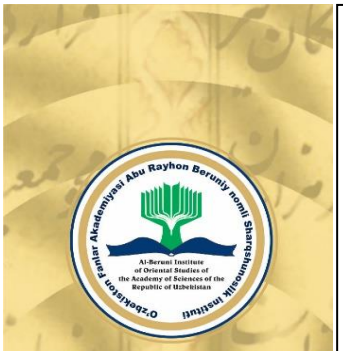


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J. HOGENDIJK

PROFESSOR ASHRAF AKHMEDOV AND THE QANUN MAS'UDI OF ABU RAYHAN BIRUNI

It is an honour for me to contribute for this volume of studies for Professor Ashraf Akhmedov. Although I never had the opportunity to meet Professor Akhmedov in person, I was introduced to his work early in my career. When I was a student, I visited professor Fuat Sezgin (1924–2018) in the city of Frankfurt in Germany. Professor Sezgin knew many languages and he insisted that I learn to read Russian so that I could consult the important books and articles that had been written in Russian on the works of Arabic-Islamic scientists. I was able to purchase a Russian translation of the Qanun Masudi of Biruni in the Brill antiquarian bookshop in Leiden, and I regularly exchanged books with Professor B.A. Rozenfeld in Moscow. Then I met Professor G.P. Matvievskaya, who presented me with a collection of books that had been printed in Tashkent. Thus I learned about the treatise by Ibn al-Haytham (965-ca. 1041) on the extraction of the cube, which was first published by Professor Akhmedov in 1977 [7: 113–117].

Professor Akhmedov made many contributions towards publicizing the legacy of Abu Rayhan Biruni, the unique and incomparable scholar in the Arabic-Islamic tradition. [See 3]. In the Netherlands we know about Biruni because Arabic manuscripts of his works are preserved in the library of the University of Leiden. Uzbek and Russian scholars have paid attention to many of these Leiden manuscripts. The unique manuscript Leiden.Or. 133/2 ff. 33-48, which is the only extant copy of Biruni's list of his own works, has been translated into Uzbek [15: 230–243]. The Leiden library also possesses unique manuscripts of two mathematical letters by Biruni (Or. 168, 134b–137b), of which the first was translated into Russian [13: 96, 159–161]. The library possesses one manuscript of Biruni's geographical work on the projection of spheres (Or. 14, ff. 300–314),which Professors Akhmedov and Rozenfeld translated into Russian [8: 127–153], and one manuscript of Biruni's trigonometrical treatise on chords in Or. 513 f.108–129, which has also appeared in several Russian translations most recently in [9]. Finally, the Leiden library contains two manuscripts of Biruni's work Istiāb on the construction of the astrolabe (Or. 591/4 and Or. 123/3), which work has not yet been translated into any language.

The largest and most substantial astronomical work by Biruni is the Qanun Mas'udi. This work consists of 11 treatises (māqalāt), which Biruni

wrote around 1030 in Arabic. The work is dedicated to the Ghaznavid sultan al-Mas‘ud and is now known to be extant in more than twenty Arabic manuscripts[1]. Biruni wrote the work for specialists in astronomy, with the purpose of building astronomy on a solid and clear foundation. Therefore the work is full of complicated numerical, geometrical and astronomical arguments, and it may be compared in size and scope to the Almagest of Ptolemy of Alexandria (ca. 150 AD) . Because Biruni mastered the material completely and tried to explain it very thoroughly, the Qanun Mas‘udi is probably the most important source for a modern researcher who wants to familiarize himself deeply with astronomy in Islamic civilization.

In the 1880 s, some European orientalists realized the importance of Biruni’s works in general but they paid little attention to he Qanun Mas‘udi, perhaps because of the difficulty of the work. The German orientalist Max Krause (1909–1944) wanted to publish the Arabic text of the work [11: 1–15] but he died in the second world war. Apparently he had prepared an Arabic transcript of the Qanun Masudi in 1220 handwritten pages, but this was never published[2].In 1954–1956 the Arabic text was published in three volumes in Hyderabad (India) in an edition of more than 1000 pages [4, 5, 6]. Apparently, the editors in Hyderabad did not make the necessary effort to work through the scientific arguments in Biruni’s text. Thus, the Hyderabad edition contains thousands of errors (for some examples see below).

The task to make sense of Biruni’s arguments in the Qanun Mas‘udi was left to a group of scholars including Professors Akhmedov, under the supervision of professor B.A. Rozenfeld. The result of their work was published in the Russian translation of the Qanun Masudi in two volumes in 1973 and 1976. Volume one contains an introduction, translation of Books 1–5 by P.G. Bulgakov and B.A. Rozenfeld with notes, with contributions by M.M. Rozhanskaya (translation and notes) and A. Akhmedov (notes) [1]. Volume 2 contains the translation of Books 6-11 by B.A. Rozenfeld and A. Akhmedov with notes, with contributions by M. M. Rozhanskaya (translation and notes), S.A. Krasnova and Yu.P. Smirnov (translation), and indices by A. Akhmedov [2]. The hundreds of notes to the translations in the two volumes include many corrections to the Hyderabad edition. The indices to vol. 2, which were prepared by Professor Akhmedov, have been very useful to me for many years.

[1]See the website for details on the manuscripts [17].
[2]See the obituary in Der Islam 1950, p. 106. The manuscript edition by Krause now seems to be in Hyderabad, India, according to [4: 10] see below.

Translating the Qanun Mas‘udi is an extremely complex task. Biruni was not only a mathematician and astronomer but also an expert in Arabic literature and a poet. His language is concise and often challenging, with a characteristic flavour, and he sometimes plays with the Arabic language. He also introduced Sanskrit expressions from time to time.

My first example shows the difficulty of translating Biruni. The example is found in Book 3 of the Qanun Masudi, which was translated in volume 1 of the Russian translation. Book 3 of the Qanun Mas‘udi, on trigonometry,had previously been translated into German by Carl Schoy in 1927. It is interesting to compare the beginning of Chapter 5 of Book 3 in the German and Russian translations.

In Schoy‘s translation the chapter begins as follows (my translation from the German, parentheses and question marks occur in Schoy’s translation) [16: 31]:

“About the ratio which exists between the diameter and the circumference of the individual circle.

This is easy to express in a (small) number. And verily, only the one of those who wanted to (fix it), really changed (?) something in this matter, but these changes only related to the procedure and the improvement (of it?), as well as the division of the circumference, regarding which the men of this science differ from one another. The circumferences have 360 parts, and each of these parts is subdivided in sexagesimal division. The origin of this may lie in the fact that this number (360) between the number of days holds the middle between the days of the solar and lunar year, but there is no compulsion to make this assumption. And the circumference of a circle has a ratio to the diameter, and the number of the circumference should be set in ratio to that of the diameter, and this gives the approximate knowledge of that ratio”[1].

[1]German text: Über das Verhältnis, welches zwischen dem Durchmesser und dem Umfang des einzelnen Kreisesbesteht.

Dasselbe ist leicht in einer (kleinen) Zahl auszudrücken. Und wahrlich, nur der eine unter denen, die (sie festsetzen) wollten, anderte (?) wirklich etwas an der Sache, aber diese Änderungen bezogen sich nur auf das Verfahren und die Verbesserung (desselben?), wie auch die Einteilung des Kreisumfangs, hinsichtlich welcher die Männer dieser Wissenschaft von einander abweichen. Die Umfänge halten 360 Teile, und jeder dieser Teile ist nach sexagesimaler Teilung weiter geteilt. Der Ursprung hiervon dürfte in der Tatsache liegen, daß diese Zahl (360) zwischen der Anzahl der Tage des Sonnen- und jener des Mondjahres die Mitte hält, ohne daß jedoch ein Zwang zu dieser Annahme vorliegt. Und der Umfangeines Kreises steht zu seinem Durchmesser in einem Verhältnis, und es soll die Zahl des Umfanges zu jener des Durchmessers ins Verhältnis gesetzt werden, und das gibt die angenäherte Kenntnis jenes Verhältnisses.

In the quoted passage, Biruni says that a circle was divided into 360 parts because the 360 is a number between the 365 or 366 days of a solar year and the 354 or 355 days of a lunar year. The rest of the passage is unclear in Schoy's translation. The difficulties were resolved in the Russian translation [1: 271][1]. Here is an English translation from the Russian:

"On the ratio between the diameter and the circumference of the circle.

Although the unit also applies to objects of counting, if we consider the one in [the totality of entities] possessing substance, then it does not appear as true in its essence, but [accepted] conditionally and by common agreement, such as the parts of the division of the circumferences of circles, about which the people of this art have agreed that there are three hundred and sixty of them, and that each of them is divided into sexagesimal parts.

The reason for [choosing] this [division number of the circle] is only that it mediates between the days of the solar and lunar year,[2] and not its obligatory nature.

The circumference of a circle has a certain ratio to its diameter, therefore the number of the circumference also has a ratio to the number of the diameter, although it is irrational".

The Russian translation [1: 545] adds two footnotes explaining the Arabic terminology "objects of counting", and "the one in [the totality of entities] possessing substance," with a reference to a publication by G.P. Matvievskaya including number concepts in the Arabic tradition in general [12].

Thus, the confusion in Schoy's translation has been cleared up and the meaning of the text has become transparant. Schoy did not realize that the beginning of this text is a technical discussion of the role of the number

---

[1]Arabic text in [5: 303] Russian translation:

Об отношении между диаметром и окружностью.

Хотя единичное и относится к объектам счета, но если рассматривать единицы в [совокупности сущностей], обладающих веществом, то они не являются истинной по своей сущности, а [принять] условно и по общему соглашению, как и части деления окружностей кругов, о которых согласились люди этого искусства, что их – триста шестьдесят, и что каждая из них делится на шестидесятые части. Причина [выбора] этого [число деления окружности] – лищь в том, что оно посредничает между днями солнечного и лунного года, а не обязательность его.

У окружности круга, к его диаметру имеется некое отношение, поэтому у числа окружности к числу диаметра также есть отношение, хотя оно и иррационально.

[2]Biruni means that the number 360 is in the middle between the $365\frac{1}{4}$ days of the solar year and the $354\frac{11}{30}$ days of the lunar year.

“one”in the definition of unit of measurement. The example shows how easily one can be deceived by the difficult language of Biruni.

My second and third example will be from volume 2 of the Russian translation. Book 6 of the Qanun Masudi, on the theory of the sun, has not been translated into any Western language.

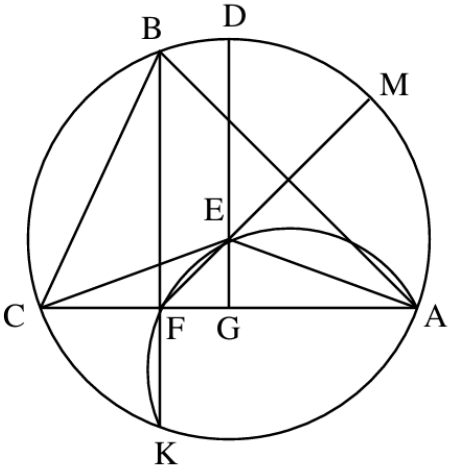


Figure 1

My second example is a computation by Biruni, which was misrepresented in the Hyderabad edition of the Arabic text (5: 655) and which was corrected by Rozenfeld and Akhmedov in the Russian translation [2: 46]. This computation in Chapter 7 of Book 6 of the Qanun Mas‘udi concerns the solar apogee.

Already in Greek antiquity the astronomers knew that the sun moves with a slightly variable speed against the background of the fixed stars. Ptolemy and most Arabic astronomers explained this irregularity by the assumption that the sun moves with constant speed on a circle whose centre E does not coincide with the centre of the earth F (Figure 1, taken from the Russian translation p. 46). Ptolemy put the radius of the circle equal to 60 units, and he determined the eccentricity EF and the position of E as seen from the Earth F (that is, the position of the solar apogee M) on the basis of observations of the solar noon altitude at three suitable moments in time. The procedure was repeated by Arabic astronomers, who found more accurate results than Ptolemy.

In Chapter 7 of Book 6 of the Qanun Mas‘udi, Biruni wanted to determine the position of the solar apogee using the method of Ptolemy but on the basis of his own observations. Biruni considers the circle ABC, which is the circular path of the sun, and he puts the radius of this circle equal to 1.

The earth is at F which does not coincide with the centre E of the circle.

The points A, B and C indicate the positions of the sun at the beginning of spring, summer and fall respectively. Biruni determined the times of these events in Jurjaniyya (now Kunya-Urgench, Turkmenistan) in the year 1016 AD. The solar altitude is maximal at the beginning of summer, minimal at the beginning of winter, and the exact average between the maximum and minimum at the beginning of spring and fall. Of course, the beginnings of the seasons do not necessarily happen at noon on a certain day, and Biruni (and other astronomers) usually found the exact beginnings by a process of interpolation between observations of noon altitude on successive days. In any case, Biruni found that in the year 1016 AD, the length of spring season was 93+28/60 days and the length of the summer season was 93+28/60 days; we will use the standard sexagesimal notation 93;28 and 93;8. Using his previously obtained value of the velocity of the sun on the circle (ca. 0°59′8″ ... degrees per day), he computed the lengths of the arcs AB and BC on the circle as arc AB = 92;7,11,2 degrees (this notation means 92 + 7/60 + 11/3600 + 2/210600 = 92°7′11″2‴ and arc BC = 91;47,31,30 degrees. From the definition of the seasons it can be shown the points A, B and C are 90 degrees apart from each other, as seen from the earth F, therefore $\angle AFB = 90°$ and $\angle BFC = 90°$.

Biruni then performs a complicated computation of the length of EF and the position of the solar apogee M, on the basis of his favorite trigonometric theorems. I now give examples of steps in the computation which were misrepresented in the Hyderabad edition. The errors were corrected by Rozenfeld and Akhmedov, and the corrected values appear in brackets behind the wrong values in the Hyderabad edition. These corrected values must be what Biruni intended, as is evident from a structure of the computation as a whole.

We have from a table of chords:

AB = 2;24,24,27,39 [1;26,24,27,39]

BC = 1;26,10,9,4

AC = 1;59,55,47 [1;59,55,47,44]

AF = $\frac{1}{2}$ ($\frac{AB^2 - BC^2}{AC}$ + AC) = 1; 0, 8, 11, 28

FC = AC − AF = 0;19,46,36,16 [0;59,47,36,16], and so on.

In the end Biruni found that point M is in approximately 25 Gemini and he also determined the length of FE (approximately 0;2). In his computations, Biruni used the Arabic alphabetical (abjad) numbers for integers and for sexagesimal fractions. Thus the numbers 3 and 8 are very similar to one another, the numbers 19 and 59 differ by only a dot, and so on. As a result, confusion can very easily occur. The editors of the Hyderabad edition clearly did not check the computations[1].

My third and final example is an argument in a geometrical figure (Figure 2, taken from [2: 62]of the Russian translation) in Chapter 8 of Book 6, where Biruni again computes the solar apogee, this time from other data. He uses the complicated geometrical Figure 2 in which many points are labelled by letters of the Arabic alphabet. Because some of these letters are very similar in Arabic (for example B and Z, B and I, I and N, N and D, etc.), mistakes were frequently made by scribes of the manuscripts, who often did not understand the contents. If there is more than one manuscript, the labels in the same figure may be different, and in such situations one can only decide between the readings by means of the mathematical context. This work had not been done by the editors of the Hyderabad edition.

In Figure 2, point A represents the sun in the exact middle of spring, B in the exact middle of the summer, and C in the exact middle of the fall. Biruni explains why these points are easier to determine by observations than the beginning of summer. From his observations he was able to determine the time which the sun needed to pass from A to B and from B to C. Point F is again the centre of the earth, point E is the centre of the circle on which the sun moves, and Biruni wished to determine the direction of E as seen from F (given by $\angle$AFE) and the length of FE if the radius of the circle is 1.

The computation[2] involves geometrical arguments which are often misrepresented in the text of the Hyderabad edition. We only mention two

[1] For a modern evaluation of this computation by Biruni see Table 1 in [14: 322].

[2] For a modern evaluation of this computation by Biruni see [14: 321]. (Mid-Seasons) and Table 2 in [14:326].

examples. In the Hyderabad edition we find [5:679] statements which can be translated by the modern formulas DK · KL + $\mathrm{BK}^2 = \mathrm{BI}^2$

and $\frac{1}{2}$ (DK+KL) = DL (or BL in one of the manuscripts). These erroneous statements were corrected by Rosenfeld and Akhmedov (see [2:62]), and the corrected statements can be represented as to DK · KL+ $BK^2 = BD^2$ and $\frac{1}{2}$ (DK+KL) = DX. There is no doubt that this is what Biruni intended, also because the two statements were consequences of his favourite theorems on arcs in a circle.

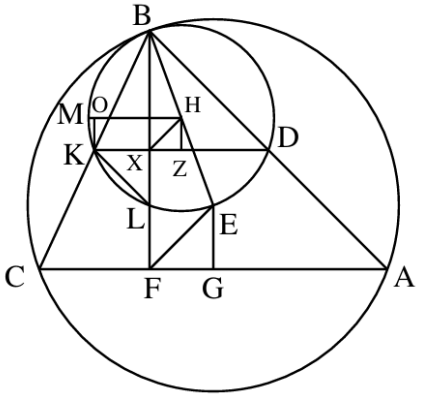


Figure 2

My three examples show that translating an Arabic mathematical or astronomical manuscript is only possible after one has worked to understand the scientific contents. This is what Rozenfeld and Akhmedov have done in the case of the Qanun Mas‘udi. Their corrections are indispensable for any future editor or translator of the text.

Professor Akhmedov has done an immense amount of labour to make the difficult Arabic text of the Qanun Mas‘udi available in Russian and Uzbek translations. Since the publication of these translations, many articles have been written on sections of the Qanun Masudi. Until now, the entire text of the Qanun Mas‘udi has not been translated into any language other than Russian and Uzbek, in spite of the importance of the work [10: 59–81]. Thus, the translations and commentaries to which Professor Akhmedov contributed are immensely valuable.

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ЯН ХОГЕНДАЙК

ПРОФЕССОР АШРАФ АҲМЕДОВ ВА АБУ РАЙҲОН БЕРУНИЙНИНГ “МАСЪУД ҚОНУНИ” АСАРИ

Ушбу мақолада проф. Ашраф Аҳмедов ва у ҳаммуаллифликда амалга оширган Абу Райҳон Берунийнинг “Қонуни Масъудий” асари русча таржимаси ва бу таржиманинг аҳамияти ҳақида сўз юритилган. “Қонуни Масъудий” Беруний томонидан араб тилида ёзилган энг йирик астрономик асар ҳисобланади. У ғазналик Султон Масъудга (1030–1040) бағишланган “Китоб” (*Мақолот*)дан иборат.

“Қонуни Масъудий” тўрт қўлёзмаси асосида 1954–1956 йилларда 3 жилдда Ҳайдарободда нашр қилинган. Нашр ҳажми 1482 бетни ташкил қилади. Асар танқидий нашр бўлишига қарамай, унда кўплаб хатоликлар мавжуд эди. 1973–1976 йилларда икки жилдда А. Аҳмедов, Г.П. Булгаков, Б.А. Розенфельд ва бошқа олимлар ёрдамида нашр этилган русча таржимага юз бетдан ортиқ изоҳлар ёзилган ва уларда нашрдаги ана шу хатоликлар ҳам тузатилган. Ҳайдаробод нашридан ташқари, русча таржимага асарнинг Лондон ва Берлиндаги 11 қўлёзма нусхаси жалб этилган.

Мақолада учта мисол орқали проф. А. Аҳмедов ва проф. Б. Розенфельдларнинг “Қонуни Масъудий” арабча матнини таржима қилишда айнан асарнинг илмий мазмуни устида чуқур ишлаганликлари кўрсатиб берилган. Мазкур русча нашрнинг “Қонуни Маъсудий” устидаги бўлажак тадқиқотлар учун катта илмий аҳамиятга эга эканлиги очиб берилган.

Калит сўзлар. *Абу Райҳон Беруний, "Қонуни Масъудий" қўлёзмалари, "Қонуни Масъудий" нашрлари, Ашраф Аҳмедов, Борис Розенфельд, ўрта асрлар мусулмон астрономияси тарихи, ўрта асрлар мусулмон математикаси тарихи.*

ЯН ХОГЕНДАЙК

ПРОФЕССОР АШРАФ АХМЕДОВ И "КАНОН МАС'УДА" АБУ РАЙХАНА БИРУНИ

В данной статье речь идет о значении русского перевода труда Абу Райхана Беруни «Канон Мас'уда», сделанном профессором Ашрафом Ахмедовым в соавторстве. Этот труд считается самым крупным произведением по астрономии, написанным Беруни на арабском языке. Оно посвящено газнийскому Султану Мас'уду (1030–1040) и состоит из 11 Книг (*Макалат*).

На основе четырех рукописей «Канон Мас'уда» в 1954–1956 годах в Хайдарабаде был издан в трех томах. Издание состоит из 1482 страниц. Несмотря на то, что оно является критическим, в нем были допущено множество ошибок. В 1973–1976 годах А. Ахмедовым, Г.П. Булгаковым, Б.А. Розенфельдом и другими был издан русский перевод труда в двух томах. Это издание было снабжено комментариями на ста страницах и исправлениями имеющихся ошибок. Помимо Хайдарабадского издания, в русском переводе были использованы рукописи, хранящиеся в Лондоне и Берлине.

В статье на основе трех примеров показано, как проф. А. Ахмедов и проф. Б. Розенфельд в процессе перевода арабского текста «Канона Мас'уда» основательно потрудились именно над его научным содержанием. Автор статьи раскрыл большое научное значение этого перевода для будущих научных исследований.

Ключевые слова: *Абу Райхан Беруни, рукописи «Канона Мас'уда»* – издания «Канона Мас'уда», Ашраф Ахмедов, Борис Розенфельд, история *мусульманской астрономии средневековья, история мусульманской математики средневековья.*

JAN HOGENDIJK

PROFESSOR ASHRAF AKHMEDOV AND THE QANUN MAS'UDI OF ABU RAYHAN BIRUNI

This article by Dutch historian of mathematics, Professor Jan Hogendijk discusses the significance of the Russian translation of Abu Rayhan Beruni's work "The Canon of Mas'ud", made by Professor Ashraf Akhmedov in co-authorship. This work is considered the largest work on astronomy written by Beruni in Arabic. It is dedicated to the Ghazni Sultan Mas'ud (1030–1040) and consists of 11 Books (*Maqalat*).

Based on four manuscripts, the "Canon of Mas'ud" was published in Hyderabad in 1954–56 in three volumes. The edition consists of 1482 pages. Despite the fact that it is critical, many errors were made in it. In 1973–76, A. Akhmedov, G.P. Bulgakov, B.A. Rosenfeld and others published a Russian translation of the work in two volumes. This edition was provided with commentaries on one hundred pages and corrections of existing errors. In addition to the Hyderabad edition, manuscripts stored in London and Berlin were used in the Russian translation.

The article, based on three examples, shows how Prof. A. Akhmedov and Prof. B. Rosenfeld, in the process of translating the Arabic text of the "Canon of Mas'ud", worked hard precisely on its scientific content. The author of the article revealed the great scientific significance of this translation for future scientific research.

Key words: *Abu Rayhan Beruni, manuscripts of "Canon of Mas'ud", editions of "Canon of Mas'ud", Ashraf Akhmedov, Boris Rezenfeld, history of Muslim astronomy in the Middle Ages, history of Muslim mathematics in the Middle Ages.*