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Articles

Note on a Steelyard Balance in an Arabic Manuscript in Hebrew Characters from Yemen[1]

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Abstract

The website of *Les Enluminures*, an antique store based in Paris specialising in illuminated medieval manuscripts, displays a few pages of a precious manuscript containing several Arabic scientific texts on astronomy, optics and philosophy, in Hebrew characters of Yemenite style. The codex's provenance is from Sanaa, and it is dated 904/1499. On folio 83v, a short passage on statics includes a picture of the steelyard balance, which is the subject matter of this note. In the following short account, we present a short description of the manuscript, with a focus on the folio containing the drawing of the steelyard, which is transcribed into Hebrew and Arabic characters and translated into English. This preliminary work yielded a first result: the determination of the source of the first part of the Arabic text in Hebrew characters in an important scientific and didactic book of the polymath al-Bīrūnī.

Résumé

Le site web *Les Enluminures*, une maison d'antiquaires de Paris, spécialisée dans les manuscrits médiévaux, affiche quelques pages d'un précieux manuscrit contenant plusieurs textes scientifiques arabes d'astronomie, d'optique et de philosophie, en caractères hébreux, écrits dans un style yéménite. Le codex provient de Sanaa et est daté de 904/1499. Sur le feuillet 83v, un court passage de statique contient l'image d'une balance à peson, qui constitue le sujet de cette note. Nous souhaitons présenter une brève description du manuscrit, puis nous concentrer sur le feuillet contenant le dessin de la balance, qui est transcrit en caractères hébreux et arabes et traduit en anglais. Cet examen préliminaire a fourni un premier résultat : la détermination de la source de la première partie du texte, un fameux livre scientifique à caractère didactique d'al-Bīrūnī.

[1] [N. d. l'Ed. The Editorial Committee of *nCmY* is grateful to *Les Enluminures* for having kindly reacted to his message and shared an image of the folio of the manuscript with acceptable resolution. This allowed definitely the transcription of the text in Hebrew characters to happen].

ملخص

يعرض موقع الويب التابع لمتجر *Les Enluminures* لبيع المحفوظات القديمة، الذي يوجد مقره بباريس ويتخصص في مخطوطات العصر الوسيط، بضع صفحات من مخطوط ثمين يتضمّن مجموعة من النصوص العلمية العربية في الفلك والمناظر والفلسفة، كُتِبَت بحروف عبرية وبأسلوب يمني. يعود منشأ هذا المجموع إلى صنعاء ويتحدّد تاريخه في 904 هـ/1499 م. في الورقة 83ظ، نجد نصا قصيرا يحتوي على صورة ميزان قبّاني (قرسطون) يشكّل موضوع هذه الورقة، التي نهدف من نشرها إلى تقديم وصف موجز للمخطوط والتركيز على الفقرة المتعلّقة بالميزان. ونقدم في المقالة النص مكتوبا بحروف عبرية وعربية وفي ترجمة إنجليزية. وقد أدى الفحص الأوَّلي إلى العثور على نتيجة أولى تتمثّل في تحديد مصدر القسم الأول من النص في كتاب علمي وتعليمي شهير للعالِم المعروف البيروني.

Keywords

steelyard balance, Arabic science, Hebrew Manuscript, Yemen, Kūšyār b. Labbān (d. 420/1029), History of Sciences, science of weights

Mots-clés

balance à peson, science arabe, manuscrit hébreu, Yémen, Kūšyār b. Labbān (m. 420/1029), histoire des sciences, science des poids

كلمات مفتاحية

الميزان القباني، العلم العربي، مخطوط عبري، اليمن، كوشيار بن لبّان (مات 1029/420)، تاريخ العلوم، علم الأثقال

I. Introduction

The website[2] of *Les Enluminures*, an antique store based in Paris specialising in illuminated medieval manuscripts[3] displays a few pages of a manuscript by the Persian astronomer and mathematician Kūšyār b. Labbān (d. 420/1029), *Al-zīǧ al-ǧāmiʿ wa-al-balīġ* (The comprehensive and extensive astronomical tables), in Arabic in Hebrew characters, in a recognizable Yemenite style. According to the extensive description provided by the auction house online, the manuscript is on paper, its provenance is

[2] I mentioned the Hebrew manuscript which is the subject matter of the present note in an invited lecture presented on 18 October 2017 at the Institute for Advanced Studies, Princeton: "The Corpus of the Arabic Science of Weights: Textual Tradition, Theoretical Scope and Significance in the History of Mechanics" (seminar of Professor Sabine Schmidtke at the School of Historical Studies https://www.hs.ias.edu/islam_past_events). The present note originated in discussions with Dr. Anne Regourd held in Doha, Qatar, in early 2020. I thank her for engaging encouragement and stimulating comments on an earlier version of the paper.

[3] *Les Enluminures*: Original Illuminated Manuscripts specializing in manuscripts and miniatures from the Middle Ages and the Renaissance; online at https://www.lesenluminures.com.

from Sanaa, and it is dated 904/1499.[4] On folio 83v, a short passage on statics includes a picture of the steelyard balance, which is the subject matter of this note. In this note, we wish to present a short description of the manuscript, with a focus on the folio containing the drawing of the steelyard, hoping that this short account will help in providing more information on the codex and its contents.

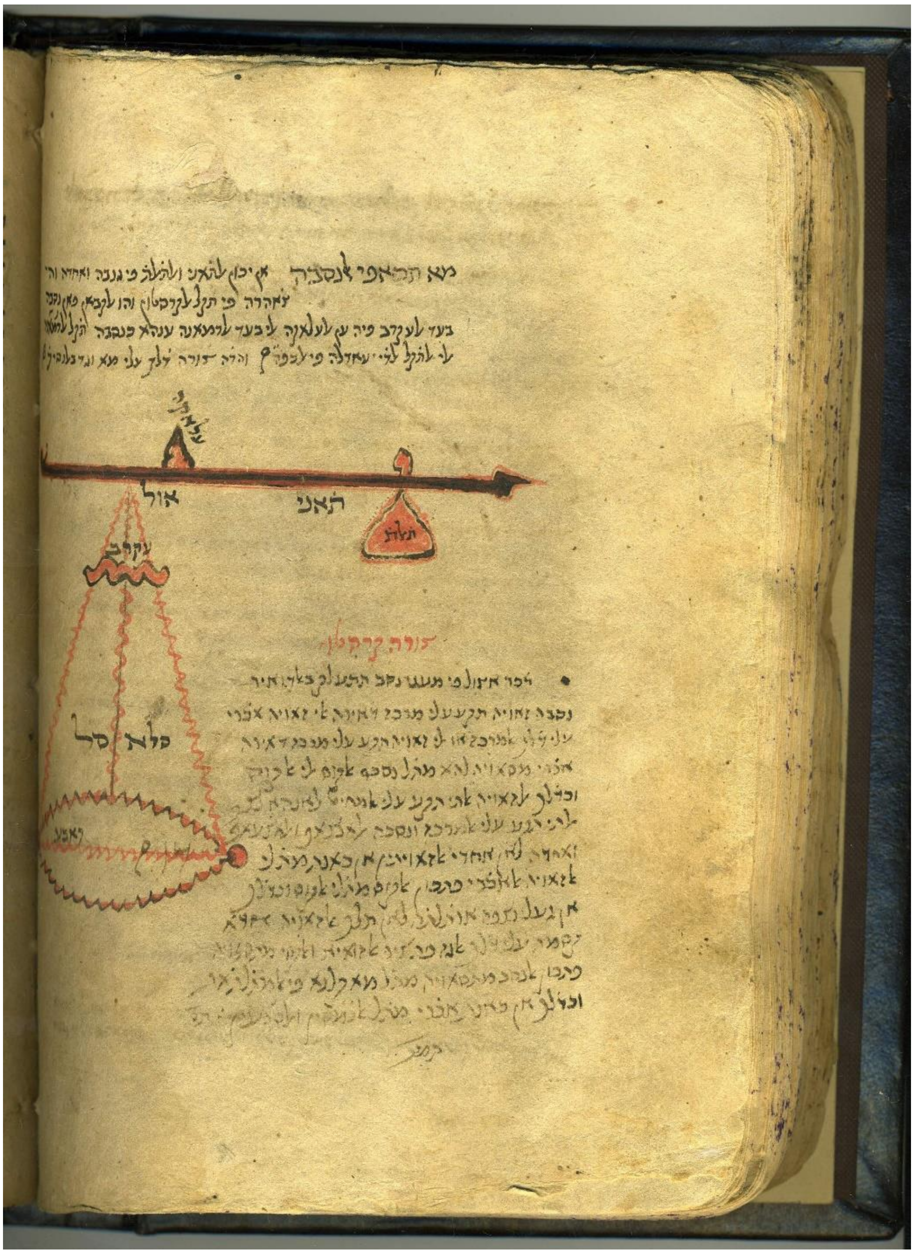

Fig. 1. Picture of the steelyard in the Hebrew manuscript on f. 83v © *Les Enluminures*.

[4] See the full description of the manuscript, its historical details and philology at https://www.textmanuscripts.com/medieval/astronomy-hebrew-60473.

II. Description of the codex[5]

The codex in Hebrew characters of which f. 83v presents a short passage on statics, including a picture of the steelyard (*qarasṭūn*), is composed of iii + 128 + iii folios (134 in total). Its paper size is 235 × 165 mm, f. 6 is a singleton (186 × 120 mm). It does not contain any watermarks. There is a modern foliation in Arabic numerals on the upper left fore edge recto side in pencil, and a medieval foliation on the verso side. The codex is written in black ink, contains table rulings, diagrams, and headings in rubric, with single column text throughout (justification 170 × 110 mm).

It also contains over one hundred large astronomical tables in rubric and black ink on ff. 25v–82r (justification 167 × 112 mm), seventy-seven geometric calculations in rubric and black ink on ff. 83r, 86v–91v, 92v–94v, 95v–96v, 97v, 99v–106r, and 109v, and twenty-one calculation tables in rubric and black ink on ff. 1r, 82v, 118v–119r, 125v–126r, 127v, and 128v.

The main part of the codex reproduces in Hebrew characters the *Zīǧ* of Kūšyār b. Labbān, an early and little-studied astronomical handbook which survives in nine Arabic-alphabet copies and four Hebrew-alphabet copies, of which this one is among the most interesting. Contemporary notes in the manuscript claim that it is based upon Kūšyār's own autograph, and it contains the complete tables (absent in many of the extant copies), which is evidently a positive feature and a good tool to gain precise knowledge about the measures and data contained in these tables.

[5] In the following description of the codex, we follow mainly the description provided online on the website of the auction house.

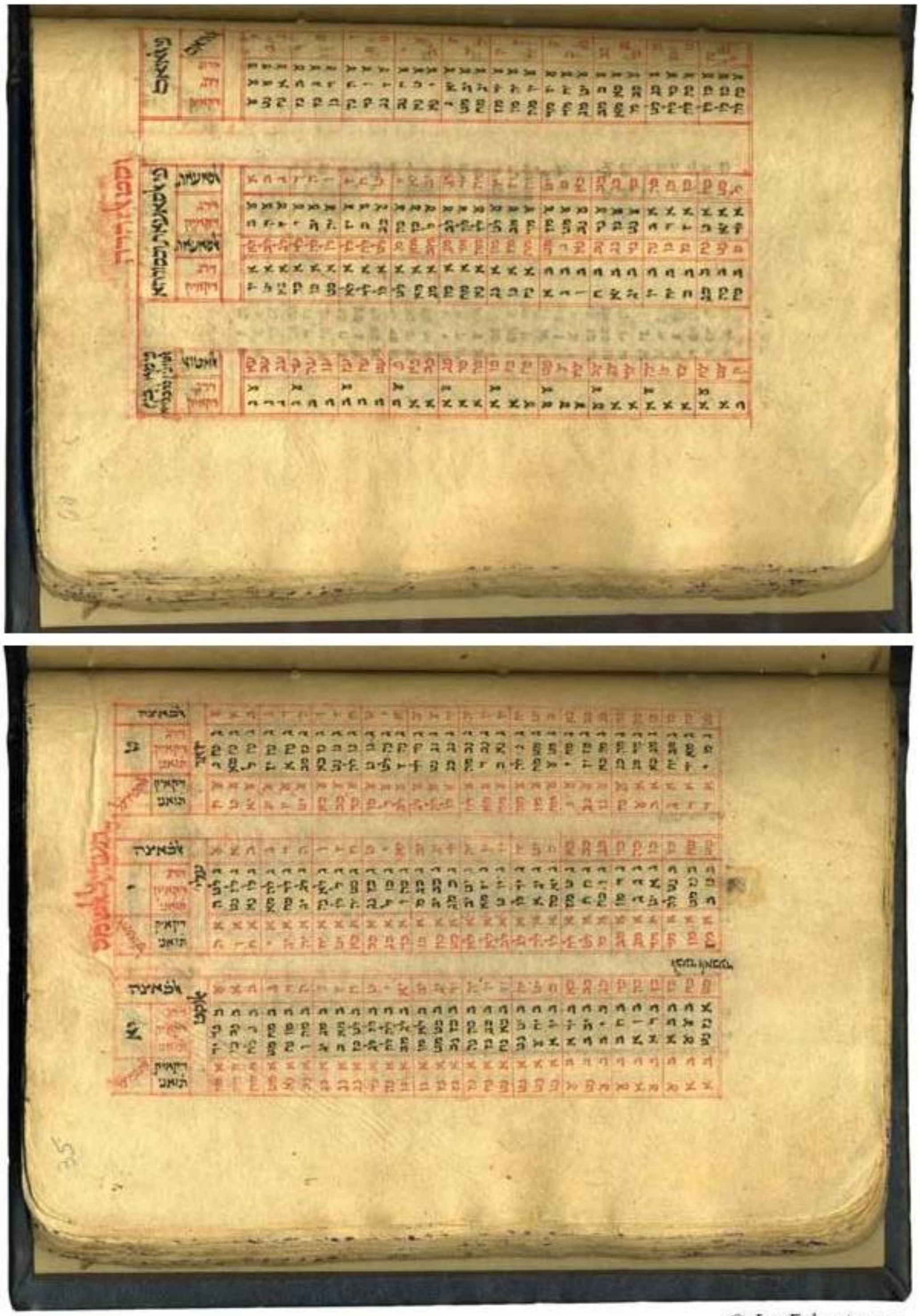

Fig. 2. Two pages of astronomical tables from the Hebrew manuscript.

The codex was written in Yemen, in Sanaa precisely, in 1499, according to the date stated in the colophon. The collection (*maǧmūʿ*) contains the following texts and fragments, all of them, like the *Zīǧ* of Kūšyār, are in Arabic, written out in Hebrew characters.

- f. 1r: a note on the Milky Way (*al-maǧarra*).
- f. 1r: a short passage copied from *Al-zīǧ al-Ḥākimī* of the renowned Egyptian astronomer Ibn Yūnus (10th century)[6].
- f. 83v: a short passage on statics, the ancient and medieval science of equilibrium, including a picture of the steelyard balance.
- ff. 84r–84v: a long note on the dateline (or, in their terms, the possibility that the same instant could be Thursday for one person and Friday for another, for example).
- f. 84v: a short passage on finding hidden things, by a certain Muḥammad b. Aflaḥ al-Ḫazarūnī, on whom no further information could be gleaned from historical sources.
- f. 85r: two short items attributed to Plato's *Timaeus*.
- ff. 1–119: Kūšyār b. Labbān's *Al-zīǧ al-ǧāmiʿ*, tables and instructions for their use in computing the positions of the planets and other astronomical information (the tables start on f. 84).[7]
- ff. 119v–120r: The beginning of a treatise on twilight. The author mentions Ibn Muʿāḏ al-Ǧayyānī (d. after 471/1079)[8] and Abū ʿAbd al-Raḥmān b. Ṭāhir.[9] The first is a known Andalusi mathematician and astronomer who also wrote on the subject.
- ff. 120v–125v: Fragment of a rather extensive, unidentified work on arithmetic, divided in *maqāla* (book), *bāb* (chapter), and *faṣl* (section).

Apparently, the logic behind binding the texts in this collection suggests that it was done by someone familiar with scientific subjects. He probably collected them for his own use, and with the aim of preserving these Arabic texts in Hebrew characters, to ensure their transmission in the cultural milieu of the Yemenite Hebrew community.

As for the provenance of the manuscript, the online description informs us that it was in the collection of the Yemeni Jewish scholar Joseph Qafah, himself born in the old city of Sanaa in 1917. Written in Yemen (Sanaa) in 1499, dated by colophon, the co-

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[6] D. A. King, "Ibn Yūnus," 2007, pp. 573–574.

[7] According to the description online of the manuscript, obviously from here onwards a new numbering begins.

[8] E. Calvo, "Al-Jayyānī," 2007, pp. 652–563.

[9] Probably Abū Manṣūr ʿAbd al-Qāhir b. Ṭāhir al-Baġdādī (d. 428/1037), a mathematician who wrote a famous *Kitāb fī al-misāḥa* on arithmetics. See A. S. Saʿīdān, "The 'Takmila fi'l-Hisab' of al-Baghdadi," 1987, pp. 437–443.

dex is part of the heritage of the Jewish community of Sanaa, which was a robust community of the country and the only non-Muslim minority.

III. The Arabic science of weights and balances

The balance is an instrument of everyday life, charged with history and science. In Islamic classical times, this familiar instrument was the object of an extensive scientific and technical debate of which dozens of treatises on different aspects of its theory, construction, and use are the precious remains. Being the focus of intense research work in the last decades, the Arabic science of weights is now a constituent part of the history of theoretical mechanics.[10] Different sorts of balances were the object of such an extensive enquiry, including the normal equal-armed balance (called in Arabic *mīzān*, *ṭayyār*, and *šāhīn*), the steelyard (called successively *qarasṭūn*, *qaffān*, and *qabbān*) and sophisticated balances for weighing absolute and specific weights of substances.

Several drawings of balances are preserved in Arabic manuscripts, such as those of al-Ḫāzinī (fl. ca. 515/1121 [Fig. 3]),[11] al-Ḥarīrī (d. 516/1122),[12] and al-Qazwīnī (d. 682/1283).[13] Further, some specimens of the Arabic medieval balances have survived and are presently kept in museums [Fig. 4].

[10] The corpus of the Arabic science of weights was reconstructed and its status reevaluated in studies such as: M. Abattouy, "Greek Mechanics in Arabic Context: Thābit ibn Qurra, al-Isfizārī and the Arabic Traditions of Aristotelian and Euclidean Mechanics," 2001; id., *Matn al-Muẓaffar al-Isfizārī fī ʿilmay al-aṯqāl wa-al-ḥiyal. Taḥqīq naqdī wa-dirāsa tārīḫiyya li-nuṣūṣ ǧadīda fī taqlīd al-mīkānīkā al-ʿarabiya* [The Mechanical Corpus of al-Isfizārī in the Sciences of Weights and Ingenious Devices: Critical Edition and Historical Analysis of New Texts in the Tradition of Arabic Mechanics], 2013 [in Arabic]; id., "The Corpus of Mechanics of Al-Isfizārī: Its Structure And Signification in the Context of Arabic Mechanics," 2016, pp. 124–146; id., "The Corpus of the Arabic Science of Weights (9th–19th Centuries): Codicology, Textual Tradition and Theoretical Scope," 2018.

[11] On Al-Ḫāzinī and his encyclopedia of mechanics *Kitāb mīzān al-ḥikma* [Book of the balance of wisdom] (515/1121), see a short bio-bibliographic outline in M. Abattouy, "Al-Khāzinī," 2007, and online at http://islamsci.mcgill.ca/RASI/BEA/Khazini_BEA.htm.

[12] Abū Muhammad al-Qāsim al-Ḥarīrī was a poet and writer, author of the famous *Maqāmāt* [The Assemblies], a collection of stories written in a style mixing verse and literary prose. See: Th. Preston, *Makamat Or Rhetorical Anecdotes of Al Hariri of Basra*, 1850, and the English translation by Th. Chenery, *The Assemblies of Al Harîri*, 1867, vol. 1.

[13] Abū Yaḥyā Zakariyā b. Muḥammad al-Qazwīnī a physician and geographer, author of a celebrated treatise of cosmography *ʿAǧāʾib al-maḫlūqāt* [The Wonders of Creation], extant in illustrated manuscripts. See: P. Berlekamp, *Wonder, Image, and Cosmos in Medieval Islam*, 2011.

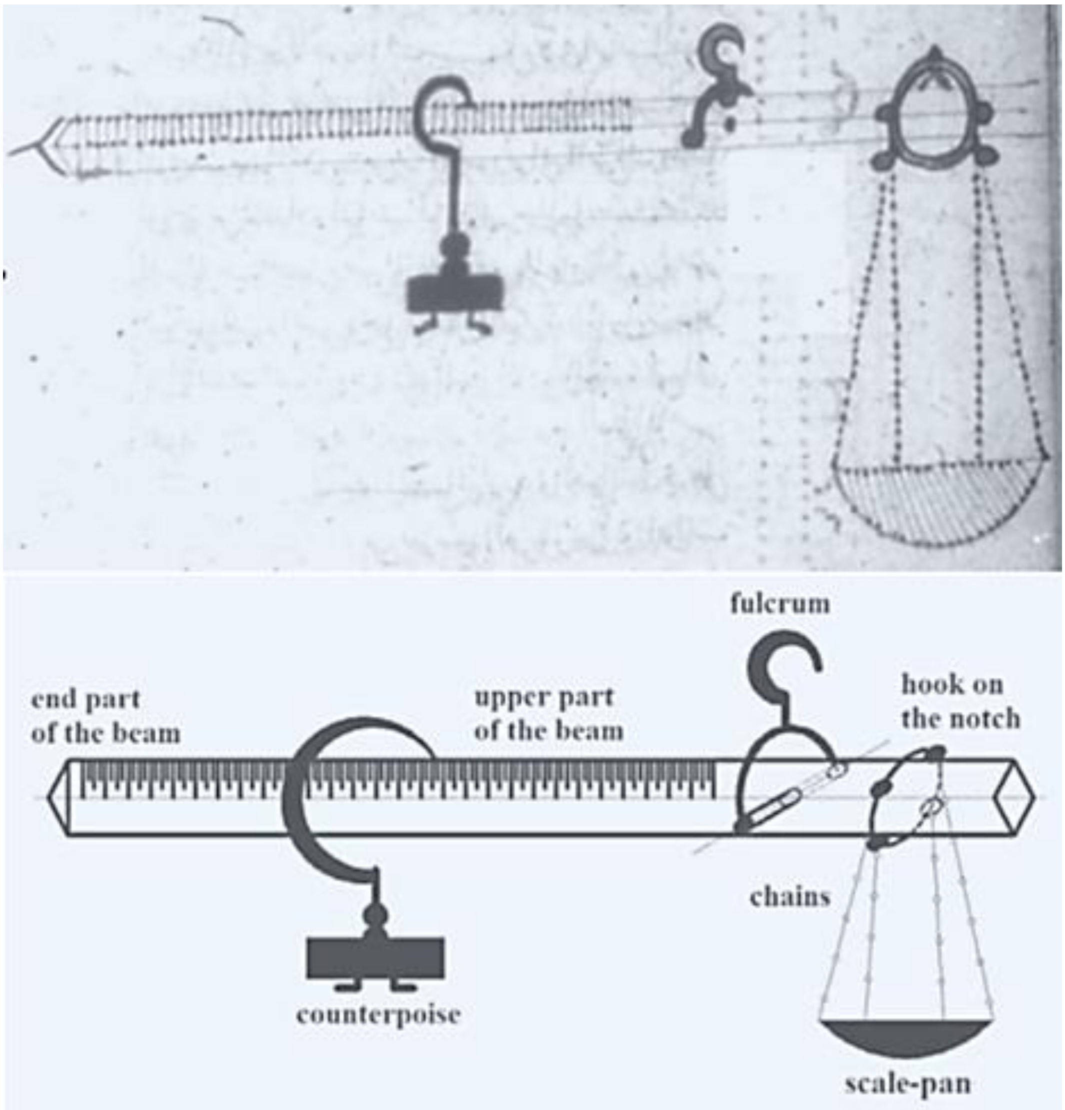

Fig. 3. Picture of a steelyard and its graphical reproduction,
from al-Ḫāzinī's *Book of the Balance of Wisdom* (515/1121).[14]

[14] M. Abattouy, *The Corpus of Al-Isfizārī in the Sciences of Weights and Mechanical Devices. New Arabic Texts in Theoretical and Practical Mechanics from the Early XIIth Century. English Translation, Partial Analysis and Historical Context*, 2015, p. 83.

Fig. 4. Steelyard in bronze with engraved inscription (Middle East; 8th–9th century, arm: 52.5 cm; David Museum in Copenhagen, Inv. no. 12/1994).[15]

The balance most widely used in the Islamic lands of medieval times was the equal-armed platform scale, made mostly in copper. There were tiny balances for gold and jewels, average ones for retail traders, and huge balances for the merchants of grains, wood, wool, etc. In general, the balances had beams and weights made of steel or iron. Steelyards were also widely employed.

The use of steelyards dates back to Ancient times in the Mediterranean region. A counterweight is moved along the arm until it and the object to be weighed are in balance. The arm can typically be turned, since it has several balance points and their scales, making it possible to weigh both heavy and light objects. Steelyards were used

[15] The steelyard is engraved not only with numerals and a weight indicator (*raṭl* = ca. 1 pound), but also an early religious inscription in Kufi script: "In the name of the merciful and compassionate God/ there is no god but Allāh, He alone, He has no equal/ Muḥammad is the messenger of Allāh." See online: https://www.davidmus.dk/en/collections/islamic/materials/metal/art/12-1994.

since the advent of Islam, and the balance shown in Fig. 4 bears the name of the Umayyad Caliph Marwān b. Muḥammad, known as Marwān II (r. 127/744–132/750 CE).

The Greek name of the steelyard balance is *charistion*. The instrument was used extensively in Roman times. It later entered the Arab world, where its name was rendered as *qarasṭūn*.[16] Composed of a lever or a beam (*ʿamūd*) suspended by a handle that divides it into two unequal arms, the center of gravity of the instrument is located under the fulcrum. In general, the shorter arm bears a basin or a scale-pan in which the object to be weighed is set or suspended from a hook. The cursor-weight, *rummāna* in Arabic, moves along the longer arm in order to achieve equilibrium. This arm, which has generally a quadrangular cross section, bears two different scales which are engraved along the two opposite sides. Due to the fact that the steelyard can be suspended by two hooks, there are two independent graduations. According to the choice made, there will be different relations between the lengths of the longer and smaller arms of the lever, corresponding to the different scales. On the beam or near the fulcrum, the number of units or fractions corresponding to the capacity of the balance was engraved, as was the official stamp of the authorities. The advantage of the steelyard is that it provides an acceptable precision in weighing and allows heavy loads to be supported by small counterweights. In addition, it can be carried around easily.[17]

IV. A "Hebrew" balance similar to Arabic steelyards

The balance we find in the above-mentioned manuscript is identical to Arabic specimens preserved in manuscripts or as mechanical vestiges, like the ones reproduced in Figs 3–4. Its depiction looks similar to Arabic pictures of this kind of balance: Two unequal arms compose a beam from which a scale and a moving weight are suspended; the moving weight is supposed to be displaced along the beam to ensure equilibrium with the weighed object deposited in the scale pan [Fig. 1]. The illustration depicts a scale balance in rubric and black ink (dimensions: 100 × 110 mm).

Here are the few components of the rudimentary drawing:

- The beam occupies the middle of the page in the form of a bar from which a scale hangs; its extremity on the right finishes in a triangular form intended to prevent the moving weight from falling off. The beam is drawn in thick black ink, with borders in red. The usual markings or graduations are absent from it; they are usually employed to mark specific positions along the beam which are intended to help signal the reading of weights. Their absence is another proof of the rudimentary character of the drawing.

[16] On the ancient history of the steelyard, see Th. Ibel, *Die Wage im Altertum und Mittelalter*, 1908; P. Damerow, J. Renn, S. Rieger & P. Weinig, "Mechanical Knowledge and Pompeian Balances," 2002.

[17] M. Abattouy, "The Arabic Science of Weights (*ʿilm al-athqāl*): Textual Tradition and Significance in the History of Mechanics," 2008, pp. 84–89.

- An important piece of traditional steelyards is also absent: the conventional "tongue" or *lisān*, a protuberant piece attached to the beam to ascertain equilibrium when it meets the suspension system of the balance.
- The scale for weighing is prominently depicted on the right, suspended from the short arm of the steelyard with three chains in red, with a pan at the bottom.
- The usual *rummāna* or moving weight in the form of a pomegranate is clearly visible in the right part of the depiction, near the end of the beam. It is a mobile object, sliding along the beam and acting as counterpoise to the weight(s) placed in the scale suspended from the short part of the beam; this short part of the beam doesn't appear in the manuscript page (it is left to the reader to imagine its presence on f. 83r). The movable cursor is a fundamental part of the equilibrium system when it is produced by even distribution of weights on each side of the vertical axis.
- The names of different parts of the balance are marked clearly, each part designated by the corresponding word.
- The hook (*ʿaqrab*) from which to suspend the balance is absent too; it should be placed precisely on the notch near the position where the round chain attached to the scale meets the body of the beam, in the middle of the short part of the later. It is maybe marked on the right hand page, absent from the available picture. The suspension item indicated in the middle of the beam does not apply to the classical depictions of steelyards.

The drawing of the balance is inserted on the page and surrounded by text, which is a traditional usage we find in medieval manuscripts, from all cultural areas. It is preceded and followed by two paragraphs of text, which the author of this note was unable to understand, because of his ignorance of Hebrew characters. It is clear that the text is about the steelyard balance depicted on this same page. It is probably part of a longer text.

V. Transcription and translation of the passage on statics

The transcription and translation of the explanatory Judaeo-Arabic text found on the side of the illumination of the balance is an important achievement, due to the kind collaboration of our colleague Gabriele Ferrario.[18] This important passage was transcribed into Hebrew and Arabic characters, then translated into English.

We present hereafter the edition, the Arabic transliteration and English translation of the Judaeo-Arabic text on the page 83v of the codex, and then some comments on the content.

[18] University of Bologna, Department of Philosophy and Communication Studies. The author wishes to thank Gabriele Ferrario for his transcription of the concerned passage in Hebrew and Arabic characters, and its translation into English.

Text edition

מא תכאפי אלנסבה אן יכון אלת̄אני ואלת̄אלת̄ פי גנבה ואחדה והי צ̆אהרה פי ת̄קל אלקרסטון והו אלקבאן פאן נסבה בעד אלעקרב פיה ען אלעלאקה אלי בעד אל**ר**מאנה ענהא כנסבה ת̄קל אלרמאנה אלי אלת̄קל אלד̄י **יעאדלה** פי אלכפה – והד̄ה צורה ד̄לך עלי מא וגד באלנסיך

סורה קרסטון

ד̄כר אצול פי מעני נסב תתעלק באלדואיר נסבה זאויה תקע עלי מרכז דאירה אלי זאויה אכ̄רי עלי ד̄לך אלמרכז או אלי זאויה תקע עלי מרכז דאירה אכ̄רי מסאויה להא מת̄ל נסבה אלקוס אלי אלקוס וד̄לך אלהאויה אלתי תקע עלי אלמחיט לאנהא נצף אלתי תקע עלי אלמרכז ונסבה אלאצנאף ואלצ̆עאף ואחדה לאן אחרי אלזאויתין אן כאנה מת̄לי אלזאויה אלאכ̄רי פתכון אלקוס מת̄לי אלקוס וכד̄לך אן געל נצפה או ת̄לת̄ה לאן תלך אלזאויה אד̄א קסמה עלי ד̄לך אלגז פתציר אלזואיה אלקסי מת̄ל זאויה פתכון אלנסב מתסאויה מת̄ל מא קלנא פי אלמת̄לת̄את וכד̄לך אן כאנת אכ̄רי מת̄ל אלחמסין אלסבעין – תם

תמת

Arabic transliteration

ما تكافي النسب ان يكون الثاني والثالث في جنبه واحده وهي ظاهرة في ثقل القرسطون وهو القبان؛ فإن نسبه بعد العقرب فيه عن العلاقة الى بعد الرمانة عنها كنسبة ثقل الرمانة الى الثقل الذي يعادله في الكفة - وهذه صورة ذلك على ما وجد بالنسيك [sic].[19]

صورة قرسطون

ذكر أصول في معنى نسب تتعلق بالدوائر نسبة زاوية تقع على مركز دائرة إلى زاوية أخرى على ذلك المركز او إلى زاوية تقع على مركز دائرة أخرى مساوية لها مثل نسبة القوس إلى القوس وذلك الزاوية التى تقع على المحيط لأنها نصف التي تقع على المركز ونسبة الانصاف والضعاف واحدة لأن احدى الزاويتين أو كأنه مثلي الزاوية الأخرى فتكون القوس مثلي القوس وكذلك إن جعل نصفه أو ثلثه لأن تلك الزاوية إذا قسمت على ذلك الجز[ئ] فتصير زواية القسي مثل زاوية فتكون النسب متساوية مثل ما قلنا في المثلثات وكذلك إن كانت أخرى مثل الخمسين السبعين - تم

تمت

[19] The last word is incomprehensible.

English translation

What is the inverse ratio (*takāfuʾ al-nisba*)? It is when the second and the third [terms] are on the same side, and this is apparent/obvious in the weights of the steelyard (*qarasṭūn*), which is the *qabbān*, where the ratio of the distance of the hook (*al-ʿaqrab*) from the fulcrum (*ʿilāqa*) to the distance of the [running/mobile] counterpoise (*rummāna*) from it is like the ratio of the weight (*ṯiql*) of the counterpoise (*rummān*) to the weight that balances it in the scale (*kaffa*). And this is its image, according to what was found in the [manuscript copy?].

Image of the steelyard

Mention of the principles on ratios related to circles.

The ratio of an angle that is located on the centre of a circle to another angle located on that centre, or to an angle located on the centre of another equal circle, is like the ratio of the arc to the arc. This is so, because the angle that is formed on the circumference is half the one that is formed on the centre, and the ratios of the parts and of the multiples are equal; for one of the angles is like two angles, then the arc is double the arc. The same is correct in the case of the half or the third. So if this angle is divided on this portion—, then the [little] angle of the arc is like the angle and the ratios are equal, as we said in the case of triangles, and similarly if the other is (like) fifty or seventy. The End. [The treatise] is completed.

The original text is divided in two parts: The first part is a sentence quoting the formula of the law of the lever as formulated by Abū al-Rayḥān Muḥammad b. Aḥmad al-Bīrūnī (362/973–after 442/1050), the famous Muslim polymath from the first half of the 5th/11th century. The passage is extracted from his book *Kitāb al-tafhīm li-awāʾil ṣināʿat al-tanǧīm* [Book of instruction in the elements of the art of astrology], written in Ghaznah, Afghanistan, in 1029 CE.[20]

By discovering the source of the first part, it is proved beyond doubt that at least in part, the text preceding the illumination is related to the balance and belongs to one of the classical treatises on this topic. As for the second passage, no source was found.[21]

[20] Al-Bīrūnī, *Kitāb al-tafhīm li-awāʾil ṣināʿat al-tanǧīm* [Book of instruction in the elements of the art of astrology], 1934, reproduced from Brit. Mus. MS. Or. 8349. Publication in facsimile of the manuscript, with English translation facing the text by R. Ramsay Wright.

[21] The author of this note analysed thoroughly the fortunes of *nisba mutakāfiʿa*; see: M. Abattouy, “Sur quelques démonstrations grecques et arabes de la loi du levier: transmission et transformation,” 2000.

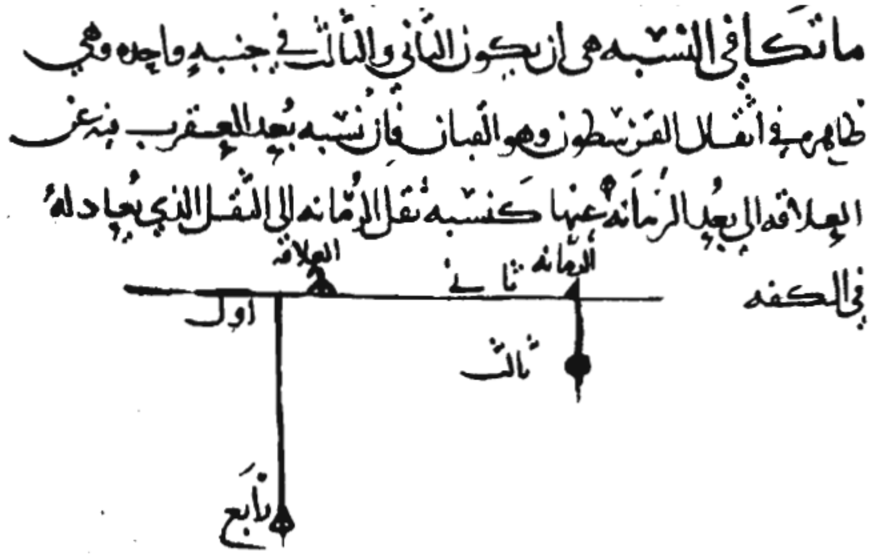

Fig. *5*. Extract from the facsimile of al-Bīrūnī's manuscript of *Kitāb al-tafhīm* related to the inverse ratio, the mathematical relation laying at the core of the law of the lever.[22]

VI. Conclusion

In medieval times, Arabic-speaking Jews copied out many Arabic books on science, philosophy, and other subjects into the Hebrew alphabet. The copied text in the Judeo-Arabic codex under scrutiny in this note of Kūšyār b. Labbān, entitled *Al-zīǧ al-ǧāmiʿ*, is his major astronomical work, a *Zīǧ* [astronomical handbook with tables]. It is written in Arabic, the scientific language in the Islamic territories between 9th–16th centuries at least. It consists of four Books: I) Elementary operations; II) Tables; III) Cosmology; IV) Proofs.[23] The *Zīǧ* of Kūšyār b. Labbān is extremely interesting because it is a relatively early work, which contains two parts (Books III–IV) on theoretical foundations, not provided in most other *zīǧ*s, and because Kūšyār's own innovations made his methods somewhat different from those of his predecessors in the Arabic tradition of astronomy and even in Ptolemy's *Almagest*, the latter being the most important source of ancient Greek astronomy.[24] It was known in the Islamic world from the ninth century, after it was translated twice at least and extensively commented upon. The version contained in this codex includes tables and instructions for their use in computing the

[22] Al-Bīrūnī, *Kitāb al-tafhīm li-awā'il ṣināʿat al-tanǧīm*, 1934, p. 17, definition no. 55.

[23] The Arabic original of the *zīǧ* was edited in part with English translation and commentary: M. Bagheri, *Books I and IV of Kūshyār ibn Labbān's Jāmiʿ Zīj: An Arabic Astronomical Handbook by an Eleventh-Century Iranian Scholar*, 2006. The critical edition was based on nine different manuscripts, preserved in Istanbul (3), Cairo, Leiden (2), Berlin, Moscow and Alexandria. Only three of these manuscripts contain the entire text.

[24] See for more details E. S. Kennedy, *A Survey of Islamic Astronomical Tables*. *Transactions of the American Philosophical Society*, 1956; Gl. van Brummelen, "Mathematical Methods in the Tables of Planetary Motion in Kūshyār b. Labbān's *Jāmiʿ Zīj*," 1998.

positions of the planets and obtaining other astronomical information. This astronomical handbook was popular among the Jews of Yemen, and there are three other copies transcribed into Hebrew characters, all of them of Yemeni provenance.[25]

Furthermore, we identified the source of the first part of the folio on the balance in a famous sentence of al-Bīrūnī's *Kitāb al-tafhīm* presenting the law of the lever, the most important law of ancient and medieval mechanics, used since Greek times to describe equilibrium in the various types of balances.

The source of the second part should be a text of mathematics, on the geometry of circles, arcs and angles. The determination of this text should give us a further idea on the scientific texts available to the scribe who copied or authored the folio 83v in Sanaa in 1499.

Bibliography

Manuscript source & object

KUSHYAR IBN LABBAN, *Al-zij al-jami wa-l-baligh* ("The comprehensive and extensive tables") [Astronomical handbook], online at:

https://www.textmanuscripts.com/medieval/astronomy-hebrew-60473

Les Enluminures: Original Illuminated Manuscripts specializing in manuscripts and miniatures from the Middle Ages and the Renaissance. Website:

https://www.lesenluminures.com

Steelyard, bronze with engraved inscription Middle East; 8th–9th century, David Collection, Copenhagen, Islamic Art: Metal, Inv. no. 12/1994. Online at: https://www.davidmus.dk/en/collections/islamic/materials/metal/art/12-1994

Edited sources

Bagheri, Mohammad. 2006. *Books I and IV of Kūshyār ibn Labbān's Jāmiʿ Zīj: An Arabic Astronomical Handbook by an Eleventh-Century Iranian Scholar*, Doctoral thesis, Utrecht University, The Netherlands.

Al-Bīrūnī, Abū al-Rayḥān Muḥammad ibn Aḥmad (362/973-after 442/1050), *Kitāb al-tafhīm li-awāʾil ṣināʿat al-tanǧīm* [Book of instruction in the elements of the art of astrology], pub. in facsimile of the manuscript, with English translation facing the text by R. Ramsay Wright, London, Luzac, 1934.

[25] Identified by Y. T. Langermann, "Arabic Writings in Hebrew Manuscripts: A Preliminary Relisting," 1996, p. 151. For more on astronomy in Yemen, see David A. King, *Mathematical Astronomy in Medieval Yemen: A Bibliographical Survey*, 1983.

Studies

Abattouy, Mohamed. 2000. "Sur quelques démonstrations grecques et arabes de la loi du levier : transmission et transformation," in: Abdessalam Ben Maissa (ed.), *Āliyyāt al-istidlāl fī al-ʿilm. Les mécanismes de l'inférence dans les sciences*, Rabat, The Faculty of Letters Press, coll. "Colloques et séminaires," 84, pp. 7–43. A PDF version of the article is online at:

https://www.academia.edu/44293239/M_Abattouy_2000_Quelques_d%C3%A9monstra-tions_grecques_et_arabes_de_la_loi_du_levier_Transmission_et_transformation

_____ . 2001. "Greek Mechanics in Arabic Context: Thābit ibn Qurra, al-Isfizārī and the Arabic Traditions of Aristotelian and Euclidean Mechanics," *Science in Context* 14, pp. 179–247.

_____ . 2007, "Al-Khāzinī," in: Thomas Hockey (ed.), *The Biographical Encyclopedia of Astronomers*, New York, Springer, pp. 629–630; online at: http://islamsci.mcgill.ca/RASI/BEA/Khazini_BEA.htm

_____ . 2008. "The Arabic Science of Weights (*ʿilm al-athqāl*): Textual Tradition and Significance in the History of Mechanics," in: Emilia Calvo, Merce Comes, Roser Puig & Monica Rius (eds), *A Shared Legacy: Islamic Science East and West*, Barcelona, Universitat de Barcelona, pp. 83–114.

_____ . 2013. *Matn al-Muẓaffar al-Isfizārī fī ʿilmay al-aṯqāl wa-al-ḥiyal. Taḥqīq naqdī wa-dirāsa tārīḫiyya li-nuṣūṣ ǧadīda fī taqlīd al-mīkānīkā al-ʿarabiyya* [The Mechanical Corpus of al-Isfizārī in the Sciences of Weights and Ingenious Devices: Critical Edition and Historical Analysis of New Texts in the Tradition of Arabic Mechanics], London, Al-Furqān Foundation, pp. 14–28. [In Arabic].

_____ . 2015. *The Corpus of Al-Isfizārī in the Sciences of Weights and Mechanical Devices. New Arabic Texts in Theoretical and Practical Mechanics from the Early XIIth Century. English Translation, Partial Analysis and Historical Context*, London, Al-Furqān Foundation.

_____ . 2016. "The Corpus of Mechanics of Al-Isfizārī: Its Structure And Signification in the Context of Arabic Mechanics," *Micrologus: Nature, Sciences and Medieval Societies* 24, pp. 121–172.

_____ . 2018. "The Corpus of the Arabic Science of Weights (9th–19th Centuries): Codicology, Textual Tradition and Theoretical Scope," in: Ibrahim Chabbouh & François Déroche (eds), *Research Articles and Studies in Honour of Iraj Afshar*, London, Al-Furqān Foundation, pp. 229–278.

Berlekamp, Persis. 2011. *Wonder, Image, and Cosmos in Medieval Islam*, New Haven/London, Yale University Press.

Brummelen, Glen van. 1998. "Mathematical Methods in the Tables of Planetary Motion in Kūshyār ibn Labbān's *Jāmiʿ Zīj*," *Historia Mathematica* 25, pp. 265–280.

Calvo, Emilia. 2007. “Ibn Muʿādh al-Jayyānī,” in: Thomas Hockey et al. (eds), *The Biographical Encyclopedia of Astronomers*, New York, Springer, pp. 652–563. Online at:

https://islamsci.mcgill.ca/RASI/BEA/Ibn_Muadh_BEA.htm

Chenery, Thomas. 1867–1898. *The Assemblies of Al Harîri*, transl. from the Arabic, with an introduction, and notes, historical and grammatical, London, Williams & Norgate [Imprint on cover: Royal Asiatic society, 1898], 2 vols.

Damerow, Peter, Jürgen Renn, Simone Rieger & Paul Weinig. 2002. “Mechanical Knowledge and Pompeian Balances,” in: Jürgen Renn & Giuseppe Castagnetti (eds), *Homo Faber: Studies on Nature, Technology, and Science at the Time of Pompeii*, Rome, L’Erma, pp. 93–108.

Ibel, Thomas. 1908. *Die Wage im Altertum und Mittelalter*, Erlangen, Junge.

Kennedy, Edward S. 1956. *A Survey of Islamic Astronomical Tables*. *Transactions of the American Philosophical Society*, Philadelphia, The American Philosophical Society, “Monograph,” 46, part 2.

King, David A. 1983. *Mathematical Astronomy in Medieval Yemen: A Bibliographical Survey*, Malibu (CA), Undena Publications for the American Research Center in Egypt, ser. “Publications of the American Research Center in Egypt, Catalogs,” 4.

_____ . 2007. “Ibn Yūnus,” in: Thomas Hockey et al. (eds), *The Biographical Encyclopedia of Astronomers*, New York, Springer, pp. 573–574. Online at:

https://islamsci.mcgill.ca/RASI/BEA/Ibn_Yunus_BEA.htm

Langermann, Y. Tzvi. 1996. “Arabic Writings in Hebrew Manuscripts: A Preliminary Relisting,” *Arabic Sciences and Philosophy* 6, pp. 137–160.

Preston, Theodore. 1850. *Makamat or Rhetorical Anecdotes of Al Hariri of Basra, Translated from the Original Arabic with Annotations*, London, James Madden/Cambridge, Cambridge University Press.

Saʿīdān, Aḥmad Salīm. 1987. “The ‘Takmila fi’l-Hisab’ of al-Baghdadi,” in: David A. King & George 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, New York Academy of Sciences, pp. 437–443.

Sezgin, Fuat. 1978. *Geschichte des arabischen Schriftums*. Vol. 6: *Astronomie bis ca. 430H*, Leiden, E. J. Brill.