Al-Andalus, a Bridge Between Arabic and European Science

Julio SAMSÓ
University of Barcelona

0. Abstract

The purpose of this paper is to outline the conditions in which Eastern Islamic science reached al-Andalus and was later transmitted to medieval Europe, mainly through translation. Until the end of the 10th century al-Andalus was more or less systematically aware of the scientific productions of the Mashriq, but the situation changed with the fall of the Caliphate: Eastern books written after ca. 950 AD only exceptionally reached the great cities of the *ṭawā'if* kingdoms. As a consequence, Eastern books translated into Latin or Castilian in the 12th and 13th centuries, were usually written before ca. 950. Later Arabic sources translated into these languages were local Andalusī productions. The paper analyses the two elements necessary for this process of scientific transmission: the existence of libraries and the presence of patrons who sustained the needs of translators.

Key Words: Al-Andalus, Arabic Science, European Science.

Al-Andalus, puente entre las ciencias árabe y europea

Resumen:

Este artículo se propone analizar las condiciones generales de la llegada de fuentes científicas árabes orientales a al-Andalus, las cuales, en una fase ulterior, fueron transmiticas a la Europa medieval mediante, sobre todo, traducciones. Hasta fines del siglo X al-Andalus se mantuvo al corriente de la mayor parte de la producción científica oriental, pero la situación cambió con la caída del Califato. Los libros orientales escritos después de c. 950 sólo llegaron de manera excepcional a las capitales de los taifas. Por consiguiente, los libros orientales traducidos al latín o al castellano en los siglos XII y XIII suelen ser anteriores a c. 950. Las fuentes árabes posteriores a esta fecha que fueron objeto de traducciones suelen ser resultado de la producción local andalusí. El artículo analiza las dos condiciones necesarias para que se lleve a cabo el proceso de transmisión: la existencia de bibliotecas y el mecenazgo que permitía que los traductores pudieran dedicarse a su trabajo.

Palabras clave: al-Andalus, ciencia árabe, ciencia europea.

الأندلس جسر بين العلوم العربية والأوروبية

ملخص

يرمي هذا المقال إلى تحليل الشروط العامة لوصول المصادر العلمية العربية المشرقية إلى الأندلس، والتي تم نقلها في فترة لاحقة إلى أوروبا في العصور الوسطى عن طريق الترجمة بصورة خاصة. فلغاية نهاية القرن العاشر كانت الأندلس على اطلاع على غالبية النتاج العلمي المشرقي، غير أن تلك الحالة تغيرت بسقوط الخلافة. فالكتب المشرقية المؤلفة بعد سنة 950 كانت تصل بشكل استثنائي إلى عواصم دول الطوائف. وعليه فإن الكتب المشرقية المترجمة إلى اللغة اللاتينية أو القشتالية في القرنين الثاني عشر والثالث عشر يعود تأريخها عادة إلى ما قبل سنة 950. والمصادر العربية التي تلي هذا التاريخ والتي ترجمت تكون عادة نتاج التأليف المحلي الأندلسي. يحلل هذا المقال الشرطين الضروريين لحصول عملية النقل: وجود مكتبات وتوفر من يرعى العلوم والفنون وهو ما كان يجعل المترجمين منكبين على عملهم.

الكلمات المفاتيح: الأندلس، العلوم العربية، العلوم الأوروبية

1. Presentation

This paper has been extracted from the first chapter of a book I am writing and which will keep me occupied for some time. It deals with the history of medieval astronomy on either side of the Straits of Gibraltar and sets out to demonstrate that Andalusī astronomy, Maghribī astronomy, and the astronomy practised in the Christian kingdoms of the Iberian Peninsula all stem from a common tradition and should be analysed together, as a whole.

One of the problems on which I have focused my research has been the role played by al-Andalus in the transmission of Islamic astronomy to Europe during the Middle Ages, mainly through a process which began in Catalonia in the 10th century and ended in Toledo, or perhaps in Seville, three centuries later. Can this role explain why important astronomers such as al-Bīrūnī do not seem to have been translated into Latin, or any other European language, or why the very important astronomical contributions of the so-called "Marāgha school", from the thirteenth century onwards, do not seem to have reached Europe, in spite of the fact that Copernicus's

astronomical models would seem to have many points in common with the production of Marāgha?

In this paper I will attempt to provide an answer to the question raised by Dimitri Gutas, amongst others, as to the criterion followed by the Barcelona, Tarazona, Tudela and Toledo-based translators when selecting scientific texts for translation. According to Gutas, "Everything —that is the entire Arabic corpus of writings up to the 12th century— was theoretically available to anyone who might wish to translate it. But this is certainly not what happened." This author tries to explain the selection of the texts which appear in Ibn Ḥazm's *Risāla fī faḍl al-Andalus* and in Ṣā'id's *Ṭabaqāt al-Umam* as "andalusocentrism". According to him "the works actually selected were those that were appreciated and cultivated by the Arabic-writing Andalusians of the 11th century."[1]

I will try here to give a different answer to this question, based on the following hypotheses:

1) The only Eastern books which were transmitted and translated were those which reached al-Andalus. In my opinion, the connection with the Mashriq was almost totally severed with the fall of the Caliphate and was progressively replaced by a new nexus with the countries of the Maghrib.
2) In order to do their work, translators needed libraries containing the books which they were going to translate and patrons who would provide them with a reasonable living.

2. The Beginnings: 10th Century Catalonia

The transmission process began in and around Barcelona towards the end of the 10th century. As a result, we have a collection of texts of clear Arabic ascendancy on the astrolabe, on other astronomical instruments such as the horary quadrant —which Millàs called the *quadrans vetustissimus*—,[2] an instrument similar to al-Battānī's *bayḍa* and on various types of sundials which seem to be of Latin origin. Most of the corpus is about the

[1] D. Gutas, "What was there in Arabic for the Latins to Receive? Remarks of the Modalities of the Twelve Century Translation Movement in Spain", in: Andreas Speer and Lydia Wegener, *Wissen über Grenzen. Arabisches Wissen und lateinesches Mittelalter*, Walter de Gruyter, Berlin-New York, 2007, 3-21. The two litteral quotations appear in pp. 6 and 8. I wish to thank Cristina Álvarez Millán for generously drawing my attention to this paper.

[2] J. M. Millàs Vallicrosa, "La introducción del cuadrante con cursor en Europa", *Isis,* 17 (1932), 218-58 [reprinted in: Millàs, *Estudios sobre Historia de la Ciencia Española,* Barcelona, 1949, 65-110].

construction and use of the astrolabe,[3] and the corresponding texts seem to have clear connections with Arabic treatises on the subject written by members of Maslama al-Majrīṭī's (d. 1007) school,[4] although Paul Kunitzsch has confirmed the existence of another source, since one of the texts in the collection, the *Sententiae astrolabii,* is a translation of a treatise by al-Khwārizmī (fl. 830).[5] Seniofredus, also known as Lupitus (Llobet) Barchinonensis, archdeacon of Barcelona Cathedral (975-95), appears to have been involved in this process of transmission.

I insist on the word "transmission" rather than "translation" because I believe only a small part of the corpus is the result of the translation of a very limited number of Arabic sources, including an Arabic translation of Ptolemy's *Planisphaerium*. Most of the texts, however, seem to be notes taken during or immediately after an oral explanation in which drawings and actual instruments were used.[6] Only Arabic astrolabes were available at first, although we also have the famous "Carolingian astrolabe", which seems to be the only case of a "translated" astrolabe from an Arabic original.[7] A minimal knowledge of Arabic was necessary to read the inscriptions (mainly the *abjad* notation, star names etc.) if one had to use an astrolabe. This is why the *Astrolabii sententiae* or *De utilitatibus astrolabii* contain Arabic terms (in some cases even full sentences), which are in fact totally unnecessary to understand the text because they are immediately followed by the Latin

[3] An edition of the Latin texts was published by J. M. Millàs Vallicrosa, *Assaig d'història de les idees físiques i matemàtiques a la Catalunya Medieval*, in «Estudis Universitaris Catalans», Sèrie Monogràfica I, Barcelona, 1931.

[4] Julio Samsó, "Maslama al-Majrīṭī and the star table in the treatise *De mensura astrolabii"*, in Menso Folkerts and Richard Lorch (eds.), *Sic itur ad astra. Studien zur Geschichte der Mathematik und Naturwissenschaften. Festschrift für den Arabisten Paul Kunitzsch zum 70. Geburtstag*, Wiesbaden, 2000, 500-22 [reprinted in: Samsó, *Astronomy and Astrology in al-Andalus and the Maghrib,* Ashgate Variorum, II, Aldershot, 2007].

[5] Paul Kunitzsch, "Al-Khwārizmī as a source for the *Sententiae astrolabii"*, in D.A. King and G. Saliba (eds.), *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, 1987, 227-36.

[6] J. Samsó, "Els inicis de la introducció de la ciència àrab a Europa a través de Catalunya", in Joan Vernet & Ramon Parés (dirs.), *La ciència en la història dels Països Catalans. I. Dels àrabs al Renaixement*, València, 2004, 115-59, esp. pp. 132-41; Arianna Borrelli, *Aspects of the astrolabe, "architectonica ratio" in tenth- and eleventh-century Europe,* Sudhoffs Archiv 57, Wissenschaftsgeschichte, Franz Steiner Verlag, Stuttgart, 2008, 118-29.

[7] M. Destombes, "Un astrolabe carolingien et l'origine de nos chiffres arabes", *Archives Internationales d'Histoire des Sciences,* 15, 1962, 3-45; see the *Proceedings* of the symposium on the Carolingian astrolabe held in Zaragoza in 1993 and published in *Physis,* 22, 1995, 450 pages.

translation. A good example of the kind of instrument used can be found in the bilingual drawings of an Arabic astrolabe made by Khalaf ibn al-Mu'ādh, extant in ms. BnF lat. 7412 and studied by Kunitzsch.[8] Here all the inscriptions on the instrument have been carefully copied in Kufic script and are perfectly legible in an 11th century manuscript. An evolution of this kind of bilingual illustration can be seen in a photograph of the (no longer extant) 12th century ms. Chartres 214 fol. 30r, where we find a clumsy attempt to reproduce the Arabic inscriptions from the instrument, which become almost illegible here. A third example, which is even worse, can be seen in the London ms. British Library Old Royal 5 B, fol. 71r, the date of which is doubtful; here the draughtsman has made an unsuccessful attempt to reproduce the Arabic inscriptions, and seems to have given up, leaving most of the spaces blank. It is obvious that the author of the BnF ms. drawings was familiar with Arabic, but the other two clearly weren't, and the successive copies of Arabic inscriptions made by illustrators who did not know the Arabic alphabet became progressively more corrupt and illegible.

Someone reading the old corpus might be puzzled by the fact that it contains very little astrological material. The situation has been somewhat clarified since David Juste's publication of the *Alchandreana*, a collection of Latin astrological texts showing clear signs of Arabic influence.[9] This is a series of eight texts sharing similar techniques of prediction: the data for the horoscope is calculated using numerological procedures (numerical values of the letters forming the name of the subject) and the prediction is based on isolated elements (the onomatomantic ascendant, the planetary hours, the position of the planets in the triplicities or in the lunar mansions, etc.). This kind of very simplified astrology is represented in two other works written in the Iberian Peninsula during the 13th century: the Alfonsine *Libro de las Cruzes* and Raimundus Lullius's *Tractatus de nova astronomia*. Both books show the same tendency towards simplification which we found in the *Alchandreana* collection, although they have little else in common with it. As for the origin of the name *Alchandreana*, I can only suggest that, bearing in mind that one of the derivations of the corpus is the so-called *Liber Arcandam*, very popular from the 16th century onwards, *Alchandreus* might be a corruption of *Arkand*, the Arabic name of an Indian astronomical book

[8] Paul Kunitzsch, "Traces of a Tenth-Century Spanish-Arabic Astrolabe", *Zeitschrift für Geschichte der Arabisch-Islamischen Wissenschaften,* 12, 1998, 113-20.

[9] David Juste, *Les* Alchandreana *primitifs. Étude sur les plus anciens traités astrologiques latins d'origine arabe (X^e siècle)*, Brill, Leiden-Boston, 2007, XVI + 726 pages + 6 plates.

which, according to Ibn Ḥayyān, was available in Córdoba in the mid 9th century (see below, 3.2.1).

3. The Ebro Valley and Toledo (12th-13th Century)

3.1 The selection of texts for translation

This first transmission of texts on astronomical instruments in the 10th century was not the start of a continuous process of translation, or of other forms of transmission, as it was soon interrupted in the 11th century. Marie Thérèse d'Alverny is one of many scholars intrigued by this interruption: "Why this promising prelude was not followed immediately by an increasing stream of translations during the eleventh century is a question still unsolved."[10]

The two problems, raised respectively by Gutas (selection of texts for translation) and d'Alverny (interruption of the process in the 11th century), can in my opinion be shown to be interrelated if we accept the following two principles:

1. Only those Oriental works which had reached al-Andalus could be the object of translation. Gutas agrees on this point: "The translations done in Spain in the 12th century were done on the basis of Arabic manuscripts available in Spain at that time, and upon recommendation, apparently, of such local experts, all of whom, naturally must have shared the Andalusocentric bias we see in Ibn Ḥazm and Ṣā'id".[11]
2. A translator needed two things in order to be able to carry out his work: a) the availability of libraries to provide him with the raw material he needed for his translations; b) patronage, allowing him to satisfy the minimum necessities of life.

The second principle explains why the transmission process was interrupted in the 11th century. The work in Catalonia towards the end of the 10th century had been centred around one very specific topic: the astrolabe, and, to a lesser extent, the horary quadrant and al-Battānī's *bayḍa*. The bibliography needed was limited to a reduced number of Arabic sources and instruments. No large library was required. Patronage was also unnecessary: the aforementioned Seniofredus/Lupitus was the archdeacon of Barcelona

[10] M. Th. d'Alverny, "Translations and translators", in R. L. Benson and G. Constable, *Renaissance and Renewal in the Twelfth Century*, Harvard U. P., Cambridge, MA, 1982, 421-62 [reprinted in: D'Alverny, *La transmission des textes philosophiques et scientifiques au Moyen Âge*, Charles Burnett (ed.), Variorum, Aldershot, 1994 (see p. 440)].

[11] Gutas, "What was there in Arabic...?", p. 9.

Cathedral, whilst one of the presumed authors of the *Alchandreana* collection seems to have been Miró Bonfill (d. 984), Bishop of Gerona from 971. The process could not continue during the 11th century because there were no libraries available: not a single major Muslim city was conquered by any of the Christian kings; consequently, there was no need for patronage. The situation changed radically towards the end of the century when Alfonso VI of Castile conquered Toledo in 1085, and again in 1118 with the conquest of Zaragoza by Alfonso I of Aragon. One should bear in mind that these two cities were two great centres of research in the fields of Astronomy and Mathematics. This was the starting point of the translation process.

Having clarified this point, we can now move on to the problem of the selection of Arabic sources for translation. My impression is that the selection was made on chronological grounds. Let us begin by putting the authors translated by Gerard of Cremona into chronological order (I omit Greek authors translated into Arabic). To this end I have used the list of his translations established by his disciples (*socii*):[12]

3.1.1 Gerard of Cremona

Oriental Sources:

VIII-2: Māshā'allāh, Jābir b. Ḥayyān
IX-1: Banū Mūsā, al-Khwārizmī, al-Farghānī, al-Kindī, Ibn Māsawayh
IX-2: al-Rāzī, Thābit b. Qurra, Yaḥyā b. Sarāfyūn, al-Nayrizī
X-1: al-Fārābī, Aḥmad b. Yūsuf, Abū Kāmil
XI-1: Ibn Sīnā, Ibn al-Haytham (*Optics*)

Andalusian and Maghribī Sources:

X-1: Isḥāq Isrā'īlī, al-Zahrāwī, 'Arīb b. Sa'īd
XI: *De motu octaue spere*, Ibn al-Zarqālluh, Ibn Mu'ādh, Ibn Wāfid
XII: Jābir b. Aflaḥ

With the exception of Ibn Sīnā and Ibn al-Haytham, the list of Oriental authors translated by Gerard of Cremona ends around 950. Works translated after that date are Andalusian. The same conclusion can be reached if we analyse works translated into Hebrew during the 13th and 14th centuries in

[12] See Charles Burnett's critical edition of the *Vita* and *Commemoratio librorum,* in his paper "The coherence of the Arabic-Latin translation program in Toledo in the twelfth century", *Science in Context,* 14, 2001, 249-88. The text appears in pp. 273-87. Reprinted in: Burnett, *Arabic into Latin in the Middle Ages. The Translators and their Intellectual and Social Con-*

the Languedoc and Provence by Jewish translators, most of whom came from the other side of the Pyrenees.[13] This time the exception belongs to the first half of the 11th century: ʻAlī b. Riḍwān.

3.1.2 Hebrew translations (13th-14th century)

Oriental Sources:

VIII-2/IX: Māshāʾallāh, Jābir b. Ḥayyān, Sahl b. Bishr, al-Kindī, Abū Maʻshar, al-Farghānī, Ḥunayn b. Isḥāq, Thābit b. Qurra, Qusṭā b. Lūqā, al-Rāzī.

X-1: al-Fārābī

XI-1: ʻAlī b. Riḍwān, Ibn al-Haytham, Ibn Sīnā

Andalusian sources:

X-1: al-Zahrāwī

X-2/XI-1: Ibn al-Ṣaffār, Ibn al-Samḥ

XI-2: Ibn al-Zarqālluh, Ibn Muʻādh

XII: Jābir b. Aflaḥ, Maimonides, Ibn Rushd, al-Bitrūjī

Similar results can be obtained for authors translated into Castilian in the court of Alfonso X, for the sources of Arabic medical translations in the list drawn up by Danielle Jacquart[14] or that for Arab mathematical works offered by Richard Lorch.[15]

It would seem, therefore, that scientific works written in the Mashriq after around 950 only exceptionally reached al-Andalus, and consequently only rarely became available for translation into Latin in the 12th century. This is confirmed by the analysis of the works to which Toledo astronomer and patron Ṣāʻid al-Andalusī (1029-1070) had access and mentions in his *Ṭabaqāt al-Umam*. The task was carried out by Richter-Bernburg,[16] who re-

text, Ashgate-Variorum, VII, Farnham, Surrey, 2009.

[13] D. Romano, "La transmission des sciences arabes par les Juifs en Languedoc", *Proceedings* of the symposium *Juifs et judaïsme de Languedoc,* published in *Cahiers de Fanjeaux,* 12, 1977, 363-86 [reprinted in: Romano, *De Historia Judía Hispánica*, Barcelona, 1991, 239-73].

[14] D. Jacquart, "The influence of Arabic medicine in the medieval West", in: R. Rashed (ed.), *Encyclopaedia of the History of Arabic Science,* 3, *Technology, Alchemy and Life Sciences*, Routledge, London, 1996, 963-84. The list appears on pp. 981-4.

[15] R. Lorch, "Greek-Arabic-Latin: the Transmission of Mathematical Texts in the Middle Ages", *Science in Context,* 14, 2001, 313-31. List on pp. 317-8.

[16] Lutz Richter-Bernburg, "Ṣāʻid, the *Toledan Tables* and Andalusī Science", in D. A. King and G. Saliba (eds.), *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, 1987, 373-401.

marked that, in the fields of medicine and astronomy, Ṣā'id's information on the Mashriq rapidly decreased from the end of the 10th century and that the two Mashriqī scholars close to his own time and mentioned in the *Ṭabaqāt* are Ibn Yūnus (d. 1009) and Ibn al-Haytham (965-1041).[17]

3.2 Libraries

3.2.1 The Royal Library of Cordova

Let us now consider the problem of the libraries in al-Andalus, starting with the royal library in Cordova.[18] The origins of this library may date back to around the year 800. The publication, some years ago, of volume II-1 of Ibn Ḥayyān's *Muqtabis* has afforded us information on the books brought to Cordova from Baghdad by the astrologer 'Abbās b. Nāṣiḥ (fl. c. 800-50), including a list of what are presumably astronomical tables, called *al-Zīj*, *al-Qānūn, al-Sindhind*, and *al-Arkand*.[19] There seems to be little doubt as to the identification of the *Sindhind* (probably al-Khwārizmī's *Zīj*, the use of which is well documented in al-Andalus in the 10th century); *al-Qānūn* probably refers to Ptolemy's *Handy Tables* and *al-Arkand* is another set of Indian astronomical tables introduced in Baghdad in the 8th century. The reference to *al-Zīj* is too vague to allow identification.

Although we have little information regarding the fate of the library in the 9th century, it seems clear that it existed and was accessible to scholars who frequented the royal court. One of them —poet and astrologer 'Abbās

[17] Richter-Bernburg, "Ṣā'id...", 379.

[18] Julián Ribera, "Bibliófilos y bibliotecas en la España Musulmana", in: Ribera, *Disertaciones y opúsculos,* 1, Madrid, 1928, 181-228; David Wasserstein, "The library of al-Ḥakam II al-Mustanṣir and the culture of Islamic Spain", *Manuscripts of the Middle East,* 5, 1990-1, 99-105 [my thanks to Maribel Fierro for providing me with a digitalised copy of this paper]; M.J. Viguera, "Bibliotecas y manuscritos árabes en Córdoba", *Al-Mulk. Revista del Instituto de Estudios Califales*, 5, 2005, 97-113; Christine Mazzoli-Guintard, "De la collection à la dispersion, la bibliothèque des Omayyades de Cordoue (IXe-XIe siècles)", in: Anne-Marie Cocula and Michel Combet, Château (eds.), *Livres et manuscrits IXe-XXIe siècles. Actes des Rencontres d'Archéologie et d'Histoire en Perigord*, Bordeaux, 2006, 9-22. See also M. F. al-Wasif, "Al-Mustanṣir al-Ḥakam", *Biblioteca de al-Andalus,* 6, Almería, 2009, 590-8.

[19] Maḥmūd 'Alī Makkī (ed.), *Al-sifr al-thānī min kitāb al-Muqtabis li-Ibn Ḥayyān al-Qurṭubī,* Riyāḍ, 1424/2003, 278 and 525-7; Spanish translation by M. 'A. Makkī and F. Corriente, *Crónica de los emires Alḥakam I y 'Abdarraḥmān II entre los años 796 y 847*, Zaragoza, 2001, 169-170. See also: M. Forcada, "Astronomy, Astrology and the Sciences of the Ancients in early al-Andalus", *Zeitschrift für Geschichte der Arabisch-Islamischen Wissenschaften,* 16, 2004-5, 1-74 (see pp. 20-2).

b. Firnās (d. 887)— borrowed al-Khalīl's *Kitāb al-'Arūḍ* from it and became a celebrity because he was able to understand this difficult book on Arabic metrics.[20] Ibn Ḥayyān also reproduces a poem dedicated to emir Muḥammad (852-86) by 'Abbās b. Firnās, in which he complains about the fact that Ibn al-Shamir (or Shimr), another court astrologer, has for a long time held in his possession a book described as *al-daftar al-muḥkam,* which 'Abbās wants to use.[21] This book probably contained another set of astronomical tables.[22]

The library reached its apogee during the caliphate of al-Ḥakam II al-Mustanṣir (961-76). Al-Ḥakam became caliph when he was 47, and up to that time he had spent his life collecting books, which were bought for him by his agents in the Middle East and then incorporated into his collection in his private residence (*Dār al-Mulk*). In 951, his father 'Abd al-Raḥmān III (912-61) ordered his brother 'Abd Allāh's execution, and al-Ḥakam inherited his private library. When al-Ḥakam rose to the throne, his collection was incorporated into the royal library and sources state that six months were required for the transfer of all the books. It is not known with certainty where the library was kept: perhaps in the royal palace (al-Qaṣr) opposite the great mosque, or in the royal residence of Madīnat al-Zahrā' outside the city.[23] One way or the other it must have been enormous: historical sources claim that it contained 400,000 volumes, a number which is clearly exaggerated and is probably a stereotype for it is also attributed to the Library of Alexandria and to the one assembled by Almería *ṭā'ifa* king Zuhayr's vizier Abū Ja'far Ibn 'Abbās in the 11th century.[24] In any case it seems that the catalogue, which contained only the titles of the books, filled 44 volumes, each one made up of 20 or 50 folios, according to the source. We do not know what the exact contents of the library were, but a study carried out in

[20] E. Terés, «'Abbās ibn Firnās», *Al-Andalus,* 25, 1960, 239-49.

[21] The reference is *al-Muqtabis* II-1, 281-2: see M. 'A. Makkī (ed.), *Ibn Ḥayyān, al-Muqtabas min anbā' ahl al-Andalus*, Beirut, 1393/1973.

[22] J. Vernet, "La maldición de Perfecto", in: Y. Maeyamaa & W.G. Saltzer (eds.), *Prismata. Naturwissenschaftsgeschichtliche Studien. Festschrift für Willy Hartner,* Wiesbaden, 1977, 417-8 [reprinted in: Vernet, *Estudios sobre Historia de la Ciencia Medieval*, Barcelona-Bellaterra, 1979, 233-4].

[23] According to Viguera, "Bibliotecas", historian Ibn Ḥayyān stated, in a passage preserved by Ibn Bassām and al-Maqqarī, that there were books from al-Ḥakam's library in the Royal Palace after its burning in the time of al-Manṣūr.

[24] The library of the Banū Rustum of Tāhart at the end of the 8th cent. and beginning of the 9th cent. seems to have contained 300,000 volumes according to historical sources.

1994 on the number of books circulating in Cordova around the year 975, documented 897 books of which 44 dealt with medicine, 32 with astronomy, astrology and mathematics, 8 with philosophy and 5 with alchemy and agronomy.[25]

At an unknown date between 981 and 989, *ḥājib* al-Manṣūr b. Abī ʻĀmir (gov. 981-1002), attempted to gain favour with the orthodox *fuqahā'* by ordering a selective burning of al-Ḥakam's library. The hostility of the *fuqahā'* was directed mainly against the Sciences of the Ancients (*'ulūm al-awā'il*), whilst disciplines such as arithmetic, medicine, and *mīqāt* were spared.

During the siege of Cordova by Berber troops in 1010, part of the library was sold in an auction and, in this way, its books reached Toledo and other *ṭā'ifa* capitals. The rest of the library was destroyed by the Berbers. So far as has been established to date, only one book has survived from al-Ḥakam's library: it contains the *Mukhtaṣar* by Abū Muṣʻab (d. 242/856-7), a compendium of the legal doctrines of Mālik b. Anas.[26] It was identified by E. Lévi-Provençal and it is now preserved in the library of the Qarawiyyīn mosque-university in Fez. The explicit reads "copied by Ḥusayn Ibn Yūsuf, servant of the *imām* al-Mustanṣir bi-llāh" and it is dated in the "month of Shaʻbān, 359 H."/9th June-7th July 970.[27]

3.2.2 King al-Mu'taman's library in Zaragoza

Al-Ḥakam's library was the last instance of a general library in al-Andalus receiving a significant proportion of the most relevant books written in the Mashriq. During the *ṭā'ifa* period (1031-86), none of the monarchs ruling over the small kingdoms resulting from the fall of the caliphate had either sufficient interest or the financial capacity to continue with such a policy. In spite of this, there can be no doubt that smaller, more specialised libraries existed, though they were rarely able to keep up to date with the latest Oriental novelties. The library of King Yūsuf Ibn Hūd al-Mu'taman of Zaragoza (r. 1081-5) is especially relevant to our purpose, be-

[25] Maribel Fierro, "Manuscritos en al-Andalus. El proyecto *H.A.T.A.* (Historia de los Autores y Transmisores Andalusíes)", *Al-Qanṭara,* 19, 1998, 473-501 (see p. 490).

[26] Joseph Schacht, "On Abū Muṣʻab and his "Mujtaṣar", *Al-Andalus,* 30, 1965, 1-14 (see p. 8).

[27] There is a good photograph of the page in: Jerrilynn D. Dodds (ed.), *Al-Andalus. Las artes islámicas en España,* Madrid-New York, 1992, The Metropolitan Museum of Art and Ediciones El Viso, 177.

cause he was a highly competent mathematician, author of the *Istikmāl*, a major treatise on geometry and number theory which circulated throughout the Islamic world from Morocco to Marāgha in Iran. It is possible that al-Muqtadir (1046-81), al-Mu'taman's father, who was also interested in mathematics, had already begun to build up the library. A study by J. P. Hogendijk[28] provides us with a full list of the mathematical sources quoted in the *Istikmāl*. They include Arabic translations of Greek classics: Euclid's *Elements, Data* and *Porisms*, Ptolemy's *Almagest*, Apollonius's *Conics* and *Plane loci*, Archimedes's *Sphere and Cilinder* and *Measurement of the circle*, and the commentaries by Eutocius, as well as the treatises on the *Sphere* by Theodosius and Menelaos. Among Arab authors we find *Measurement of plane and spherical surfaces* by the Banū Mūsā (active around 830), *On the sector figure* and *On amicable numbers* by Thābit b. Qurra (d. 901), *On the quadrature of the parabola* by Ibrāhīm b. Sinān (d. 946) and finally *Analysis and synthesis, Optics* and *On known data* by Ibn al-Haytham (d. c. 1040), who is once again the exception.

What we do *not* find in al-Mu'taman's *Istikmāl* are the works of the great Oriental mathematicians —apart from Ibn al-Haytham— who were active between c. 950 and c. 1050: Abū Ja'far al-Khāzin (d. c. 965), Abū l-Wafā' al-Būzjānī (940-97), Abū Sahl al-Kūhī (fl. c. 988), Abū Maḥmūd al-Khujandī (d. c. 1000), Abū Nasr Manṣūr Ibn 'Irāq (died before 1036) and al-Bīrūnī (973-1048).

This is in line with the hypothesis which I presented in 3.2.1: new sources published in the East only exceptionally reached al-Andalus. There were, of course, authors who must have had access to privileged information: one of them is Ibn Mu'ādh al-Jayyānī (d. 1093) whose treatise on spherical trigonometry (*Kitāb majhūlāt qisī al-kura*) was the first Western book to deal with the new trigonometrical theorems (sine law, cosine law, tangents law, rule of four, Geber's theorem...) which had been discovered precisely by some of the aforementioned Middle Eastern mathematicians and astronomers.[29] Ibn Mu'ādh's book was never translated into Latin, but the new trigonometry was reintroduced in the *Iṣlāḥ al-Majisṭī* by Jābir b. Aflaḥ (12th cent.) which *was* translated into Latin and Hebrew.

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[28] His first paper on the topic was published in 1986: J.P. Hogendijk, "Discovery of an 11th Century Geometrical Compilation: the *Istikmāl* of Yūsuf al-Mu'taman ibn Hūd, King of Saragossa", *Historia Mathematica,* 13, 1986, 43-52.

[29] See Samsó, "«Al-Bīrūnī» in al-Andalus", in: J. Casulleras and J. Samsó (eds.), *From Baghdad to Barcelona*, Barcelona, 1996, 583-612 [reprinted in: Samsó, *Astronomy and Astrology in al-Andalus and the Maghrib*, Ashgate-Variorum, 6, Aldershot, 2007].

In 1110 the Almoravid emir conquered Zaragoza and King 'Imād al-Dawla (1110-30), grandson of al-Mu'taman, took up residence in the fortress of *Rūṭa* (Rueda del Jalón), where he held out even after the conquest of Zaragoza in 1118 by King Alfonso I of Aragon. It is logical to imagine that al-Mu'taman's library was ubicated, throughout this period, in Rueda. The problem is to determine what happened to the library when King al-Mustanṣir (1130-46) exchanged Rueda for territory near Toledo, as a result of an agreement reached in 1140 with Alfonso VII of Castile. It is quite possible, as Burnett suggests, that the library, or what was left of it, ended up in Toledo.[30]

3.2.3 Use of al-Mu'taman's library by the Ebro Valley translators

Al-Mu'taman's library was doubtless accessible to Bishop Michael (1119-51) of Tarazona —a town near Rueda—, who acted as patron to the translation work of Hugo of Santalla. Hugo translated Ibn al-Muthannā's commentary of al-Khwārizmī's astronomical tables for him, a book which was also translated into Hebrew by Abraham b. 'Ezra (c. 1092–c. 1167),[31] and Hugo's dedicatory incipit contains the following significant passage:

> Quia ergo, mi domine Tyrassonensis antistes, ego Sanctalliensis, tue petitioni ex me ipso satisfacere non possum huius commenti translationem, quod ... in Rotensi armario et inter secretiora bibliotece penetralia tua insaciabilis filosophandi aviditas meruit repperiri, tue dignitati offerre presumo.[32]

which may be translated:

> My lord Bishop of Tarazona, as I, Sanctallensis, cannot satisfy your request myself, I offer your dignity the translation of this commentary... which your insatiable philosophical avidity deserved to find in a cupboard in Rota [= Rueda], in the most secret part of the library.

Santalla's translation is not dated, but one might ask oneself if Bishop Michael had come to some kind of arrangement with 'Imād al-Dawla or

[30] Burnett, "The Coherence of the Arabic-Latin Translation Program...", 251.

[31] Bernard R. Goldstein, *Ibn al-Muthannā's Commentary on the Astronomical Tables of al-Khwârizmî. Two Hebrew versions edited and translated with an astronomical commentary by...,* New Haven and London, 1971, Yale U.P.

[32] Eduardo Millás Vendrell, *El comentario de Ibn al-Muṭannā'* [sic] *a las Tablas Astronómicas de al-Jwārizmī. Estudio y edición crítica del texto latino en la versión de Hugo Sanctallensis*, Madrid-Barcelona, 1963, 95-6.

with his son al-Mustanṣir. Had he bought all or part of the library? Was the library really transfered to Toledo?

In any case, this library seems to have been the origin of the books translated not only by Hugo of Santalla, but also by Hermann of Carinthia (fl. 1138-43) and Robert of Ketton (fl. 1141-57) who were, at that time, working in the nearby town of Tudela.[33] The library may too have been used by Petrus Alfonsi of Huesca (c. 1062–after 1110), who collaborated with Adelard of Bath (fl. 1100-50) and furnished him with Andalusian manuscripts, including al-Khwārizmī's *zīj* in the revision by Maslama al-Majrīṭī. I would suggest that the library might also have been accessed by Abraham b. 'Ezra (fl. 1140-60, born in Tudela), Abraham bar Ḥiyya (fl. Barcelona, 1133-45) and by the latter's collaborator Plato of Tivoli, some of whose translations are carefully dated between 1133 and 1145. All of these authors seem to share interests in mathematics, astronomy, astrology and other forms of divination.

3.2.4 The libraries of Toledo

We have no information about any Arabic libraries in Toledo, but it is obvious that such libraries existed, given the high level of scientific activity —especially in the field of astronomy— attained by 11th century Toledo scholars. There can be no doubt that there were important private libraries in the city, as we know from M. Marín's study of the Toledo *'ulamā'*, most of whom were dedicated to the religious sciences, although some were also interested in the "sciences of the ancients".[34] Mark of Toledo's reference to the *armaria arabum*[35] shows that some of these libraries were still extant at the beginning of the 13th century.

To these we should add the possible presence in Toledo of parts of al-Ḥakam II's library, auctioned in Cordova in 1010. In support of this idea we have Ṣā'id al-Andalusī's comment that he had seen a book with notes written in al-Ḥakam's own hand stating that al-Ḥasan b. Aḥmad b. Ya'qūb al-Hamdānī —one of the sources used by Ṣā'id— had died in prison in Ṣan'ā' in 334/946.[36] It is also possible that the remains of al-

[33] Charles Burnett, "The coherence of the Arabic-Latin Translation Program...", 251: "...whose library had been used by the translators of the Valley of the Ebro".

[34] Manuela Marín, "Los ulemas de Toledo en los siglos IV/X y V/XI", *Entre el Califato y la Taifa: mil años del Cristo de la Luz*, Toledo, 2000, 67-96.

[35] Ramón Gonzálvez Ruiz, *Hombres y libros de Toledo*, Madrid, 1997, 58.

[36] Ṣā'id, *Ṭabaqāt al-Umam,* ed. Ḥayāt Bū 'Alwān, Beirut, 1980, 149: French translation by

Mu'taman's library reached Toledo too. Charles Burnett argues that "the texts on geometry that Gerard of Cremona chose to translate correspond to those used by one of the kings of the dynasty in the late eleventh century".[37] This is of course true, as Gerard translated Euclid's *Elements* and *Data*, Ptolemy's *Almagest*, Archimedes's *On the Measurement of the Circle,* Theodosius's and Menelaus's treatises *On the Sphere,* a treatise *On Geometry* by the Banū Mūsā and Thābit ibn Qurra's *On the Sector-Figure*. Furthermore, the manuscripts of Theodosius's and Menelaus's *Spherics* used by al-Mu'taman belong to the same family as those translated by Gerard of Cremona.[38]

Ṣā'id's *Ṭabaqāt* is a good guide as to what astronomical sources were available in Toledo towards the middle of the 11th century, although caution is necessary because in some cases Ṣā'id's information seems to be second hand.[39] This may well be true of his reference to Ibn al-Haytham and probably also of Ibn Yūnus.[40] In some cases, however, there is clear evidence that he had direct access to the sources because he gives details of their contents or because such details are given in works written by other members of the Toledo group. Such is the case of some of Aristotle's works which he analyses in detail.[41] He is also familiar with Ptolemy, mentioning the *Almagest*, the *Geography*, the *Optics*, the *Tetrabiblos* and the *Kitāb al-Qānūn*,[42] there being no doubt that he at least had direct access to the *Almagest.* He also refers, probably through secondary sources, to Theon of Alexandria's version of the *Qānūn,* as well as to a certain *Kitāb al-aflāk* in which, according to Ṣā'id, Theon describes the structure (*hay'a*) of the celestial spheres and the planetary models in a simple way, without Ptolemy's geometrical proofs. He is probably referring to Theon's *Commentary of the Almagest*. In the *Qānūn* (he must mean Theon's commentary on the *Handy Tables*), Ṣā'id finds a de-

Régis Blachère, *Ṣā'id al-Andalusī, Kitāb Ṭabaḳāt al-Umam (Livre des Catégories des Nations)*, Paris, 1935, 116.

37 Burnett: "The Coherence of the Arabic-Latin Translation Program...", 251.

38 Richard Lorch, "The Transmission of Theodosius' *Spherica*", in M. Folkerst (ed.), *Mathematische Probleme im Mittelalter: der lateinische und arabische Sprachbereich*, Harrassowitz, Wiesbaden, 1996, 159-83: J. P. Hogendijk, "Which Version of Menelaus' *Spherics* was used by al-Mu'taman ibn Hūd in his *Istikmāl*?", in M. Folkerst (ed.), *Mathematische Probleme...,* 17-44.

39 A thorough analysis of Ṣā'id's sources in Richter-Bernburg, "Ṣā'id...", 377-85.

40 *Ṭabaqāt,* ed. Bū 'Alwān, 149-50; tr. Blachère, 116.

41 *Ṭabaqāt,* ed. Bū 'Alwān, 76-82; tr. Blachère, 62-9.

42 *Ṭabaqāt,* ed. Bū 'Alwān, 88-91; tr. Blachère, 72-3.

scription of the trepidation model, according to the *aṣḥāb al-ṭillasmāt.*[43] It is also clear that Ṣā'id had access to the *Kitāb fī l-ḥarakāt al-samāwiyya* by al-Farghānī (d. 861)[44] and to al-Battānī's *zīj.*[45] He considers both works to be useful summaries of the *Almagest.*

Ṣā'id was also acquainted with al-Khwārizmī's *zīj*,[46] the adaptation to the Islamic calendar and to the geographical coordinates of Cordova made by Maslama al-Majrīṭī and the versions prepared by Maslama's disciples.[47] His reference to al-Ḥasan b. al-Ṣabbāḥ's *zīj* (9th cent.) is interesting, because he states that the mean motions followed the *Sinhind* system —which implies that they were sidereal— while he used Ptolemaic equations and the table of the solar declination according to recent observations.[48] This description fits in well with the main characteristics of Andalusī-Maghribī *zīj*es, from the *Toledan Tables* to Ibn al-Raqqām (d. 1320).

Within the Khwārizmian tradition, an important source with which Ṣā'id was undoubtedly familiar is Ibn al-Ādamī's *Niẓām al-'iqd,* a *zīj* left unfinished by its author and completed by his disciple al-Qāsim b. Muḥammad b. Hāshim al-Madā'inī, known as al-'Alawī, in 949. It is in this book that Ṣā'id found information about the introduction of the *Sindhind* in Baghdad, during the caliphate of al-Manṣūr (754-75), and the version of this *zīj* which al-Fazārī prepared. In the *Niẓām,* Ṣā'id found the first accurate description of the trepidation theory, which allowed him to come to grips with the problem, study it and reach unprecedented solutions, the results of which he described in his non-extant *Iṣlāḥ ḥarakāt al-nujūm.*[49]

Another source clearly available to Ṣā'id and his collaborators were two works by al-Ḥasan b. Aḥmad b. Ya'qūb al-Hamdānī (d. 946): *Kitāb fī sarā'ir al-ḥikma* and *Kitāb al-iklīl.* The *Sarā'ir al-ḥikma* contained a systematic treatment of astronomy and astrology and is quoted by al-Istijī,[50] one of Ṣā'id's

[43] *Ṭabaqāt,* ed. Bū 'Alwān, 109; tr. Blachère, 86.

[44] *Ṭabaqāt,* ed. Bū 'Alwān, 141; tr. Blachère, 110.

[45] *Ṭabaqāt,* ed. Bū 'Alwān, 91; tr. Blachère, 73. Another reference to al-Battānī's *zīj,* as well as to his commentary on the *Tetrabiblos,* in *Ṭabaqāt,* ed. Bū 'Alwān, 142-3; tr. Blachère, 111-2.

[46] *Ṭabaqāt,* ed. Bū 'Alwān, 132; tr. Blachère, 102-3.

[47] *Ṭabaqāt,* ed. Bū 'Alwān, 168-77; tr. Blachère, 129-36.

[48] *Ṭabaqāt,* ed. Bū 'Alwān, 143-4; tr. Blachère, 112.

[49] *Ṭabaqāt,* ed. Bū 'Alwān, 130-2, 146-7; tr. Blachère, 102, 114.

[50] J. Samsó & H. Berrani, "The Epistle on *Tasyīr* and the projection of rays by Abū Marwān al-Istijī", *Suhayl,* 5, 2005, 163-242 (see pp. 194-5).

disciples. The *Kitāb al-iklīl* was a historical book on Ḥimyar tribal genealogies, but also contained astronomical and astrological material.[51]

In spite of the information given by Ṣā'id on the observations made c. 830 during the caliphate of al-Ma'mūn (813-833), and on the *zīj*es based on these observations authored by Yaḥyā b. Abī Manṣūr, Khālid b. 'Abd al-Malik al-Marwazī, Sanad b. 'Alī and 'Abbās b. Sa'īd al-Jawharī —which, according to Ṣā'id, were accessible to all scholars of his time—,[52] the presence of such sources in Toledo during Ṣā'id's lifetime seems highly unlikely.[53] The same can be said of the three *zīj*es produced by Ḥabash al-Ḥāsib, although it seems that Ḥabash's treatise on the use of the astrolabe[54] *had* reached al-Andalus in the 11th century, as Ibn al-Samḥ (d. 1035) used it.[55] Information on the Ma'mūnī solar observations *was*, however, accessible to Ṣā'id through the book on the solar year attributed to Thābit ibn Qurra (836-901), which both our author[56] and Ibn al-Zarqālluh[57] had clearly read, although they attributed to Thābit observations which had in fact been carried out by al-Ma'mūn's astronomers in 830-831.

In the field of astrology, besides Ptolemy's *Tetrabiblos,* Ṣā'id had access to a number of works by Abū Ma'shar (d. 886); he provides us with a long list of these books[58] but only gives details of his *al-Zīj al-kabīr* and the small *zīj* entitled *Zīj al-qirānāt*. Ṣā'id must have had the opportunity of reading Abū Ma'shar's great *Introduction to Astrology* (*al-Madkhal al-Kabīr*), quoted by his disciple al-Istijī,[59] who also mentions the *Kitāb al-milal wa-l-duwal,*[60] possibly

51 *Ṭabaqāt,* ed. Bū 'Alwān, 66, 113, 147-9 ; tr. Blachère, 53, 89-90, 114-6.

52 *Ṭabaqāt,* ed. Bū 'Alwān, 132-3; tr. Blachère, 103-4.

53 In spite of this, J. Chabás and B. R. Goldstein ["Andalusian Astronomy: *al-Zīj al-Muqtabis* of Ibn al-Kammād", *Archive for History of Exact Sciences,* 38, 1996, 317-34, see pp. 2 and 32] have found evidence of the influence of Ibn Abī Manṣūr's *zīj* in the work of Ibn al-Zarqālluh's disciple Ibn al-Kammād (fl. 1116). The allusions to the collection of Ma'mūnī *zīj*es in Abraham b. 'Ezra's *De rationibus tabularum* are probably less significant, as Ibn 'Ezra had access to Eastern sources which never reached the Iberian Peninsula: see J. Samsó, "«Dixit Abraham Iudeus»: algunas observaciones sobre los textos astronómicos latinos de Abraham ibn 'Ezra", *Iberia Judaica,* 4, 2012, 171-200.

54 *Ṭabaqāt,* ed. Bū 'Alwān, 140-1; tr. Blachère, 109-10.

55 M. Viladrich, *El "Kitāb al-'amal bi-l-aṣṭurlāb" (Llibre de l'ús de l'astrolabi) d'Ibn al-Samḥ. Estudi i traducció*, Barcelona, 1986, 70-7.

56 *Ṭabaqāt,* ed. Bū 'Alwān, 103-4; tr. Blachère, 81-2.

57 Cf. J, Samsó, "Trepidation in al-Andalus in the 11th century", in Samsó, *Islamic Astronomy and Medieval Spain*, Ashgate-Variorum, VIII, Aldershot, 1994 (see p. 8).

58 *Ṭabaqāt,* ed. Bū 'Alwān, 144-5; tr. Blachère, 112-3.

59 Samsó & Berrani, "The Epistle on *Tasyīr*", 213-4.

Ṣā'id's source for his description of the Persian cycles governing the history of the world.[61] In addition he had access to the *Kitāb al-mudhakkarāt*[62] and to the *Kitāb al-Ulūf,*[63] from which he gathered his information about the Hermetic legend. Finally I would just mention al-Ḥusayn/al-Ḥasan b. al-Khaṣīb (fl. 844), author of a *Kitāb fī l-mawālīd*,[64] also quoted by al-Istijī.[65]

3.2.5 Al-Andalus between Mashriq and Maghrib

The limited number of astronomical sources available to an astronomer like Ṣā'id is clearly significant because it shows, once again, that the supply of Oriental books to al-Andalus was interrupted towards the middle of the 10th century, and because it exemplifies the kind of Middle Eastern sources used by Andalusian astronomers in the following centuries. Furthermore, from the 11th century onwards, Andalusian scholars seem to have considered that a student did not need to complete his education by travelling to the great cities of the East, and that the cultural level of al-Andalus was equivalent to that of Baghdad, Damascus or Cairo. A statistical survey based on the recently published *Biblioteca de al-Andalus*[66] shows a major reduction in the number of "journeys in search of knowledge" (*riḥla fī ṭalab al-'ilm*) to the East undertaken by Andalusian scholars between the 11th and the beginning of the 13th centuries, coupled with an increase in their travels to the Maghrib. One need only remember that first-rate scholars such as Ibn Ḥazm, Ibn al-Zarqālluh, Ibn Rushd or Ibn Zuhr do not seem to have travelled to the East.

	Number of biographies	Travellers to the East	%	Travellers to the Maghrib	%
Emirate & Caliphate (8th-10th cent.)	456	101	22,15%	12	2,63%
Ṭawā'if (11th cent.)	428	58	13,55%	24	5,60%
Almoravids & Almohads (1085-1232)	995	126	12,66%	249	25,03%

[60] Samsó & Berrani, "The Epistle on *Tasyīr*", 187-8.

[61] *Ṭabaqāt,* ed. Bū 'Alwān, 62-3; tr. Blachère, 50-1.

[62] *Ṭabaqāt,* ed. Bū 'Alwān, 102, 142; tr. Blachère, 81, 111.

[63] *Ṭabaqāt,* ed. Bū 'Alwān, 68-9; tr. Blachère, 55. On the Hermetic legend see also *Ṭabaqāt,* ed. Bū 'Alwān, 106-8; tr. Blachère, 84-6.

[64] *Ṭabaqāt,* ed. Bū 'Alwān, 145-6; tr. Blachère, 113. The full title is *al-Kitāb al-muqni' fī l-mawālīd,* extant in at least two Escorial manuscripts (940 and 978).

[65] Samsó & Berrani, "The Epistle on *Tasyīr*", 193-5.

[66] J. Lirola (ed.), *Biblioteca de al-Andalus*, Almería, 2004-12, Fundación Ibn Tufayl, 8 vols.

The lack of contact with Oriental culture and science affected not only the work of translators, but also the history of Andalusian science as a whole. The golden half-century of the *ṭawā'if* (c. 1035-85) saw a splendid flourishing of science in al-Andalus (mainly in the fields of Astronomy, Mathematics and Agronomy), but from then on Andalusian science was forced to proceed on the basis of its own resources. This lead, on the one hand, to a certain originality, but, on the other, to steady decline after the 12th century. One of the reasons for this decline was, without doubt, the almost total lack of contact with Eastern Islamic Science, which continued active until well into the 15th century.

3.3 Patronage

Sponsoring translations seems to have been one of the responsibilities which the Church took upon itself, until the middle of the 13th century when the royal patronage of King Alfonso X of Castile (r. 1252-84) took over.[67] Initially, that is in Catalonia at the end of the 10th century, the only people whose names appear in connection with the old corpus of Latin texts on astronomical instruments, and the *Alchandreana* collection, are Archdeacon Seniofredus/Lupitus and Bishop Miró Bonfill. Once the production of translations really got under way in the Ebro Valley (1119-57), Bishop Michael of Tarazona (1119-51) acted as patron to Hugo of Santalla, as is evidenced by the incipit which he dedicates to his sponsor.[68] It is clear that some kind of relationship also existed between Hugo of Santalla and the translators working in nearby Tudela, namely Hermann of Carinthia and Robert of Ketton; however there is no evidence that Bishop Michael sponsored *their* translations, and we have no information about how they supported themselves until 1141-3, when both Hermann and Ketton are known to have worked for Peter the Venerable, abbot of Cluny, on the translation of the *Qur'ān* and other religious texts. As Ketton's contribution

[67] This royal patronage is not without precedents: Johannes Hispalensis dedicates his translation of the pseudo-Aristotelic *Secret of Secrets* to Queen Teresa of Portugal (1112-28): see Ch. Burnett, "«Magister Iohannes Hispalensis et Limiensis» and Qusṭā ibn Lūqā's *De differentia spiritus et animae:* a Portuguese contribution to the Arts Curriculum?", *Mediaevalia, Textos e Estudos,* 7-8, 1995, 221-67 [reprinted in: Burnett, *Arabic into Latin in the Middle Ages. The Translators and their Intellectual and Social Context*, Ashgate-Variorum, V, Farnham, Surrey, 2009].

[68] Charles H. Haskins, *Studies in the History of Mediaeval Science,* Cambridge MA, 1924, Harvard U.P., 67-81.

was probably more important than Hermann's, he was rewarded with the post of archdeacon of Pamplona (1143-57).[69]

Various archbishops of Toledo are also known to have been interested in translations: such is the case of Raymond of La Sauvetat (1125-52)[70] and his successor John (1152-66)[71]. This interest continued into the 13th century: the library of Sancho of Aragón (1266-75) contained eleven translations from the Arabic,[72] whilst Gonzalo Pétrez (= Gonzalo García Gudiel) (1280-99) maintained a *scriptorium* where books were copied, and ordered new translations from Juan González of Burgos and Solomon the Jew. Two inventories of Pétrez's possessions, dated in 1273 and 1280, include some thirty books translated from Arabic, including autograph copies handwritten by Michael Scot and Hermann the German.[73]

It is particularly significant that the majority of the great Toledo translators held posts linked to Toledo Cathedral. Dominicus Gundissalinus was archdeacon of Cuéllar, a town belonging to the Toledan see, and his name appears on cathedral documents dated up to 1181.[74] A Mossarab (d. 1215), who might possibly be identified as Johannes Hispanus, was dean of Toledo and archdeacon of Cuéllar after Gundissalinus.[75] Gerard of Cremona (mentioned in cathedral documents dated 1157, 1174 and 1176), Mark of Toledo, Michael Scott[76] and Hermann the German (d. 1272) were all canons of Toledo. The latter appears as canon of the cathedral in 1263 and was bishop of Astorga between 1266 and 1272.[77] There seems to be no doubt that this was the way in which the archbishops of Toledo exercised their patronage over translations.

3.3.1 The kingdom of Castile in the 13th century: the Alfonsine corpus

The patronage of Alfonso X of Castile (r. 1252-84) stands out as the first clear instance of royal sponsorship of a serious programme of transmission of Arabic astronomical materials into a non-Latin language, namely

[69] C. S. F. Burnett, "A Group of Arabic-Latin Translators Working in Northern Spain in the mid-12th Century", *Journal of the Royal Asiatic Society,* 1977, 62-108.

[70] Burnett, "The coherence of the Arabic-Latin Translation Program...", 250.

[71] Burnett, "The coherence of the Arabic-Latin Translation Program...", 251-2.

[72] Gonzálvez Ruiz, *Hombres y libros de Toledo*, 272-4, 280-93.

[73] Gonzálvez Ruiz, *Hombres y libros de Toledo*, 426-44, 467-512.

[74] Burnett, "The coherence of the Arabic-Latin Translation Program...", 264.

[75] Burnett, "The coherence of the Arabic-Latin Translation Program...", 252.

[76] Burnett, "The coherence of the Arabic-Latin Translation Program...", 252-3.

[77] Gonzálvez Ruiz, *Hombres y libros de Toledo*, 588-600.

Castilian. This ocurred almost a century earlier than the appearance, in French, of the *Practique de astralabe* by Pèlerin de Prusse (1362), and even longer before Geoffrey Chaucer wrote his treatise on the same subject for the education of his son Lewis (1391). The King's collaborators translated many new Arabic originals which had not previously been put into Latin,[78] texts probably found in the libraries of Cordova and Seville after their conquest in 1236 and 1248 by Alfonso's father Fernando III (1217-52). The pattern set in 3.1 for the chronology and origin of the books translated remains the same: Middle-Eastern sources dated after the end of the 10th century are limited to Ibn al-Haytham —who also appeared in the previous lists— and the physician-astrologer 'Alī b. Riḍwān:

Middle-Eastern sources
IX-2: al-Battānī, Qusṭā b. Lūqā
X-2: al-Ṣūfī
XI-1: Ibn al-Haytham (*Cosmology*), 'Alī b. Riḍwān

Andalusian and Maghribī sources
X-1: *Picatrix*
X-2: Maslama, Ibn al-Samḥ
XI-1: Ibn Abī l-Rijāl, 'Abd Allāh al-Ṭulayṭulī (*Libro de las Cruzes*)
XI-2: Ibn al-Zarqālluh, 'Alī b. Khalaf, Ibn Wāfid, Ibn Baṣṣāl

It is important to bear in mind that the Alfonsine corpus directly reflects the King's interest in astrology and magic, and is structured into two great miscellaneous collections.[79] The first is made up of works on astronomy and astrology and includes the famous *Libros del Saber de Astronomía* or *Astrología*.[80] This collection comprises:

[78] The exceptions are al-Battānī's canons, Ptolemy's *Tetrabiblos* and Ibn al-Haytham's *Cosmology*.

[79] Here I am adapting the classification proposed by Evelyn S. Procter, in *Alfonso X of Castile Patron of Literature and Learning*, Oxford, 1951, Clarendon Press, 5, who suggests three collections: astronomical, astrological and magical. However, it seems to me artificial to separate astronomy and astrology in Alfonso's works, whilst the *Lapidario*, considered by Procter as belonging to the astrological collection, seems to fit better into the magical one.

[80] The whole collection was edited uncritically by Manuel Rico y Sinobas, *Libros del Saber de Astronomía del Rey D. Alfonso X de Castilla, copilados, anotados y comentados por...,* Madrid, 1863-7, 5 vols. A facsimile edition of the royal codex (ms. Villamil 156 preserved in the Universidad Complutense de Madrid) has been published by Ebrisa, Barcelona, 1999, Planeta de Agostini.

1. The four *Libros de la Ochava Espera* or *Libro de las Estrellas Fixas* ("Books of the Eighth Sphere" or "Book of the Fixed Stars"). This is an adaptation of the *Uranography* by 'Abd al-Raḥmān al-Ṣūfī (903-98), containing a detailed description of the 48 Ptolemaic constellations (46 in the Alfonsine treatise) and the 1022 stars found in the star-catalogue of the *Almagest*. The *Almagest* material is supplemented with specific information on the astrological characteristics of each star.[81]
2. Secondly, a series of treatises on the construction and use of different astronomical instruments which functioned as analogue computing devices: the armillary sphere; the celestial sphere; spherical, plane and universal astrolabes (*azafea* and *lámina universal*). Only the armillary sphere was used for direct observation, whilst the rest were invaluable in the solution of problems in spherical astrology such as the division of the ecliptic into the twelve astrological houses without having to resort to computation. The so-called *cuadrante sennero*, not included in the *Libros del Saber*, had similar applications.[82] These instruments were therefore highly useful tools for the practising astrologer. I should mention here that whenever Alfonso's collaborators were able to locate an Arabic source dealing with the construction and use of a particular instrument, this source was immediately translated into Castilian. When this was not the case, one of the collaborators (usually Rabbí Isḥāq b. Ṣīd) would compose an original treatise on the subject.
3. A third group of texts were connected with the determination of the hour, a key factor to be taken into account, together with the local latitude, when casting a horoscope. Instruments in this category include the horary quadrant, usually called *quadrans vetus*, and the collection of Alfonsine clocks, consisting of two types of sundials, a clepsydra, the mercury clock and a candle clock.
4. Lastly, two treatises on the construction and use of the *equatorium*, an astronomical instrument which contains a series of Ptolemaic planetary models, drawn to scale, which are used to obtain, with minimal computation, the planetary longitudes for a given date and hour, essential when casting a horoscope.[83] This is also the object of other Alfonsine astronomical works not included in the *Libros del Saber*, namely the translations of al-Battānī's *zīj*[84] and Ibn al-Zarqālluh's *Almanach,* and of course the

[81] Mercè Comes, "Al-Ṣūfī como fuente del libro de la «Ochaua Espera» de Alfonso X", in: M. Comes, H. Mielgo y J. Samsó (eds.), *"Ochava Espera" y "Astrofísica". Textos y Estudios sobre las Fuentes Arabes de la Astronomía de Alfonso X*, Barcelona, 1990, 11-113 [reprinted in: Comes, *Coordenadas del cielo y de la Tierra,* Barcelona, 2013]; Julio Samsó y Mercè Comes, "Al-Ṣūfī and Alfonso X", *Archives Internationales d'Histoire des Sciences,* 38, 1988, 67-76 [reprinted in: Samsó, *Islamic Astronomy and Medieval Spain,* Ashgate-Variorum, XVII, Aldershot, 1994].

[82] José María Millás Vallicrosa, "Una nueva obra astronómica alfonsí: el Tratado del cuadrante «sennero»", *Al-Andalus,* 21, 1956, 59-92.

[83] Mercè Comes, *Ecuatorios andalusíes. Ibn al-Samḥ, al-Zarqālluh y Abū-l-Ṣalt*, Barcelona, 1991.

[84] Georg Bossong, *Los Canones de Albateni. Herausgegeben sowie mit Einleitung, Anmerkungen und Glossar versehen*, Tübingen, 1978.

famous *Alfonsine Tables*, which are rather unusual in the context of Andalusian astronomy as they compute tropical longitudes.

With the *Libros del Saber* and the series of astronomical tables we have all the instruments necessary for casting a horoscope. However, in order to interpret it, we need information on astrological theory. This is the purpose of the *Libro de las Cruzes*, an astrological handbook probably based on a late Latin source but which was in use in al-Andalus at least until the 11th century. More elaborate astrological theory can be found in the translation of the *Cuadripartito* (*Tetrabiblos*), and in Aly Aben Ragel's (='Alī Ibn Abī l-Rijāl) *Libro conplido en los iudizios de las estrellas* (*al-Kitāb al-bāri' fī aḥkām al-nujūm*)[85] a work which, curiously enough, was unknown to Ṣā'id of Toledo.

Besides the aforementioned books we have another Alfonsine translation (extant only in its Latin version) which is purely astronomical: Ibn al-Haytham's *Cosmology* (*Kitāb fī hay'at al-'ālam*).[86] This seems to be the Alfonsine corpus's sole concession to the theoretical problems of cosmology.

The second collection is of a magical character and its purpose is not so much to predict the future as to alter it by applying the principles of talismanic magic, including the production of talismans at an astrologically propitious moment, using adequate materials, oral invocations to the planetary gods, fumigations, ointments, and so on. This subject is also dealt with in other Alfonsine works such as the *Picatrix*,[87] the series of *Lapidarios* (four are extant in Castilian while we also have the indices of another ten)[88] and in the book entitled *Libro de la mágica de los signos.*[89]

I would like to close by saying something about King Alfonso X's collaborators, given that his own personal intervention was minimal. His team was composed of a Muslim convert (Bernardo el Arábigo), four "Spanish" Christians (Fernando de Toledo, Garci Pérez, Guillén Arremón d'Aspa and

[85] Gerold Hilty (ed.), *El libro conplido en los iudizios de las estrellas*, Madrid, 1954, Real Academia Española (Books 1-5); Gerold Hilty (ed.), *El libro conplido en los iudizios de las estrellas. Partes 6 a 8,* Zaragoza, 2005 (Books 6-8).

[86] José Luis Mancha, "La versión alfonsí del *Fī hay'at al-'ālam (De configuratione mundi)* de Ibn al-Hayṭam (Oxford, Canon. misc. 45, ff. 1r-56r)", in: M. Comes, H. Mielgo y J. Samsó (eds.), *"Ochava Espera" y "Astrofísica". Textos y Estudios sobre las Fuentes Arabes de la Astronomía de Alfonso X*, Barcelona, 1990*,* 133-207.

[87] David Pingree, *Picatrix. The Latin Version of the Ghāyat al-Ḥakīm*, London, 1986, The Warburg Institute.

[88] Sagrario Rodríguez M. Montalvo, *Alfonso X. "Lapidario" (según el manuscrito escurialense H.I.15),* Madrid, 1981, Gredos.

[89] Alfonso D'Agostino, *Il "Libro sulla magia dei segni" ed altri studi di Filologia Spagnola*, Brescia, 1979.

Juan d'Aspa), four "Italians" (Juan de Cremona, Juan de Mesina, Pedro de Regio and Egidio Tebaldi de Parma) and five Jews (Yehudah b. Mosheh, Isḥāq b. Ṣīd —usually written Rabiçag—, Abraham Alfaquín, Samuel ha-Leví and Mošé).[90] These four groups were not equally important. Bernardo el Arábigo and three of the Spanish Christians only worked in collaboration with a Jew. Fernando de Toledo was the only one who worked on his own, translating the treatise on Ibn al-Zarqālluh's *azafea* in 1255 or 1256; however, this translation was considered unsatisfactory and was the object of revision in 1277. As for the Italians, Juan de Cremona and Juan de Messina participated in the revision of the treatise on the *azafea*, whilst the other two were responsible for the retranslation into Latin of the Castilian texts of the Alfonsine corpus. As for the Jews, they were the most productive group as they participated in the elaboration of 23 works, both translations and original texts; the relative importance of each of them can be appreciated in the following list:

Yehudah b. Mosheh	7 works
Isḥāq b. Ṣīd (Rabiçag)	11 works
Abraham Alfaquín	2 works
Samuel ha-Levi	2 works
Mošé	1 work

4. Conclusions

The European reception of Arabic science was the result of a process of transmission which originated in the Iberian Peninsula, and al-Andalus was the bridge across which all this knowledge circulated. Only books actually reaching al-Andalus could be translated and one of the hypotheses defended in this paper is that the arrival of Eastern books was interrupted with the fall of the Cordovan Caliphate. Only exceptionally did books from the Mashriq, produced after ca. 950, reach Cordova or the main *ṭā'ifa* cities. This explains why the great works of Eastern Islamic science produced from the 10th century onwards were rarely known in Medieval Europe: they simply never reached the bridge across which transmission took place.

[90] Evelyn S. Procter, "The Scientific Works of the Court of Alfonso X of Castile: the King and his Collaborators", *Modern Language Review,* 40, 1945, 12-29; David Romano, "Le opere scientifiche di Alfonso X e l'intervento degli ebrei" [reprinted in: Romano, *De Historia Judía Hispánica*, Barcelona, 1991, 147-81; Norman Roth, "Jewish Collaborators in Alfonso's Scientific Work", in Robert I. Burns (ed.), *Emperor of Culture. Alfonso X the Learned of Castile and his Thirteenth Century Renaissance*, Philadelphia, 1990, 59-71 and 223-30.

The transmission process began in Catalonia towards the end of the 10th century, but was interrupted for over a hundred years and did not resume until the beginning of the 12th century. I contend, and this is my second hypothesis, that transmission recommenced only when great Arabic libraries were once more accessible to Latin scholars, that is after the fall of Toledo (1085), Zaragoza (1118), Cordova (1236) and Seville (1248). With each conquest of one of these cities, new libraries became available and had a bearing on the selection of sources to be translated. At the same time, translators were dependent on patrons, who provided them with a living but whose personal tastes also influenced the choice of texts. We know of two clear instances of this: Bishop Michael of Tarazona, whose personal interests were taken into account by translator Hugo Sanctallensis, and Alfonso X, surrounded by a team of (mainly) Jews, but also 'Spaniards' and 'Italians', who oversaw the process of translation and the revision of the translated texts. Here it should be pointed out that Alfonso X constitutes the first true instance of royal patronage; before him, only high-ranking members of the Church seem to have been interested in patronising translations.

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