and those allegedly derived from him found in Arabic sources, the prevailing explanation considers Arabic data improvements or corrections resulting from the newer independent observations and calculations made by Arab geographers and astronomers. This theory, however, does not hold for the above examples, since in the ninth century the Arabs did not have independently - obtained measurements for the old Greek toponyms in the region;[10] their post-Islamic acquaintance with the East African coast must have early revealed that names like Rhapta no longer existed there, and a new inventory of place-names began to be compiled, making Ptolemy's lists irrelevant.

9. At least two versions, in Syriac only, are hypothesized for Ptolemy. Krachkovskii, pp. 81, 86 .

10. On the early degree measurements and updating Ptolemy see Krachkovskii, pp. 82 – 88. On early Arab contact with East Africa see, e. g. , George Fadlo Hourani, *Arab Seafaring in the Indian Ocean in Ancient and Early Medieval Times* (Princeton . University Press, 1951) .

Following Ptolemy, the Arab translators of *Georgraphy* list longitude first and latitude second. Al - Khorezmi's text seems to describe a map, with the sequence of coordinates following the topography of the coast; the general direction of the narrative is toward the east and south. The tables follow the clime division south to north and west to east. The system is repeated in Suhrāb's work cited above. Al-Battānī's reworking of Ptolemy, descended from a different translation, contains a condensed introduction and tables of selected locations listed by the region rather than according to precise coor - dinates, although the west to east sequence is roughly approximated. Only one of Ptolemy's East African toponyms is retained here.[7] The combined list of named locations with their coordinates from Ptolemy and the three Arabic sources is offered in Table 1.

TABLE 1

	Aromata / Ṭīb		Opone / Qanānā		Rhapta / Rāfāṭā	
Ptolemy	83°	6°N	81°	4°15′N	71°	7°S
al- Khorezmi/table	72°	4°30′N	72°30′	2°45′N	65°	8°S
al- Khorezmi/text	69°30′	6°10′N	72°30′	2°20′N	66°	7°30′S
al-Battānī	82°	4°30′N				
Suhrāb/table			73°30′	3°45′N		
Suhrāb/text	69°30′	6°10′N	72°30′	2°20′N	65°05′	7°30′S

Certain questions arise in regard to these figures. First of all, unlike Ptolemy, the Arabic data cited by the same author in tables and in the text may not always coincide. The examined texts do not contain discussion of itineraries or distance measurements in other units which might be compared against the degrees. The nature of the narrative, which describes what appears on the map rather than unequivocally citing location coordinates, allows for some discrepancy between the table listings and data extrapolated from the text. For instance, *Kitāb ṣurat al- ārḍ* offers slight variations in the coordinates of all three named East African locations, while the literal reading of the text does not claim mathematical precision :

... حد بحر الاخدر ... يمر بأسفل مدينة عند طول سط والعرض و ى ويمر
على صورة القوارة بقرب أسفل مدينة الطيب ومماس لاسفل مدينة قنانا عند
طول عب ل والعرض ب ك ... ويمر إلى أسفل مدينة رافاطا عند طول سه o
والعرض ز ل خلف الاستوى ...[8]

7. Suhrāb's work was originally published in 1930 by Mžik, Al - Battānī's *zīj* by Nallino in 1904. Both are cited here in the edition by L. E. Kubbel' and V. V. Matveev, *Arabskie istochniki VII – X vekov* (Moscow- Leningrad, 1960), pp. 301, and 296 – 297 respectively .

8. Mžik, 1926, p. 75 .

least two other systems in the early centuries of Islam, becomes dominant in later sources even where no other Greek influence is noticeable. Sixth, if early on Ptolemy's impact is clearest in, and almost limited to, the works of mathematical geography, his major concepts concerning the continents and the surrounding sea, the seven climes, and the configuration of Africa penetrate the genre of descriptive geography, dictionaries and encyclopedias . Seventh, within the widely accepted cartographic and conceptual framework, the proportion of descriptive and coordinate data traceable directly to Ptolemy falls drastically from the very high in the ninth - tenth century works of the " Greek school " to very low already by about the middle of the eleventh.

* * *

The region of East Africa was known to the Greeks, as to the Arabs , only in its coastal part . Sailing from Aromata promontory one came to Azania, traveling with the south wind as far as Rhapta and Prasum. At 83° longitude and 6° latitude N, Aromata emporium lies only 2° west of Opone, firmly identified as Ras Hafun on the Horn of Africa; Rhapta, " metropolis of Barbaria ", is placed by Ptolemy at 71° longitude and 7° latitude S. The farthest African location east and south is the island of Menuthias at 85° longitude and 12° 30′ latitude S .[5]

Of all these and other less significant and mostly unidentified locations in *Geography*, for which almost twenty sets of coordinates are provided, al-Khorezmi retains five, restructuring his table not to follow the outline of the coast as in Ptolemy but to begin with the southernmost part beyond the first clime. Thus, *Rāfāṭā* (Arabic for Rhapta) comes first, and al-*Ṭīb* (Ar. for Aromata) follows in the section on the first clime. Two out of five coastal cities are designated merely as *madīna ᶜala 'l - baḥr* " town by the sea, "[6] with no transcription of the Greek toponym presumably listed in the original. Although coordinates are given, due to their significant and generally inconsistent disagreement with those of Ptolemy, no identification is possible on their basis. The fifth remaining toponym which it is possible to place on the eastern, rather than northern, coast of the Horn, is *Qanānā*. In the discussion below *Qanānā* is held to be identical with Opone.

5. Consult C. F. A. Nobbe, *Claudii Ptolemaei Geographia* (reprint Hildersheim, 1966), Bk. I, 9. 14. 17 and Bk. IV, 7 and 8. The English translation by E. L. Stevenson (New York, 1932) was used here. For identification attempts see Hans von Mžik. " Afrika nach der arabischen Bearbeitung der Γεωγραφικὴ ὑφήγησις des Claudius Ptolemaeus von Muhammad ibn Musa al Hwarizmi, " *We iner Zeitschrift für die Kunde des Morgenlandes*, No. 34 (1916) and Bernhard Struck, " Rhapta, Prasum, Menuthias, " *Zeitschrift der Geschichte für Erdkunde zu Berlin*, 1921, No. 517, pp. 188 – 196 .
6. See Hans von Mžik, *Das Kitab Surat al Ard des Abu Ga'far Muhammad ibn Musa al - Huwarizmi* (Leipzig, 1926), pp. 3 – 6 .

lar attention especially in view of the still unresolved cartographic convention which extends the African mainland south of the equator all the way east to form the southern shore of the Indian Ocean. The fact that Arab geographers of the Islamic era followed this convention while drawing on Ptolemy has allowed to regard Arabic geographic sources as carrying on Ptolemy's tradition during the centuries when his work was lost to Europe. Thus, the maps credited to Ptolemy which reappear in the West in the 15th century seem to agree with, and be confirmed by, medieval Arabic texts and maps.

A few preliminary observations are in order regarding the extent of Ptolemaic influence on Arab authors in general and in regard to East Africa in particular. First, a brief comment on the coordinates of latitude and longitude. To the extent that Ptolemy is regarded as the earliest geographer to apply them systematically,[2] all Muslim geographers who employ such coordinates may be considered as having experienced, and accepted, his method to some degree. It may be worth nothing that such authors represent a numerical minority in the field of Islamic geography, however significant their output . Second, the use of the coordinates by some authors does not guarantee the acceptance of Ptolemy's figures or even of his method of computing the coordinates; this especially concerns the longitude. The nature of discrepancies and some of the reasons causing them are discussed below. Third, there are authors acknowledging their debt to Ptolemy who not only do not use the degree coordinates but transform his cartographic projection while filling the map and text with contemporary data . Fourth, no " pure " Ptolemy can be found in Arabic texts. Even the works regarded as translations of *Geography* , such as al-Khorezmī's *Kitāb ṣurat al-arḍ* and Suhrāb's *Kitāb ^{c}adja'ib al-aqālīm al- sab^{c}a* do not contain a complete Arabic version of the Greek text or tables, as well as differ from the book structurally.[3] In addition, already in the ninth century al-Khorezmī is thought to have corrected and augmented Ptolemy's data with new information being then obtained through scholarly efforts sponsored by the early Abbasids. Fifth, the Greek latitudinal system of the division of habitable earth into seven zones (" climes " , Ar. *iqlīm*) is introduced into Arab geography with al - Khorezmī's reworking of Ptolemy[4] and, despite the parallel existence of at

2 – G. J. Toomer, "Ptolemy," *Dictionary of Scientific Biography*, vol. XI (New York : Charles Scribner's Sons, 1975), p. 198 .

3 – See discussion in Ernst Honigmann, *Die sieben Klimata und die* πόλεις ἐπίσημοι (Heidelberg, 1929), esp. pp. 120–125, 133, 155. *Krachkovskii.* esp. pp. 79–82, 94 and C. A. Nallino, " Al-Huwarizmi e il suo rifacimento della geografia di Tolomeo, " *Raccolta di scritti editi e inediti*, vol. V (Rome, 1944), 458 – 532 .

4. On *iqlīm* in Arab geography see *Encyclopaedia of Islam* (2 nd ed.) s. v. , by André Miquel, and *Honigmann.* Al-Khorezmi's manner of placing the *iqlīm* boundaries is unique : Krachkovskii, p. 95 .

Ptolemy's East Africa in Early Medieval Arab Geography

M. A. Tolmacheva*

The well- recognized debt of Arab geography to Claudius Ptolemy made a profound impression on the development of Arabic geographic science which goes far beyond mere translations of his *Geography*. From as early as the ninth century and as late as the 15th century most Arabic authors writing in the genres of descriptive and mathematical geography echoed Ptolemy as a source for systematic description of the habitable earth. The major areas in which Ptolemaic influence made an impact on Islamic scholars include(1) geographic data: description of continents and seas, and the coordinates of settlements and of topographic features,(2) geographic theory, and(3) cartography. (Ptolemaic mathematics and astronomy are not discussed here).

This paper is a re-examination of the nature and extent of the Greek influence on Arab geography traditionally ascribed to Ptolemy, limited to those early medieval Arabic works which demonstrate a recognized familiarity with Ptolemy on all three levels. These include the writings of the famous early mathematician, astronomer and geographer Muhammad ibn Musa al-Khorezmī (d. c. 232 / 846 — 847) and his less well known editor Suhrāb (the first half of the tenth century A. D.) as well as the *Kitāb al-zīj al-Ṣabi'* by the great astronomer al-Battānī (d. 317 / 929) . Their data will be explored below with a view toward certain special considerations regarding the historical geography of East Africa. In addition, some questions of general methodology of interpreting data derived from manuscript Arabic sources will be considered.

Although the general extent of Arab geographical borrowing from Ptolemy has been well explored,[1] the case of East Africa deserves particu-

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1 – See, for example, I. Iu. Krachkovskii, *Izbrannye sochineniia*, vol. 4 : *Arabskaia geograficheskaia literatura* (Moscow Leningrad, 1957), ch. III (consult also the Arabic translation by S. A. D. ᶜUthman Hashim, Cairo, 1963) , J. H. Kramers, " La littérature géographique classique des musulmans, " in J. H. Kramers, *Analecta Orientalia*, vol. I (Leiden: Brill, 1954) , pp. 172 – 204 and *Encyclopaedia of Islam* (2 nd ed.) , s. v. " Kharita, " by S. Maqbul Ahmad.

at the observatories of Delhi and Jaipur, and travelled to distant lands at the command of the raja. They took part in just about every facet of Jai Singh's astronomical endeavor. Dayānata Khān was his most favored and honored *nujūmī*, and perhaps played an important role in his overall program. He remained associated with the raja for more than 20 years .

As the involvement of the Muslim astronomers slackened, the participation by the Europeans increased, indicating the raja's growing appreciation of the contemporary astronomy of Europe.

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APPENDIX

The Arabic and Persian books at the Sawai Man Singh II Museum, Jaipur

1. *Jamiᶜ-i Shāhī*, Persian, (astrology) No. 2 (AG).
2. *Zīj-i Sulṭānī* of Ulugh Beg with commentary by Mullāh Chānd , Persian , (acquired 1725), No. 6 (AG) .
3. *Zīj-i Sulṭānī* of Ulugh Beg with commentary by ᶜAli al-Birjāndī, Persian, No. 5 (AG).
4. *Zīj-i Sulṭānī* of Ulugh Beg, Persian, (acquired 1727), No. 11 (AG).
5. *Zīj-i Khāqānī* of Ghiyāth al-Dīn al-Kāshī, Persian, (acquired 1728), No. 9 (AG) .
6. *Zīj-i Shāhjahānī* by Farīd al-Dīn Masᶜūd ibn Ibrāhīm al-Dihlawī, Persian, No. 12 (AG) .
7. . . . . , . . , second copy, (acquired 1725), No. 14 (AG) .
8. *Al- Tafhīm li-awā'il ṣināᶜat al-tanjīm* by Abu'l-Rayḥān al-Bīrunī. Persian, (acquired 1725), No. 7 (AG) .
9. *Almagest*, Arabic, (acquired 1725), two copies, Nos. 19 and 20 (AG) .
10. *Kitāb al-Manāẓir* of Ibn al-Haytham as contained in *Tanqīḥ al-Manāẓir* by Kamāl al-Dīn al-Fārisī, Arabic, No. 17,1 (AG) .
11. The Arabic treatise on the rainbow and lunar halo by Ibn al-Haytham, No. 17,2 (AG) .
12. *Lawā'iḥ as qamar* by Ḥusayn ibn ᶜAlī al-Bayhaqī al-Kāshifī, Persian, (astrology, acquired 1725), No. 91 (AG) .
13. *Al- Mulakhkhaṣ fi'l-hay'a* by Maḥmūd ibn ᶜUmar al-Jaghamīnī, with commentary by Qāḍīzāda al- Rūmī, Arabic, (acquired 1725), No. 18 (AG) .
14. *Sharḥ Tadhkira* by Nizāmu'd- dīn al-Nīshāpurī, Arabic, (acquired 1725), No. 21 (AG) .
15. . . . . , second copy, No. 22 (AG) .
16. *Sharḥ Shamshīya-Ḥisāb* of al-Birjandī with commentary, Nizāmu'd-dīn al-Nīshāpurī, Arabic, (acquired 1725), No. 10 (AG).
17. *Risālāh- hai'at al-Kursī* (?), Arabic, (acquired 1725). No. 90 (AG) .

The *Gazeta de Lisboa* goes on to add that the delegation had come to resolve questions regarding the astronomical tables used in Portugal and in India, and to acquire knowledge about the old and the new instruments of astronomical observation. The delegation stayed on in Portugal for a few months and finally returned to India in 1730 with instruments, books and astronomical tables including the one by de la Hire published in 1702.

Observers to Distant Islands

Jai Singh believed that observations must be taken from different locations on the globe. According to Jagannātha Samrāṭ the king's command was: " In every country, in the east, the south, the west and the north, everywhere observations are to be made. "[45] Accordingly, Muḥammad Sharīf was sent by the raja to *Firanga* country.[46] After having stayed there, he went to the island of " Mahaila" and determined its latitude to be 4°;12′ South.[47] In this southern country, where the pole was seen to have an altitude, he observed the shapes of the constellations there, drew them on paper and brought back the depictions. He also observed the longitude, latitude and noon colatitude of the places of his visit.[48]

In *Dastura Kaumvara*, there is no mention of any " Sharīf " receiving a gift from the raja. However, there are several entries of gifts given away as cash and in kind to one " Sheikh Muḥammad Shafī." It is possible that Shafī and Sharīf are one and the same person. The scribes of medieval India were not always careful with names. Different scribes entered the same name differently depending on how it sounded to them. Besides, the possibility of error in copying from one record to the another always exists. If this is the case, then Sheikh Muḥammad Shafī (Sharīf) left on his overseas journey shortly after 1729.

Conclusion

Jai Singh's interest in Islamic astronomy, and the participation of the Muslim astronomers in his program began sometime in the mid 1710s or even earlier. It reached a peak around 1725, and then tapered off until the death of the raja in 1743. The astronomers searched out astronomical bkoos, constructed instruments, helped with the translations, collected data

45. *Samrāṭ Siddhānta* of Jagannātha Samrāṭ, p. 1165, printed, Delhi, 1967.
46. The word *Firanga* does not necessarily mean " Europe." In the present context, it should be interpreted as " the land overseas under the control of Europeans. "
47. The latitude measurements indicate some island in the Seychelles archipelago in the Indian ocean. Pingree in reference 2 has tried to identify Mahaila with the island of Mahe. However, the island was named much later, sometime in 1742 – 43 by a French explorer after the Christian name of the Fench governor of Mauritius at the time.
48. Ref. 45 .

ignore his " chief assistant " and the "author" of an important work such as the *Zīj-i Muḥammad Shāhī*. The only reference that this author has been able to trace about Khairu'llāh, in the contemporary literature, is one by Brindāban. Writing about him and Jai Singh, in his *Safīnā-i Khushago*, Brindāban remarks that Jai Singh spent two million rupees in the course of 20 years on his astronomical pursuits, and that this was done with the advice of Khairu'llāh.[38] The statement of Brindāban has been, perhaps, too liberally interpreted than it really deserves . The author believes that Khairu'llāh played some role in the beginning perhaps, by urging the raja to undertake the ambitious task of revising astronomical tables. He might also have acted as an occasional advisor to the raja. It is doubtful, however, that he was ever involved in the program of Jai Singh to the same extent as Dayānata Khān was.

Delegation to Europe

In 1727 Jai Singh dispatched a scientific delegation to Europe.[39] In the preface to the *Zīj-i Muḥammad Shāhī* he says:

> "After seven years had been spent in this effort (observing the stars), information was received that observatories had been built in Europe, . . . , and that the business of observatory was still being carried on there. "[40]

The delegation, first of its kind from the East, left Amber in 1727, paid a courtsey visit to the Portuguese Viceroy at Goa, delivered presents to him, and then finally reached Portugal in January of 1729.[41] The delegation was led by Father Figuerado, the rector of the college of Agra. The *Gazeta De Lisboa Occidental*, in its issue of March 10, reports:

> " Around the end of the month His Majesty gave private audience to Father Manuel de Figuerrado of the Society of Jesus. . . , (he) turned over to the king the letters and the gift from the king of Amber, Sawai Jai Singh . . . He also brought along with him Pedro Ji, a Catholic and a Mogol by birth; Sheikh Ji, a Mohammeden. "[42]

The full name of the "Sheikh Ji," mentioned above, it appears, was Sheikh Asadu'llāh Nujūmī.[43] According to *Dastura Kaumvara*, the Sheikh was given a variety of gifts in 1726, a few months before the delegation left for Europe.[44]

38. Brindāban, ref. 25 .
39. Sharma, ref . 3.
40. Ref. 1.
41. *Gazeta de Lisboa Occidental*, p. 24, Jan. 20, 1729 .
42. Ibid. , p. 80, March 10, 1729 .
43. Ref. 9.
44. Ibid.

not have sought assistance of anybody else. The Muslim astronomers must have also contributed to the preparation of the Devanagari version of the *Zīj-i Muḥammad Shāhī*.[30,31]

Judging by the gifts in the *Dastura Kaumvara*, it appears that the involvement of the Muslim astronomers in Jai Singh's program, began sometime in mid 1710's, reached a peak a decade later and then tapered off sometime before his death in 1743.[32]

It is interesting to note that as the number of gifts to the Muslim *nujūmīs* decreased, the gifts to the Europeans- *firangīs* - increased, reaching a similar peak in 1735.[33] The Europeans began to participate more actively in the program of the raja after 1727, and they performed essentially the same tasks as the Muslims did except that they were not involved in data-taking at the observatories.[34] The replacement of the Muslim astronomers by Europeans indicates the raja's growing appreciation of the contemporary astronomy of Europe.[35]

Abu'l Khair alias Khairu'llāh

Khairu'llāh has been called the chief assistant of the raja,[36] and the author of the *Zīj-i Muḥammad Shāhī*.[37] However, doubts are cast on the claims made on behalf of Khairu'llāh, when one does not find any gifts or honors given to him in *Dastura Kaumvara*. It is inconceivable that the raja, generous as he was in bestowing honors on his scholars, would totally

30. There was at least one copy of the *Zīj*-i *Muḥammad Shāhī* prepared in Devanagari. The copy is listed in the inventory of the raja's personal library, taken in 1743, the year of his death Refer Tozi bundles, Pothikhana, Jaipur Rajya, Rajasthan State Archives, Bikaner.
31. The other Sanskrit translations acquired by Jai Singh are:
    1 – *Zīj* - i *Nityānandī Shāhjahānī*, probably based on the *Zīj-i Shāhjahānī* of Ibrāhīm al-Dihlavi, (acquired 1727), No. 23 AG.
    2 – *Zīj*-i *Ulughbeg*, (tables only), (acquired in 1729 from Surat), No. 45 AG.
32. There are no gifts listed in the DK for the years 1732– 1734, 1736 – 37, and 1739 – 1743, Ref. 4.
33. Ref. 4, DK, Vol. 18 and 20. See under *kaum Musalamān* and *kaum Firangī*. Also see Tozi Bundles of *Daftar Nuskha Punya*, Rajasthan State Archives, Bikaner.
34. Sharma, Ref. 3.
35. Andrew Strobl, a Bavarian Jesuit, who was one of the European astronomers employed by Jai Singh, substantiates this. In a letter written to Europe, he comments that the raja wanted Europeans for each and every one of his observatories. See Stocklein J. , *Neuve Weltbott*, No. 644, p. 15, Augsburg and Gratz, 1728.
36. For instance see Khan Ghori S. A., " The Impact of Modern European Astronomy on Raja Jai Singh, " *Indian J. Hist. Sci.* , p. 53 , vol. 15, 1980 .
37. Storey C. A. , *Persian Literature*, vol. 2, part 1, p. 95, London, 1958. Also see Nadavi, Sayyid Sulaiman, " Muslim Observatories, " *Islamic Culture*, Vol. 20 , p. 281. 1946. Khairu'llāh appears to have written a commentary on *Zīj* - i *Muḥammad Shāhī*. Refer Rahman A. et al, *Science and Technology in Medieval India- A Bibliography of Source Materials in Sanskrit, Arabic and Persian*, p. 285, New Delhi, 1982 .

copied from the existing texts. Asadu'llāh provided a copy of *Jāmi^c-i Shāhi*, a work on astrology.[21] Mullāh Imāmu'ddīn Nujūmī was responsible for preparing a copy of *Zij-i Sulṭānī* of Ulugh Beg, and according to *Dastura Kaumvara*, was awarded a sum of Rs. 100 in 1725.[22] And then again in 1726, he received a sum of Rs. 200, presumably for his labors on the manu-script.[23] The manuscript was admitted to the library in 1727.[24] Imāmu'ddīn, according to Brindāban, was a highly respected scholar of mathematics. He resided in Delhi and died in 1733.[25]

Translations into Sanskrit

Although Jai Singh solicited assistance from astronomers of all faiths, Hindus remained the mainstay of his program, and they carried out their work in Sanskrit. Primarily, for the benefit of these scholars , Jai Singh had a number of works translated into Sanskrit. Nayan sukhopādhyāya translated *Tadhkira* of Naṣīr al-Dīn al-Ṭusī with al- Birjandī's sharḥ. The translation was done with the assistance of Muḥammad Ābid, and was completed in 1729.[26] Nayanasukhopādhyāya translated three other books as well, namely: *Ūkargranthaḥ* based on some Arabic copy of *Spherics* of Theodosius; *Hayatagranthaḥ*, based on a Persian work *Hai'at*; and *Yantrarājrisālā bisa bāba* from Naṣīr al-dīn Ṭusī's *Risālā Bīsa bāba.*[27] A fourth book-*Sarvadeśīya-jarkālīyantra* – may also have been translated by him.[28] These translations were apparently done with the assistance of astronomers such as Muḥammad Ābid. Jagannātha Samrāṭ, the religious *guru* of the raja, wrote *Samrāṭ Siddhānta* based on some Persian or Arabic copy of Ptolemy's *Almagest*. According to Dikshit the work was completed in 1731.[29] Jagannātha himself was reputed to be well versed in Persian and Arabic, and might

21. Ibid. Bahura, pp. 72 – 73 .
22. *Dastura Kaumvara*, vol. 18, p. 745.
23. Ibid.
24. Bahura, ref. 7, pp. 74 – 75 .
25. Brindāban, *Safīnā - i Khushgo*, ms., f. 123, Khuda Bakhsha Oriental Public Library, Patna. Recently, the book has been published from Patna.
26. *Tadhkira of Naṣir al- Dīn Ṭusī in commentary of Ali al - Birjandī* by Nayanasukhopādhāya, ms. No. 46 AG, Sawai Man Singh Museum, Jaipur.
27. Bahura Ref. 20 :
    1. Ūkaragranthaḥ, (copied 1729, acquired 1730), No. 44 AG;
    2. Hayata- granthaḥ, (acquired 1738), No. 24 AG.,
    3. Yantrarāja risālā bīsa bāba, No. 42 AG, and
    4. Jarkālīyantram, No. 5483. Khas Mohar collection.
28. Pingree, Ref. 2.
29. Dikshit, Bal Gangadhar, *History of Hindu Astronomy*, Hindi version, p. 399, Lucknow, 1975 The Jaipur catalog gives 1728 as the completion date of the *Samrāṭ Siddhānta*. However, the date given by Dikshit appears to be more appropriate, as it is supported by internal evidence from the book .

Ghulām Ḥusain and Kisandī Khān (?) were receiving daily wages in 1733 - 34 at Jaipur along with the other observatory employees when finishing touches were being given to the observatory there.[17]

Jai Singh's primary aim in erecting the observatories had been to prepare a set of astronomical tables, i. e., a *Zij*. It is very likely that some of the astronomers mentioned above were on the team that compiled the tables for his *Zij-i Muḥammad Shāhī*. However, the *Zīj* does not mention any such astronomers or their contributions.

During the times of Jai Singh, or somewhat before him, there had been some excellent astrolabe makers in the country, and Jai Singh was a collector of fine astrolabes. His Persian astrolabes were presumably engraved or procured by his Muslim assistants. However, no names could be traced in the Rajasthan records that would definitely establish the makers of the astrolabes for the private collection of the raja.

Astronomical Texts

Jai Singh's early training had been solely under Hindu pundits just as of any other Rajput prince of the time, and he studied the Hindu school of astronomy first. However, he soon developed interest in the Persian-Arabic school of the subject, and began acquiring books and patronizing its scholars. In 1716 he received the first two Persian books for his library, *Turīya Jantra* and *Turīya Jantra Pīlkī*, from Sheikh Abdu'llāh.[18] It is noteworthy that the books were on instrumentation, indicating the raja's early interest in observational astronomy. Prior to 1716, according to inventory of his library of 1715, he had Sanskrit texts only.[19] Gradually, he acquired quite a few books in Persian and Arabic on both astronomy and astrology. Many of these books have survived, and may still be seen in the collection of the Sawai Man Singh II Museum of Jaipur.[20] A list of these books is given in the Appendix .

The books were either purchased directly from their owners, or were

17. Tozi Bundles Imarat Khana, V. S. 1791, Jaipur Rajya, Rajasthan State Archives, Bikaner.
18. File No. 424 / 1 , Jaipur Rajya, Rajasthan State Archives, Bikaner. The records in the file do not give the Persian titles of the books. It was not uncommon for Jai Singh's librarians, however, to list a book by its content, particularly, if it was not in Sanskrit or Hindi. On the other hand it is also possible that the two books brought by Abdu'llāh were Persian renditions of some Sanskrit texts .
19. Ibid. The inventory accounts for a total of 32 books on astronomy in Sanskrit.
20. Bahura, G. N., *Catalogue of Manuscripts in the Maharaja of Jaipur Museum*, Jaipur, 1971. David King has given a brief description of the manuscripts in: " A Handlist of the Arabic and Persian Astronomical Manuscripts in the Maharaja Mansingh II Library in Jaipur," *J. Hist . Arabic Sci.* , 4 (1980), pp. 82 – 85 . Also see Pingree ref. 2 .

In this paper it will be assumed, however, that the gifts, awards, and honors which the *nujūmīs* received, were primarily for their services related to astronomy.

Dayānata Khān and other Nujūmīs

Jai Singh's most favored and decorated Muslim astronomer, according to *Dastura Kaumvara*, was Dayānata Khān[5]. He came in contact with the raja at an early date, i. e., before any of his observatories were completed, and remained associated with him for more than two decades. In 1718 he received his very first and a very generous gift of Rs. 300 from the raja. Then in 1724 he was honored again with a *siropā* and some other gifts. During a period of more than twenty years that he remained associated with the raja, Dayānata Khān was decorated at least six different times. The very last gift received by him, according to the records in *Dastura Kaumvara*, was in 1739.[6] It is reasonable to assume that Dayānata Khān played a major role in the program of the raja.

The *nujūmīs* who received gifts and honors from the raja, and about whose contribution little is known, include Nizām Khān (1717),[7] Mirzā Abdu'r-raḥmān (1721),[8] Sheikh Asad ullāh (1718, 1720, 1726),[9] Sheikh Asatu'llāh (1719, 1720),[10] Muḥammad Ābid (1725),[11] Sheikh Aḥmad (1725),[12] Sayyid Muḥammad (1725 - 1726),[13] Sheikh Muḥammad Shafī (1725 , 1729),[14] and Va'iz Muḥammad Mehdī (1731).[15]

Contribution of Muslim Astronomers

The Muslim astronomers constructed the early instruments of the raja, which according to the *Zīj-i Muḥammad Shāhī*, were based on the Islamic books.[16] It is reasonable to assume that the astronomers were also involved, to some extent, in erecting the masonary instruments of the observatories of Delhi and Jaipur. According to the *Imarat Khana* records,

5. DK, Vol. 19, p. 563.
6. Ibid.
7. Ibid. The parentheses indicate the year of the gift recorded in the DK.
8. DK, Vol. 18, p. 557.
9. DK, Vol. 18, p. 540.
10. DK, Vol. 18, p. 554. It is quite likely that Asatu'llāh and Asadu'llāh (ref. 9) are the same person. The scribes of Jaipur State were not always careful with their spellings.
11. DK, Vol. 18, pp. 590 – 591.
12. DK, Vol. 18, p. 502.
13. DK, Vol. 20, pp. 193 – 194.
14. DK, Vol. 20, p. 604.
15. DK, Vol. 20, p. 192.
16. Ref. 1.

Muslim Astronomers at Jai Singh's Court

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Sawai Jai Singh (1688–1743), ruler of Amber, patronized astronomers of all faiths. Brahmin pundits, Muslim *nujūmīs* and Jesuit priests from Europe contributed to his program of rejuvenating astronomy in the country.[1] Although much is known about his Hindu and European assistants,[2,3] little has been written about his Muslim assistants. The object of this paper is to shed light on the Muslim scholars, and on the services they rendered to the cause of the raja.

Dastura Kaumvara

This paper is based primarily on the Rajasthan State Archives' *Dastura Kaumvara* books,[4] a 32 volume set, in which favors, honors, and gifts expended by the rulers of the Amber or Jaipur, over a period of several generations, are recorded. The *Dastura Kaumvara* records go back to the times of the emperor Akbar; however, they are more numerous for the Jai Singh period. In the records, the Muslim astronomers are listed under the category Muslim and identified by the title *nujūmī* (astronomers/astrologers). Jai Singh awarded his *nujūmīs* a variety of gifts, such as a *siropā* or ceremonial dress, a horse, or various amounts of cash ranging anywhere from Rs. 1 to Rs. 1000. The *Dastura Kaumvara* records sometime elaborate upon the reasons for a gift, whereas at other times they simply list the amount spent on the gift items.

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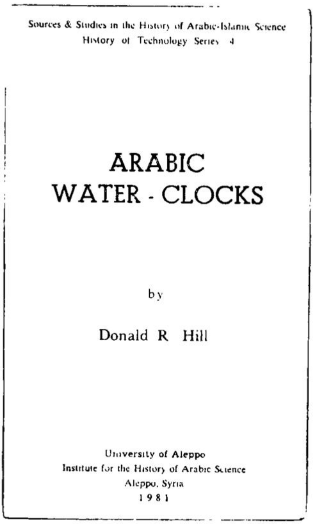
1. *Zīj-i Jadīd Muḥammad Shāhī*, Ms. London, B. L. Add. 14373: f. 1.
2. For Jai Singh's Hindu astronomers, see D. Pingree, " Indian and Islamic Astronomy at Jayasimha's Court, " to appear.
3. For his European assistants, see V. N. Sharma, " Jai Singh: His European Assistants and the Copernican Revolution, " *Indian. J. Hist. Sci.*, 17 (2), 333 – 344, 1982.
   ....., " The Impact of the Eighteenth Century Jesuit Astronomers on the Astronomy of India and China, " *Indian J. Hist. Sci.*, 17 (2), 345 – 355, 1982.
   ....., " Jesuit Astronomers in Eighteenth Century India, " *Archives Internationales d'Histoire des Sciences*, 34 (1984), pp. 99 – 107.
4. *Dastura Kaumvara*, Rajasthan State Archives, Bikaner. Originally, the records had been kept on 5 " x 7 ", loose leaves of paper, known as the *arsattas*. The *arsattas*, during the later years of the 19th century, were copied into large size books of almost 1000 pages each, as we find them today. The books have a total of almost 100,000 entries, arranged alphabetically according to the category of the recipients. However, exceptions are numerous, and scattered throughout the volumes. For example: The Jesuits, such as Manuel Figuerado, are listed under the category " Musalamān " (Muslim), and not under *Firingī*, as one would expect. The *Dastura Kaumvara* will be referred as DK henceforth.



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par les preuves que nous avons présentées (*dhakara*) dans ce traité que chaque cercle est l'équivalent d'un carré rectiligne. Il en résulte dès lors l' "erronéité" (*fasad*) de ceux qui soutiennent cette opinion illusoire (*ṭā'ifa*) et l'évidence (*wadh*)que chaque cercle est égal à un carré rectiligne. Et les opinion (*ma*ᶜ*ānin*) de la raison n'ont pas besoin d'être vérifiées (*ḥaqā'iq*) jusqu'à ce que l'homme les concrétise et les actualise (*ilā wujūd al- insān lahā wa ikhrājihā ila' l-fi*ᶜ*l*) . Mais il suffit que la preuve aille jusqu'au seuil de la réalisation (*imkān*), et l'opinion (en question) sera justifiée - que l'homme les conduise à l'acte ou non. Et voilà qui est assez pour la vérification (*taḥqīq*) de cette opinion. Nous avons atteint notre but .

Fin du traité.[39]

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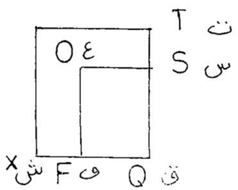
39. Suter publie encore un ajout qui figure dans les manuscrits de Berlin. Cet ajout montre que le problème de la quadrature du cercle a continué à préoccuper le monde arabe. Nous l'omettons toutefois puisqu'il n'est pas de la plume d'Ibn al- Haytham.

la ligne *DC* est donc une et ne change pas, parce que la ligne *AD* est une ligne dont la grandeur est connue et ne change pas. Qu'on relie *BC* et on obtient le triangle *BCD*. Le rapport du triangle *ABD* au triangle *BCD* est égal à celui entre la ligne *AD* et la ligne *DC*, et le rapport entre *AD* et *DC* est le même qu'entre le croissant *AEBH* et le cercle *HMEN*. Et le triangle *ABD* est au triangle *BDC* ce qu'est le croissant *AEBH* au cercle *HMEN* [$ABD : BDC = AEBH : HMEN$]. Et par inversion, le rapport du triangle *ABD* au croissant *AEBH* devient l'équivalent du rapport entre le triangle *BDC* et le cercle *HMEN* [$ABD: AEBH = BDC : HMEN$].

Quant au croissant *AEBH*, il a été prouvé qu'il est l'équivalent du triangle *AB*. Ainsi, le cercle *HMEN* est égal au triangle *BDC*, et chaque triangle est égal à un carré - comme a été démontré dans le deuxième livre des *Éléments*.

Et pour rendre un carré égal au triangle *BDC*, prenons un carré *SFQJ*[37] (fig. 3).



Fig, 3
(vat, arab
320, 5)

Le cercle *HMEN* est alors équivalent au carré *SFQJ* et le rapport entre les diamètres *AG* et *EH* est connu, parce que les grandeurs respectives de ces diamètres sont connues. Et pour que le rapport entre *AG* et *EH* soit égal à celui entre *XQ*[38] et *FQ*, il faut que le rapport de *AG* au carré à *EH* au carré soit égal au rapport entre *XQ* au carré et *FQ* au carré [$AG^2 : EH^2 = XQ^2 : FQ^2$]. Traçons sur la ligne *XQ* un carré, soit le carré *XT*. Le rapport de *AG* au carré à *EH* au carré sera alors égal au rapport entre les carrés *XT* et *QO* [$AG^2 : EH^2 = XT : QO$]. Et *AG* au carré est à *EH* au carré ce qu'est le cercle *ABG* au cercle *HMEN* [$AG^2 : EH^2 = ABG : HMEN$]. Le rapport du carré *XT* au carré *QO* est égal au rapport du cercle *ABG* au cercle *HMEN*. Le carré *QO* est égal au cercle *HMEN* et le carré *XT* au cercle *ABG*. Dès lors, il est prouvé par cette démonstration que chaque cercle est égal à un carré rectiligne. Mais quant à savoir comment trouver ce carré, nous rédigerons à ce propos un traité particulier, puisque dans ce traité nous avons uniquement voulu démontrer que cette opinion (*ma*ᶜ*nā*) est possible et que l'avis (*i*ᶜ*tiqād*) de ceux qui croient qu'il est injustifié (*lā yaṣiḥḥu*) qu'un cercle équivale à un carré est erroné. En fait, nous avons démontré

37. Comme *Suter* j'adopte *O* pour la lettre arabe ᶜ*ain*.

38. De même *X* pour la lettre arabe *shin*.

change ni de genre ni de grandeur, ni de forme ni de configuration (*hay'a*)[35] et si elle - même, la grandeur, est invariable, ne change ni de forme ni de grandeur, ni de genre ni de configuration (*hay'a*), et si donc et la grandeur et sa partie ont cettes propriétés (*ᶜala hadhihi as ṣifa*) il n'existe pour la grandeur et cette partie qu'un seul rapport qui ne change pas et n'adopte pas d'autre aspect. Si la grandeur du cercle ABG est connue (*maᶜlūm*)[36] , seront connus aussi son périmètre et son diamètre ainsi que son centre, le diamètre AG et l'arc AB qui équivaut à un quart du périmètre . Seront des connues la ligne AB (corde) et la ligne BD ainsi que le triangle ABD . J' entends par une connue ce que j'ai décrit pour le cercle ABG (*fī ṣifat addā'ira*) , qu'elle soit invariable et ne change pas, car la connue chez les mathématiciens est ce qui ne change pas. Et soit connu le demi- cercle AEB puisque la ligne AB qui est son périmètre est connu; des connues sont aussi l'arc AEB, parce qu'il ne change pas, et l'arc AHB en sorte que le croissant $AEBH$ est connu- j'entends par là qu'il est invariable quant à ses propriétés (*thābit ᶜalā ṣifa wāḥida*) . Il ne change ni de genre ni de grandeur ni de forme - par genre j'entends qu'il est une surface plane. Et soit connue la ligne KE qui forme la moitié du diamètre connu, ainsi que la ligne KH puisque les deux points K et H sont connus. Il reste alors la connue EH, c'est-à-dire (étant une connue) elle ne change ni de grandeur ni de forme ni de configuration. La ligne EH est le diamètre du cercle $HMEN$, et le cercle $HMEN$ est connu, ne change ni de grandeur ni de forme ni de configuration. Or, le cercle $HMEN$ est une partie du croissant $ABEH$ et tous deux ne changent pas d'état et appartiennent au même genre puisque l'un faitie part de l'autre. Ainsi, le croissant $AEBH$ a au cercle un rapport invariable aux propriétés fixes (*nuṣba thābita ᶜalā ṣifa wāḥida*) qui ne change pas d'aspect. Et chaque rapport de n'importe quelle grandeur à sa partie est égal au rapport de chaque grandeur à une partie semblable à cette partie (appartenant à la première grandeur). Ainsi, le rapport du croissant $AEBH$ au cercle $HMEN$ est égal au rapport de la ligne AD avec une de ses parties, que nous connaissions la grandeur de cette partie ou non, (en fait) nous ne pouvons pas la découvrir et n'arrivons pas à la trouver. Soit DC cette partie, en sorte que le rapport de AD à DC est le même qu'entre le croissant $AEBH$ et le cercle $HMEN$. Ainsi, le rapport de AD à DC est un rapport invariable qui ne change jamais. Et si ce rapport est tel,

35. K. *Kohl* traduisit l'ouvrage astronomique d'Ibn al -Haytham *Kitābfī Hay'at al - ᶜĀlim* par " Über den Aufbau der Welt " (" Sur la constitution du monde ") . " *Hay'a* " peut aussi désigner carrément l'astronomie. Naṣīraddīn at- Ṭūsī, pour ne citer qu'un exemple, a ainsi écrit un ouvrage intitulé *at-tadhkira fī ᶜIlm al- Hay'a* (" Mémoire d'astronomie "). Dans le contexte présent ' configuration ' nous semble être la traduction adéquate.

36. Ibn al-Haytham suit ici de près la terminologie et les définitions qu'il a adoptées dans son " Traité des connues géométriques " (cf. M. L. *Sédillot* : *Matériaux pour servir à l'histoire comparée. . .* , op. cit. , vol 1, 378 ss) .

Puisque ceci est prouvé, occupons- nous de nouveau du cercle, du croissant $AEBH$ ainsi que du triangle ABD. Divisons la ligne AB en deux parties égales dans le point K, de sorte que K devienne le centre du cercle AEB (fig. 2). Relions DK et prolongeons cette ligne jusqu'à ce qu'elle coupe les arcs AHB et AEB dans les deux points H et E. DKH devient ainsi le diamètre (demi- diamètre) du cercle ABG et (KHE) le diamètre (demi-diamètre) du cercle AEB parce qu'elle passe par les centres des deux. Divisons la ligne EH en deux parties égales dans le point L et faisons de ce point en décrivant avec HL pour rayon (?) le centre d'un cercle pour obtenir le cercle $HMEN$. Et ce cercle touchera du dehors le cercle ABG et de dedans le cercle AEB parce qu'il rejoint chacun des deux cercles par les bouts de son diamètre, commun à toutes les trois figures. Ce cercle se trouve en entier à l'intérieur du croissant $AEBH$, il est donc une partie de ce croissant.

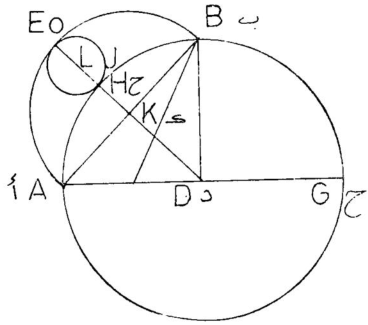


Fig 2 (Vat, arab 320, 5)

Or, chaque grandeur a un rapport déterminé avec chaque grandeur qui lui est inhérente. Mais personne ne connaît ce rapport et n'arrive à le connaître parce que le rapport des grandeurs entre elles n'est pas conçu pour la connaissance des hommes ni pour qu'il leur soit possible de le découvrir ou connaître (*laisa hiya min ajli ᶜilm an - nās bihā wa lā min ajli qudratihim ᶜalā istikhrājiha wa maᶜrifatihā*) . C'est que le rapport entre les grandeurs est quelque chose de propre aux grandeurs du même genre (*jins*). Si deux grandeurs appartiennent au même genre et chacune d'elles est limitée (*maḥṣur*), finie (*mutanāhi*) , invariable (*thābit*), fixe dans sa grandeur (*bāqi* ᶜalā *miqdārihi*), ne change aucunement d'aspect (*wajh*), n'augmente ni ne diminue et reste dans son genre, le rapport de ces deux grandeurs reste le même, il ne mue pas et ne change pas d'aspect. Et pour chaque grandeur dont une partie appartient au même genre vaut que, si cette partie est limitée, finie, ne périmètre le point *B*. Traçons alors les deux droites *BG* et *AB* et circonscrivons à ces droites les deux demi- cercles *AEB* et *BZG*.

Et je dis que les croissants *AEBH* et *BZGT* sont ensemble égaux au triangle *ABG* .

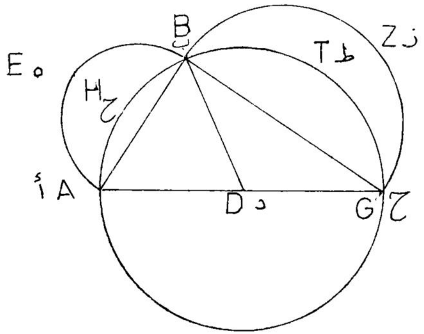


Fig. 1 (Vat arab 320, 3)

La preuve est que de deux cercles quelconques le rapport d'un cercle à l'autre est égal au rapport du carré d'un diamètre au carré de l'autre - comme il a été démontré dans le deuxième axiome du livre XII des *Éléments*. Ainsi, le cercle *BZG* est au cercle *BEA* ce qu'est *GB* au carré à *BA* au carré [$BZG : BEA = BG^2 : AB^2$] . Et par composition (*tarkib*) on obtient : $GB^2 + AB^2 : AB^2 = BZG + BEA : BEA$. Or, *GB* au carré et *AB* au carré sont égales à *AG* au carré ($GB^2 + AB^2 = AG^2$). Ainsi: $AG^2 + AB^2 = BZG + BEA : BEA$.

Et *AG* au carré est à *AB* au carré ce qu'est le cercle *ABG* au cercle *BEA* [$AG^2 : AB^2 = ABG : BEA$] . Et le rapport des cercles *BZG* et *BEA* au cercle *BEA* est égal au rapport du cercle *ABG* au cercle *BEA* [$BZG + BEA : BEA = ABG : BEA$] . Ainsi, le cercle *ABG* est égal aux cercles *BZG* et *BEA*. Dès lors, le demi- cercle *ABG* est égal aux demi- cercles *BEA* et *BZG*. Et si nous ôtons les segments *AHB* et *BTG* qui ont part (*mushtarikūn*) aux cercles *ABG* et aux deux cercles *AEB* et *BZG*, il reste le triangle *ABG* qui est l'équivalent des croissants *AEBH* et *BZGT* . Et c'est ce que nous avons voulu démontrer. Et si les arcs *AHB* et *BTG* sont égaux, les lignes *AB* et *BG* s'équivalent, de même les cercles *AEB* et *BZG*, et sont des équivalents leurs moitiés ainsi que les croissants *AEBH* et *BZGT*. Relions encore *B* et *D*, et les triangles *ABD* et *BDG* seront égaux. Or, nous avons démontré que les deux croissants sont équivalents et que les triangles *ABD* et *BDG* sont égaux. Et si chaque croissant est égal à chaque triangle , le croissant *AEBG* est égal au triangle *ABD*.

Au nom de Dieu le clément et miséricordieux qui réjouit les coeurs

Traité d'Ibn al-Haytham sur la *Quadrature du cercle* . Beaucoup de philosophes *(mutafalsifun)* sont convaincus qu'il est impossible que la surface du cercle soit équivalent à la surface d'un carré rectiligne[33] et ils repoussent cette opinion (*ma*ᶜ*nā*) dans leurs disputes et controverses. On ne trouve ainsi chez aucun des anciens ni des récents une figure rectiligne qui corresponde à la surface d'un cercle jusqu'au terme de la précision. Or, Archimède qui en fait mention dans *la mesure du cercle* n'y utilisa qu'une partie de la surface.[34] Et c'est cet état de choses (*ma*ᶜ*nā*) qui a entres autres renforcé les philosophes dans leur conviction. Puisque c'est ainsi qu'il en était , nous avons dirigé le regard de notre pensée (*naẓar al - fikr*) sur cette opinion et il nous parut possible et aucunement difficile (de la soutenir). Il y a un pendant à cela : il existe une figure lunaire limitée par deux segments circulaires qui est égale à un triangle et une autre qui forme ensemble avec un cercle un triangle. Nous avons évoqué plusieurs figures différentes de ce genre dans notre livre sur les figures lunaires. Après avoir médité sur les propriétés (*ṣifa*) des figures lunaires, il se corrobora en nous la conviction qu'une surface circulaire égale à un carré rectiligne appartient au domaine du possible (*annahu min al - mumkin*) , et nous avons approfondi la chose jusqu'à ce que la preuve fût manifeste que cette opinion est possible et qu'aucun doute n'existe quant à la possibilité (*imkān*) de la démontrer. C'est alors que nous avons rédigé ce traité.

Nous disons que pour chaque cercle dans lequel on trace un diamètre et marque dans un des demi- cercles un point au hasard (*kaifama ittafaqa*), trace à partir de ce point deux droites vers les deux bouts du diamètre et circonscrit par la suite à ces droites deux demi- cercles, (pour chaque cercle donc) vaut que les croissants limités par les périmètres des deux demi- cercles et l'arc du premier cercle sont ensemble équivalents au triangle limité dans le premier cercle. Nous avons démontré (*bayyanā*) cette opinion dans notre livre sur les figures lunaires, voulons toutefois reproduire la preuve (*burhān*) dans ce contexte.

Soit un cercle ABG (fig. 1) et un point D *comme* centre. Faisons passer par D une ligne ADG en sorte que AG soit le diamètre et marquons sur le

33. Ce pléonasme vient de ce qu'Ibn al-Haytham veut commencer par démontrer l'équivalence foncièrement possible entre une figure circulaire et une rectiligne.

34. *Suter* remarque ici à juste titre qu'Ibn al-Haytham fait probablement allusion à ce qu'Archimède opère avec le polygone de 96 côtés et n'atteint par là qu'une quadrature approximative (cf. op. cit. , p. 36) .

gination, elle, est douée d'un pouvoir cognitif[28] qui s'explique par la connexité étroite avec la raison dont il a déjà été fait mention. Non seulement ses images sont soumises aux lois optiques, mais elle est apte à distinguer les " catégories " visuelles et à les mettre en relation avec l'objet perçu[29]. D'autre part, l'imagination a une fonction de soutien. Dans le débat sur les rayons visuels, Ibn al-Haytham tranche ainsi que ces rayons ne sont que des lignes imaginaires servant à illustrer et à expliquer l'acte de la vision.[30] Ce sont justement ces deux plans de l'imagination qui fournissent les critères nécessaires pour le concept du possible d' Ibn al - Haytham : d'un côté la faculté distinctive qui discerne les aspects possibles d'une forme qu'elle soit une espèce ou une figure géométrique, de l'autre le caractère foncièrement médial de l'imagination qui permet de mettre en rapport lignes, angles et figures. L'imagination devient ainsi la pierre de touche du possible, c'est-à-dire de ce qui peut être mis en relation. Il reste, cependant, un aspect qui distingue l'opinion de la raison du jugement (*ra'y*) : celle- ci, du moins dans le contexte présent, n'a pas de fondement dans le monde sensible. L'imagination ne sert alors pas à vérifier le réel, mais se déploie dans la spéculation. D'ici à une méthodologie conjecturale telle qu'elle a été démontrée récemment pour Nicole Oresme[31] il ne reste plus qu'un pas à franchir.

La traduction a pour base l'édition critique de H. Suter.[32] Elle suit de près le texte arabe, avec toutes les répétitions et redondances apparentes, et ne prétend donc pas à un meilleur style qui d'ailleurs fausserait le caractère de l'original. Les termes techniques ainsi que les locutions qui ne peuvent être traduites littéralement sont mis entre parenthèses. (Les schémas sont tirés du manuscrit vat. arabus 320 rapporté en 1622 de Perse par Pietro della Valle .)

28. Cf. éd. *Risner*, II, 76, pp. 74 – 75 .

29. Cf. ibid. , II , 62 – 64 , pp . 66 – 68 .

30. Cf. ibid. , I, 23 , p. 14s .

31. Cf. Jeannine *Quillet* : " L'imagination selon Nicole Oresme ", *Archives de Philosophie* , 50 (1987) , 219 – 227 .– Pour l'importance de l'imagination dans la recherche scientifique chez un autre auteur du moyen âge cf. Edith D. *Sylla*, " Mathematical physics and imagination in the work of the Oxford Calculators : Roger Swineshead's *On Natural Motions*", *Mathematics and its applications to science and natural philosophy in the Middle Ages* , ed. par E. *Grant* et John E. *Murdoch*, Cambridge / London / New York . . . 1987 , 69 – 102 .

32. Pour son édition de la *Quadrature du cercle* d'Ibn al- Haytham, *Suter* a utilisé les mss. Mf. 258 et Mq. 559 de la Bibliothèque de Berlin ainsi que le vat. arabus 320 de la Bibliothèque Apostolique . – Pour d'autres manuscrits cf. G. *Nebbia*, op. cit. , 191 .

Tenons compte de ces instructions pour examiner si **l'opinion possible** dont il est question dans la *Quadrature du cercle* se réfère également à une réflexion de méthode. Pour l'approche du problème mathématique de la quadrature Ibn al-Haytham d'abord rappelle au lecteur un des ses ouvrages antérieurs qui porte sur les figures lunaires et dans lequel il a déjà évoqué des configurations géométriques où une figure circulaire est égale à une rectiligne.[25] Le procédé qui suit s'effectue en deux étapes. En voilà brièvement la description: A première vue, la démonstration ressemble à celle d'Archimède[26] dans la mesure où Ibn al-Haytham argumente au moyen de rapports et birapports qui se fondent sur de simples règles géométriques du type: le rapport d'un cercle quelconque à un autre est égal au rapport du carré de son diamètre au carré du diamètre de l'autre cercle.[27] Ibn al - Haytham omet cependant calculs et bissections d'angles. Dans une première étape, il démontre ainsi l'équivalence entre une figure circulaire et une triangulaire. Ensuite, se fondant sur un axiome du deuxième livre des *Éléments* d'Euclide selon lequel chaque triangle est égal à un carré, il entame la deuxième étape et illustre par une double analogie (si $a = b$ et $b = c$, alors $a = c$) qu'effectivement une équivalence entre cercle et carré est possible. Le traité conclut avec l'observation que

> " les opinions (*ma^cānin*) de la raison n'ont pas besoin d'être vérifiées (*haqā'iq*) jusqu'à ce que l'homme les concrétise et les actualise " .

L'argumentation d' Ibn al-Haytham dans cette *Quadrature du cercle* est, en effet, plausible, les analogies s'enchaînent sans difficulté en sorte que le lecteur accepte de prime abord facilement la démonstration. Mais de là à dire qu'elle n'a pas besoin d'être menée à terme, cela rend quelque peu perplexe. En fait, il faut se demander à cet endroit ce qu'entend Ibn al-Haytham exactement par le terme " possible ". La **possibilité** de la quadrature du cercle résulte pour lui d'une opinion de la raison. Même en admettant que cette opinion opère tout comme le jugement (*ra'y*) avec des images intérieures, ou ce qui est plus approprié dans ce contexte avec des figures géométriques représentant des rapports déterminés, les critères de la vraisemblance ne sont pas encore clairs. Pour reconstruire le fond de la pensée d'Ibn al-Haytham, il faut, ici aussi, recourir à la *Grande Optique*. Il s'y trouve une distinction importante entre imagination et fantaisie. Contrairement à la fantaisie qui n'est qu'un réservoir d'images qui n'ont pas été vérifiées, l'ima-

25. Il doit s'agir soit du " Traité abrégé sur les figures lunaires " soit du " Traité circonstancié sur les figures lunaires " qui figurent aux numéros 20 et 21 dans la liste transmise par *Ibn Abī Uṣaibi^ca*. Ni l'un ni l'autre n'a été publié. Il serait intéressant de savoir si Ibn al-Haytham va dans ses traités au-delà des considérations d'Hyppocrate.

26. Cf. *Archimède* : *La mesure du cercle*, texte établi et traduit par C. Mugler, Oeuvres, I, Paris 1970, 135 – 143 .

27. Cf. *Euclide* : *Éléments*. XII , 2. axiome .

Voilà pour l'épistémologie d'Ibn al-Haytham. Qu'en peut-on conclure pour sa *Quadrature du cercle* ? Ibn al-Haytham se propose d'abord de combattre la conviction des philosophes qui ne croient pas qu'il y ait une solution au problème de la quadrature du cercle. Il parle dans ce contexte de *maᶜnā*, d'opinion : la quadrature du cercle est à ces yeux une **opinion possible.** Le terme *maᶜnā* recouvre dans l'œuvre d'Ibn al - Haytham plusieurs sens.[21] Une des plus passionantes est certainement celle des *maᶜānin baṣariyya*, que la version latine de la *Grande Optique* traduit par " intentiones " . Pour souligner les traits les plus saillants du concept qui s'y rattache, il n'est pas sans intérêt de faire à cet endroit un rapprochement avec quelques données fondamentales de la philosophie aristotélicienne. On peut alors affirmer qu'au contraire des catégories du Stagirite qui reposent sur ce qui peut être dit, Ibn al-Haytham développe vingt-deux " catégories " à partir de ce qui peut être perçu visuellement tels que les couleurs, la grandeur, le site ou la disposition des parties d' un objet . La différence réside néanmoins dans ce qu'Ibn al-Haytham ne peut dégager , comme le propose Aristote, le fond véridique d'une opinion (*doxa*), communément admise, au moyen d' une dialectique de la langue , mais laisse décider les mathématiques de la vraisemblance. Et pour cause, si la connaissance d'un objet a pour base sa visibilité, les erreurs possibles sont, elles, relatives à la perception. Pour se préserver des illusions dûes à la vision, le jugement a besoin dès lors non d'une dialectique, mais d'une optique géométrique. Bien qu'on ne puisse indiquer un concept de base unique à toutes les significations de *maᶜnā*, il est assez manifeste que dans divers contextes Ibn al-Haytham recourt à ce terme à un niveau de réflexion systématique. Déjà en 1834 dans son article " Traité des connues géométriques d'Ibn Alhaïtham " M. L. Sédillot avait attiré l'attention sur la " géométrie spéculative " de celui-ci où l'opinion (*maᶜnā* ou *ẓann*) immuable, considérée une évidence inébranlable, joue un grand rôle.[22] Que **l'opinion** est un mot-clé dans la terminologie épistémologique d'Ibn al-Haytham ressort plus clairement encore dans un autre ouvrage. Son commentaire sur les *Éléments* d'Euclide commence ainsi par les mots :

> " Chaque opinion (*maᶜnā*) dont la vérité est obscure et dont les propriétés sont au début cachées... est soumise au doute. Et pour celui qui est rebelle à la vérité et qui doute, le chemin (qui conduit) à ses opiniâtretés est large.. Et il ne sert à rien qu'il s'en prenne à lui - même, **à moins qu'il ne vérifie une opinion par la méthode (qiyās)[23] et le discernement (tamyīz) qu'il a élaborés lui-même et dont la vérification (*ṣaḥḥa*) prend forme dans sa raison (ᶜaql) "[24] .**

21. Cf. M. *Schramm*, op. cit. , 206 , 211.
22. Cf. *Journal asiat.* , XIII (1834), 435 ff. Voir aussi ses *Matériaux pour servir à l'histoire comparée des sciences mathématiques chez les Grecs et les Orientaux* , 2 volumes , Paris 1845 – 1849 . vol. 1, 378ss.
23. '*Qiyās*' signifie aussi 'mesure' ou 'analogie' . Dans le contexte présent la traduction 'méthode nous semble être la plus appropriée.
24. *Kitāb fī Ḥall Shukūk Kitāb Uqlīdis fi'l- Uṣūl wa Sharḥ Maᶜānīhi* (Publications of the Inst. for the Hist. of Arabic- Islamic Science, C, Facsimile Editions, vol. 11) , Frankfurt a. M. 1985, 2 .

la *Grande Optique* (*Kitāb al-Manāẓir*) d'Ibn al-Haytham, ṣura est l' " espèce générale "[16] conçue d'après la perception visuelle répétée[17] d'un objet quelconque. Elle n'est donc ni dérivée d'un principe ni le résultat d'un processus d'abstraction.[18] Par ailleurs, dépendant d'un objet extérieur à la pensée l'espèce générale reste sujette à des modifications qui ont leur fondement dans les lois optiques. Le jugement a ainsi effectivement pour point de départ le domaine du sensible qui, en retour, trouve au moyen de l'optique géométrique un pendant constamment mis en cause et rectifié dans la raison. L'apport des mathématiques appliquées semble ainsi se réduire à la fonction d'un instrument de précision susceptible lui-même d'être continuellement rectifié.[19] Une analyse plus poussée du rapport complexe entre physique et mathématiques dépasserait de loin le cadre de cette introduction à la *Quadrature du cercle* d'Ibn al-Haytham. On peut néanmoins retenir deux aspects fondamentaux. 1° l'épistémologie d'Ibn al-Haytham a pour base la visualité du monde et la faculté de la raison (*ᶜaql*) de former à l'aide des lois optiques des images intérieures continuellement vérifiables et servant à rendre intelligibles les objets extérieurs. 2° la connexité entre la raison, la faculté de former des images (imagination) et de les tenir présentes (mémoire) - sans cette dernière une rectification serait impossible puisque la perception devrait toujours recommencer à zéro - est si étroite qu'il n'y a pratiquement pas de différence entre voir et comprendre : dans la *Grande Optique*, en effet, percevoir visuellement est comprendre immédiatement.[20] Si, de surcroît, le jugement (*ra'y*) dans lequel culmine et l'expérience visuelle et la reconstruction géométrique dans la raison a lui-aussi , considéré étymologiquement, une connotation visuelle, rien de moins surprenant : *ra'y* dérive, en effet, de la racine *ra'ā* " voir ".

16. Le terme est emprunté à G. *Federici- Vescovini* : " Contributo per la storia della fortuna di Alhazen in Italia : il volgarizzamento del ms. Vat. lat. 4595 e il ' commentario terzo ' del Ghiberti " *Rinascimento* , 2e série, vol. V (1965), 17 – 49 , 27 ; " espèce générale " donne une idée assez exacte de ce qu'entend Ibn al-Haytham par ṣura, pourvu qu'on tienne compte de ce qu'il s'agit d'une espèce conçue visuellement.

17. Ibn al-Haytham distingue entre une perception qui a lieu selon tous les rayons qui frappent l'œil (dans la version latine de l'édition *Risner*, *aspectus*) et une qui survient selon le seul rayon perpendiculaire et qui, par là, est perception plus distincte (intuitio) . Evidemment, c'est par la perception intuitive que se fait la vérification de l'espèce générale (cf. F. *Risner*, *Opticae thesaurus Alhazeni Arabis libri septem*. . , Bâle 1572, II, 62 – 64, pp. 66 – 68).

18. Cf. G. *Federici- Vescovini*, op. cit, 26 ss.

19. D'autre part, au début de son discours sur la lumière Ibn al- Haytham déclare que seules physique et mathématiques prises ensembles peuvent réussir à expliquer ce qu'est la lumière, l'une sa nature (*mahiyya* ; *quidditas*) les autres sa modalité (*kaifiyya* ; *qualitas*). – Pour une traduction française de ce discours cf. R. *Rashed*, *Revue d'histoire des sciences*, 21 (1968), 197 – 224 .

20. Cf. op. cit. , éd. *Risner*, II, 65 , p. 68 .

le cas, les spéculations sur les phénomènes naturels, d'autre part être insérées dans un contexte physique et perdre par là leur caractère foncièrement hypothétique.[10] C'est ainsi qu'Ibn al - Haytham substitua au modèle ptolémique une conception plus appropriée à l'expérience du monde :

> " Les mouvements de cercles et le point fictif que Ptolémée avait considérés d'une manière entièrement abstraite, nous les placerons dans des sufraces sphériques ou planes qui seront animées des mêmes mouvements. Cela, en effet, constitue une représentation plus exacte et, en même temps, plus claire à l'intelligence " .[11]

Le concours mutuel envisagé par Ibn al-Haytham entre physique et mathématiques appliquées, resté aujourd'hui encore mutatis mutandis un idéal scientifique, n'est pas facile à saisir. De plus, les écrits sur la *méthode* d'Ibn al-Haytham qui auraient pu fournir quelques renseignements précieux quant à son approche et scientifique et épistémologique ont péri.[12] Pourvu qu'on élabore certains concepts de base, il est cependant possible de reconstruire à partir de quelques autres écrits, pour le moins schématiquement, le fond systématique de sa pensée. Son autobiographie fournit ainsi un indice fort intéressant, d'autant plus important si, comme Moritz Steinschneider le soutient dans son édition des " Vite di matematici arabi ", ce témoignage d'Ibn al-Haytham a fait partie d'un ouvrage où il aurait affirmé le primat des sciences sur la foi.[13] Ibn al-Haytham commence par y décrire l'anxiété et le désir de savoir qui l'habitaient jusqu'à ce qu'il reconnut qu'il ne pouvait

> " atteindre à la vérité que par des jugements (*arā'*) dont le fondement (*ᶜunṣur*) est le domaine du sensible (*umūr ḥissiyya*) et la forme (*ṣūra*) le domaine de la raison (*umūr ᶜaqliyya*)"[14] .

On ne comprend la portée de cet aveu qu'en approfondissant le concept de forme. En fait, le terme arabe *ṣūra* signifie, tout comme le grec *eidos*, image - sans toutefois correspondre au concept aristotélicien de forme.[15] Dans

10. Pour plus de détails cf. l'excellent ouvrage de Matthias *Schramm*: *Ibn al- Haythams Weg zur Physik* (Boethius - Texte und Abhandlungen zur Geschichte der exakten Wissenschaften, vol. I) , Wiesbaden 1963 , 5 - 63 .
11. P. *Duhem* : " Le Résumé d'Astronomie d'Ibn Al-Haitam ", *Le Système du monde*, vol. II, Paris 1914, 119 – 129, 122. – Cette critique à l'égard de Ptolémée n'a rien à voir avec " le réalisme des arabes " (cf. ibid. , 117) , mais résulte tout simplement d'une réflexion de méthode .
12. Cf. Matthias *Schramm*, op. cit. , 12.
13. Cf. M. *Steinschneider* : " Vite di matematici arabi. Tratte da un opera inedita di Bernardino Baldi ", *Bullettino di bibliogr. e di storia delle sc. mat. e fis.* , 5 (1872) , 427 – 534 , 466 .
14. *Ibn Abī Uṣaibiᶜa*, op. cit. , 93. – M. *Schramm* intervient pour sa traduction dans le texte et remplace ' *annanī*' par ' *annahu*' en sorte que ' *asilu*' devienne '*aṣl*' (cf. op. cit. , 10) mais il n'y a aucune raison à cela. Cette partie de la phrase est tout à fait compréhensible telle qu'elle est.
15. Pour le débat autour des termes ' forma' et 'species' dans les traités d'optique de Robert *Grosseteste*, Roger *Bacon*, John *Pecham* et *Vitello* cf. V. *Ronchi*, *Storia della luce*, Bologna 1952 ainsi que D. C. Lindberg, " Alhazen's Theory of Vision and its Reception in the West ", *Isis*, 58 (1967), 321 – 341. Il faut se demander si la question soulevée dans ce débat n'est pas superflue du moment où le terme 'forma' est tout simplement dû à la traduction latine de la grande Optique et n'explique en soi rien à la conception spécifique d'Ibn al- Haytham.

de ce titre dont nous ayons connaissance depuis Archimède "[5] n'ait pas encore été analysé. En 1899, finalement, Heinrich Suter entreprit l'édition de cet écrit d'Ibn al-Haytham.[6] Mais depuis, ce traité est tombé dans l'oubli et c'est à peine s'il figure dans quelque bibliographie.[7] Une raison en est certainement que Suter, historien des mathématiques et orientaliste passionné, a été déçu de la solution avancée par Ibn al-Haytham. A son avis, cette *Quadrature du Cercle* est

> " une singulière mixture de vérités géométriques et d'arguments philosophiques, elle n'offre pas de démonstration complète. . . , mais donne uniquement une preuve mi-mathématique, mi-philosophique de la possibilité de la quadrature "[8] .

En fait, pour apprécier ce traité, il faut commencer par tenir compte du public auquel il s'adresse. Dans sa quadrature Ibn al-Haytham n'a pas les mathématiciens en vue. Bien au contraire, il oppose sa propre opinion à celles des philosophes ou plus exactement de ceux qui se sont adonnés à la philosophie, car il ne parle pas de *falasifa*, terme commun pour désigner les philosophes, mais de *mutafalsifun*. Ce sont ces derniers qu'il veut convaincre de la possibilité de la quadrature – quant à ceux qui attendent une démonstration mathématique, il promet à la fin de sa quadrature un autre traité qui n'a toutefois pas été transmis jusqu'à nous ou qui n'a peut-être jamais été rédigé. Mais en quoi peut consister une solution philosophique d'un problème mathématique? Nicolas de Cuse, pour citer un exemple célèbre, avait pris pour point de départ de sa quadrature du cercle le principe de la coïncidence des opposés et avait même songé à la possibilité de parfaire par là les mathématiques.[9] Il en est autrement d'Ibn al-Haytham: le pivot sur lequel reposent philosophie et mathématiques ne réside pas pour lui dans un principe philosophique applicable aux deux domaines, mais dans son épistémologie. Il n'a ainsi jamais situé son idéal scientifique dans les mathématiques pures. Son but était bien au contraire de travailler à une synthèse de la physique (aristotélicienne) et des mathématiques appliquées, c'est-à- dire, dans son cas, l'astronomie et l'optique. Ces dernières devaient par leur précision consolider ou corriger , selon

5. Moritz *Cantor* : *Vorlesungen über die Geschichte der Mathematik*, 2e éd. , Leipzig 1893 , vol. 1 , 744.

6. Heinrich *Suter* : " Die Kreisquadratur des Ibn al- Haitam. Zum ersten Mal nach den Manuskripten der königl. Bibliothek in Berlin und des Vatikans hg. u. übers", *Zeitschrift Für Mathematik und Physik, hist. – liter. Abt.* , 44 (1899), 33 – 47 .

7. Quoiqu'en dise Giorgio *Nebbia*, Helmut Ritter, n'a pas travaillé sur ce traité (cf. "Ibn al-Haytham nel millesimo anniversario della nascita " , *Physis, rivista di storia della scienza*, 9 (1967) , 165 – 214, 191). Ritter se contente à l'endroit indiqué de mentionner l'écrit en question.

8. H. *Suter*, op. cit. , 34 .

9. " Intentio est ex oppositorum coincidentia mathematicam venari perfectionem " (De mathematica perfectione, pars II, fol. 101 r, Nicolai Cusae cardinalis opera, Parisiis 1514, H – réimprimé Francfort 1962) .

La Quadrature du cercle d'Ibn al-Haytham
Solution philosophique ou mathématique ?

TAMARA ALBERTINI*

Abu ᶜAli al-Ḥasan ibn al-Ḥasan ibn al-Haytham (965 – 1040)[1] devenu célèbre dans le monde latin pour son ouvrage d'Optique[2] a traité divers problèmes d'ordre mathématique, astronomique, mécanique, politique et philosophique. Il s'est en outre intéressé à la médecine, heureusement peut-on observer, puisque c'est grâce à ce dernier penchant qu'une longue liste de ses ouvrages nous est parvenue. Ibn Abī Uṣaibiᶜa (1203 – 1270), lui-même médecin de profession, s'est ainsi chargé de transmettre et compléter dans son histoire des médecins l'autobiographie d'Ibn al-Haytham et la liste d'ouvrages que celui-ci y avait dressée.[3] Dans la liste supplémentaire d'Ibn Abī Uṣaibiᶜa figure aussi le traité sur la *Quadrature du cercle* (*maqāla fī tarbīᶜ addā'ira*). Au siècle dernier, l'existence de ce traité était connue au plus tard depuis l'ouvrage de F. Woepcke sur ᶜOmar al-Khayyam où 117 écrits d'Ibn al-Haytham sont mentionnés[4]. Moritz Cantor pouvait ainsi déplorer en 1893 que ce traité sur la *Quadrature du cercle*, " le premier

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1. Pour d'ultérieures données biographiques et une vue d'ensemble sur l' oeuvre d' Ibn al-Haytham cf. l'article de A. I. *Sabra* dans : *Dictionary of Scientific Biography*, vol. VI, 189 – 210 .

2. A. I. *Sabra* a publié le texte original arabe : Al- Ḥasan ibn al- Ḥasan ibn al- Haytham, *Kitāb al-Manāẓir*, Livres I – III , avec glossaire arabe- latin et tables de concordance, Kuwait 1983 ; ainsi qu'une traduction anglaise : *The Optics of Ibn Al- Haytham*, Livres I – III : sur la vision directe, trad. avec introd. et comm. (Studies of the Warburg Institute, 40), Londres 1989. Nous citons cependant ci-dessous selon l'ancienne édition de Friedrich *Risner* : *Opticae thesaurus Alhazeni Arabis libri septem. . .* , Bâle 1572 (reprint New York 1972) .

3, Cf. *Ibn Abī Uṣaibiᶜa* : *ᶜUyūn al- Anbā' fī Ṭabaqāt al-Aṭibbā'*, 2 volumes , éd. par August *Müller*, Le Caire/Königsberg 1882 – 1884, vol. 2, 90 ss. [trad. fr. par B. R. *Sanguinetti*, *Journal asiatique*, V, 3, 230 ss.; 4, 178ss. (1854); 5, 401 ss. ; 6, 129ss. (1855); 8, 316ss. (1856)] ; pour une traduction allemande de l'autobiographie cf. Eilhard *Wiedemann* : " Ibn al- Haiṭam, ein arabischer Gelehrter ", *Festschrift für J. Rosental*, Leipzig 1906, 149 – 178.

4. *Woepcke*, F. : *L'Algèbre d'Omar Alkhayyami*, Paris 1851, 73ss. ; pour quelques corrections cf . Heinrich *Suter* : *Die Mathematiker und Astronomen der Araber und ihre Werke* (reprint New York 1972) , Leipzig 1900, 92 s. – Bernardino *Baldi* cite dans les " Vite di matematici arabi " (éd. par M. *Steinschneider*, *Bullettino di bibliogr. e di storia delle sc. mat. e fis.*, 5(1872), 427 – 534) une traduction latine de la quadrature du cercle par Pietro della valle qui n'a cependant pas été transmise jusqu'à nous.

Editorial

We regret that the " J. H. A. S. " had stumbled and retarded for reasons out of our will. Now it is coming to the light again.

Our most gratefulness to all our subscribers, of researchers and scientific institutions, for their patience and understanding to our accidental circumstances, hoping in return that the publication schedule of the *Journal* will be, from now on, regular as before, i. e. one volume per year.

As it is not possible to publish volumes for the former period , we considered the period between 1985 – 1990 a period of suspension but with the maintenance of the volumes' succession and, consequently, the whole rights of the subscribers are respected .

In this very volume you will find the persistent works of the researchers in their trial to reveal the scientific heritage of the Arabic and Islamic civilization. This volume, therefore, includes various and rich articles dealing with diverse topics in medicine, astronomy and mathematics.

Prof. Khaled MAGHOUT, D. Sc.

Director I. H. A. S.