Keşf-i Kadîmden Vaz'-ı Cedîde

İSLÂM BİLİM TARİHİ VE FELSEFESİ

F

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THE EFFECT OF ISLAMIC SCIENCE ON THE FORMATION OF THE WESTERN SCIENTIFIC TRADITION: THE CASE OF IBN MUʿĀDH OF JAEN[1]

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INTRODUCTION

This article reviews the influence on medieval Western science of the astronomer and mathematician from al-Andalus, Abū ʻAbd Allāh [Abū Bakr, according to other sources] Muḥammad b. Ibrāhīm b. Muḥammad b. Mu'ādh al-Sha'bānī al-Jayyānī.[2]

Ibn Mu'ādh (or his copyist) signed his *Maqāla fī sharḥ al-nisba* (*Commentary on the concept of mathematical reason*) with the attributive adjective al-Jayyānī: that is to say, from Jaen in southern Spain. His lineage, the Banū Mu'ādh, was also native to Jaen and many family members held the post of judge (*qāḍī*) there. Ibn Mu'ādh al-Jayyānī followed this family tradition, as some sources call him "judge" (*qāḍī*) and "the judge of Jaen" (*qāḍī Jayyān*). In addition, he took the name of "the jurisprudent" (*al-faqīh*).

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[1] *Batı(lı) Bilim Geleneğinin Oluşumunda İslam Biliminin Etkisi: Jean İbn Mu'âdh Örneği*

[2] Yvonne Dold-Samplonius and Heinrich Hermelink, "al-Jayyānī, Abū ʻAbd Allāh Muḥammad ibn Muʻādh", *Dictionary of Scientific Biography*, Charles Scribner's Sons, New York, vol. VII, 1973, 82–83. Fuat Sezgin, *Geschichte des Arabischen Schrifttums*, vol. 5, Brill, Leiden, 1974, 109. Emilia Calvo and Josep Casulleras, "Ibn Muʻāḏ al-Ŷayyānī, Muḥammad", *Enciclopedia de la Cultura Andalusí: Biblioteca de al-Andalus*, Fundación Ibn Tufayl de Estudios Árabes, Almería, vol. 4, 2006, 197–201. Emilia Calvo, "Ibn Muʻādh, Abū ʻAbd Allāh Muḥammad ibn Muʻādh al-Jayyānī", *The Biographical Encyclopedia of Astronomers*, Springer, New York, 2007, 562–563. Julio Samsó, *Las ciencias de los antiguos en al-Andalus (*addenda *and* corrigenda *by Julio Samsó and Miquel Forcada)*, Fundación Ibn Tufayl de Estudios Árabes, Almería, 2011. First edition: Mafre, Madrid, 1992. Julio Samsó, "Ibn Muʿādh al-Jayyānī", *Encyclopaedia of Islam, THREE*, (Consulted online on 09 February 2019), http://dx.doi.org/-10.1163/1573-3912_ei3_COM_30882, first published online: 2017.

Ibn Mu'ādh al-Jayyānī appears to have carried out most of his scientific activity in Jaen during the eleventh century. Together with the name found in the sources, "the judge of Jaen", we know that he died in this city in 1093. According to a Hebrew translation of one of his texts, he also lived in Seville. His books that have come down to us tell us that he was a mathematician and astronomer, and that he was interested in the computation of astrological methods.

A translation can be seen as a sign of the curiosity aroused by work produced in a different cultural ambit. Thus, we assume that Ibn Mu'ādh al-Jayyānī's works were favourably received in the Latin western scientific milieu: the original manuscripts in Arabic of his *Liber de crepusculis matutino et vespertino* (*Book of the morning and evening twilights*) and the *Tabulae Jahen* (*Tables of Jaen*) are now lost, but they were translated into Latin in the twelfth century by the Italian translator Gerard of Cremona (born Cremona ca. 1114–died probably in Toledo in 1187), a prolific translator who mastered astronomy, mathematics, medicine and pharmacology.

Between the twelfth and the seventeenth centuries, the Latin version of Ibn Mu'ādh al-Jayyānī's *Liber de crepusculis matutino et vespertino*[3] was disseminated in (at least) the 25 manuscripts that survive today. If, as is likely, an even greater number of translations were made (but have not survived), the diffusion of this work would have been even greater. This Latin version was translated into Italian in the fourteenth century, and it was printed on several occasions in Lisbon and Basel in the sixteenth century. Ibn Mu'ādh al-Jayyānī's work was also translated into Hebrew by the translator Samuel ben Judah of Marseille (active in the early fourteenth century). This ensemble of translations and printings give us an idea of the long-lasting impact of Ibn Mu'ādh al-Jayyānī's work.

As its title suggests, the *Liber de crepusculis matutino et vespertino* deals with the determination of dawn and evening, that is, the time preceding sunrise and the later period until sunset, the two bright moments generated by the light of the Sun in the upper atmosphere. Ibn Mu'ādh al-Jayyānī uses an interval of 19 degrees for his craft and astronomical observations, although he mentions the value of 18 degrees used in al-Andalus. In relation to the phenomenon of twilight,

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[3] 'Abd al-Ḥamīd Ibrāhīm Sabra, "The Authorship of the *Liber de crepusculis*, an Eleventh-Century Work on Atmospheric Refraction", *Isis*, 58 (1), 1967, 77–85. Bernard Raphael Goldstein, "Ibn Mu'ādh's Treatise On Twilight and the Height of the Atmosphere", *Archive for the History of Exact Sciences*, 17, 1977, 97–118. A. Mark Smith, "Ptolemy, Alhacen, and Ibn Mu'adh and the Problem of Atmospheric Refraction", *Centaurus*, 45, 2003, 100–115.

the German astronomer Johannes Kepler (born Weil der Stadt 1571 – died Ratisbona 1630) obtained a very accurate measurement of the height of the atmosphere with the means at his disposal. Although far off Kepler's solution, Ibn Mu'ādh al-Jayyānī's estimation of 52 miles for the height of the atmosphere, based on mathematical calculations, was regarded as prescriptive in Latin Western science until Johannes Kepler's proposed figure became known in the seventeenth century.

A feature common to both Ibn Mu'ādh al-Jayyānī's *Liber de crepusculis matutino et vespertino* and the *Naturales Quaestiones* by Seneca (Cordoba, 4 BC – Rome, 65 AD) is the claim that sun-light is disseminated in the moist vapors of earth generating the light of dawn and evening. This coincidence regarding a phenomenon of nature establishes Ibn Mu'ādh al-Jayyānī as a transmitter of the scientific tradition of the classical period.

Ibn Muʿādh of Jaen, Islamic Science and Western Scientific Tradition

Medieval astronomers produced tables of numerical parameters to convert dates and to record the mean motions of the five planets, the Sun and the Moon, the motions of the fixed stars, the trepidation motion of the equinoxes, solar and lunar eclipses, and many more astronomical and astrological issues as well. The parameters used in the tables provide a reflection of the astronomical and astrological theories in place in the Middle Ages. Thus, some tables were based on the models of Ptolemy (active in Alexandria, second century AD), al-Khuwārizmī (active in Baghdad, ca. 830), al-Battānī (born Harran, Turkey, ca. 858 – died Samarra, Iraq, 929) and others on the model of Ibn al-Zarqālluh (active in Toledo and Cordoba – died Cordoba, 1100).

Ibn Mu'ādh al-Jayyānī's Astronomical Tables are what is known as a *zīj* (plural *azyāj*, *zījāt*) in Arabic. The term designates a composition with astronomical and astrological matters, usually comprising two parts: the tables or charts with numerical parameters, and the canons or instructions to use the tables.

Modern researchers on the history of Islamic science have determined how a table was constructed to establish its underlying astronomical and astrological doctrine and mathematical basis, and the relation of the user of a table with a certain school. This research has also drawn attention to the continuous dedication of medieval astronomers to adapting and updating the parameters of previous tables.

In relation to Ibn Mu'ādh al-Jayyānī's Astronomical Tables,[4] his numerical tables were followed by the Andalusī astronomer of the twelfth century, Ibn al-Kammād (active in Cordoba in 1116), and are preserved partially in an anonymous astronomical compilation (Tunis, ca. 1266 – 1281). As for the canons, in the Islamic West we have fragments copied in the thirteenth and fourteenth centuries in the same anonymous astronomical compilation and in a book by Ibn 'Azzūz (Constantine, died 1354). In the Latin West, an edition called *Scriptum antiquum saraceni cuiusdam de diversarum gentium Eris, annis ac mensibus et de reliquis Astronomiae principiis*, was printed in 1549 in Nuremberg on the basis of the *Tabulae Jahen* – the shortened name by which Ibn Mu'ādh al-Jayyānī's Astronomical Tables were known in their lost twelfth-century Latin version, the *Liber tabularum Iahen cum regulis suius* by Gerard of Cremona.

We can see that for the most part these testimonies preserved Ibn Mu'ādh al-Jayyānī's canons. This seems to suggest that the later Western astronomical tradition attributed more importance to Ibn Mu'ādh al-Jayyānī's canons than to his numerical tables which, originally, formed a single set. Probably, the significance of Ibn Mu'ādh al-Jayyānī's canons lay in the fact that they are not merely instructions but the explanation of astronomical and astrological methods that were little known in the West, and were therefore given preference over the numerical tables.

At the same time, the methods contained in his canons show that Ibn Mu'ādh al-Jayyānī was familiar with Eastern astronomical literature. For instance, to determine the azimuth of the qibla,[5] he chose a calculation that was widely accepted among previous Eastern Islamic astronomers: authors like Ḥabash al-Ḥāsib (ca. 850), Kūshyār ibn Labbān (ca. 971–1029) Ibn al-Haytham (ca. 965–1039), and others included the same computation in their works; Ibn Mu'ādh al-

[4] Edward S. Kennedy, "Ibn Mu'ādh on the Astrological Houses", *Zeitschrift für Geschichte der Arabisch-Islamischen Wissenschaften*, 9, 1994, 153–160. Julio Samsó, "Andalusian Astronomy in 14th Century Fez: *Al-Zīj al-Muwāfiq* of Ibn 'Azzūz al-Qusanṭīnī", *Zeitschrift für Geschichte der Arabisch-Islamischen Wissenschaften*, 11, 1997, 73–74 and 91–92. Jan P. Hogendijk, "Applied Mathematics in Eleventh Century Al-Andalus: Ibn Mu'ādh al-Jayyānī and his Computation of Astrological Houses and Aspects", *Centaurus*, 47, 2005, 87–114.

[5] Julio Samsó and Honorino Mielgo, "Ibn Isḥāq al-Tūnisī and Ibn Mu'ādh al-Jayyānī on the Qibla", *Islamic Astronomy and Medieval Spain*, Variorum Collected Studies Series, Great Britain, 1994, article nº VI. Julio Samsó, "al-Bīrūnī" in al-Andalus", *From Baghdad to Barcelona*, vol. II. Anuari de Filologia (Universitat de Barcelona) XIX, B-2. Instituto "Millás Vallicrosa" de Historia de la Ciencia Árabe, 1996, 586-587.

Jayyānī's procedure for measuring the azimuth of the qibla coincides in certain points with al-Bīrūnī's (973–1048).

In the Middle Ages, the support and respect received from a monarch was a sign of the importance of an author and his work. Ibn Mu'ādh al-Jayyānī's *Kitāb majhūlāt qisī al-kura* (*Book of the unknown quantities of the arcs of the sphere*) and the *Risāla fī maṭraḥ shu'ā'āt al-kawākib* (*Treatise on the projection of rays of the planets*) received the backing of King Alfonso X of Castile (r. 1252–1284). At his court, copies in Arabic of the two books were made, which are now preserved in the Medicea Laurenziana Library in Florence.

The first book, the *Kitāb majhūlāt qisī al-kura*,[6] is a treatise on spherical trigonometry containing theoretical and practical issues. In the introduction, Ibn Mu'ādh al-Jayyānī states that these issues are important for understanding the celestial motions and for computing the positions of planets. However, researchers contend that the *Kitāb majhūlāt qisī al-kura* is a treatise of pure trigonometry rather than of trigonometry applied to astronomy. Another reason for the interest in the *Kitāb majhūlāt qisī al-kura* is that it is the earliest treatise on trigonometry from al-Andalus known to us.

Some of Ibn Mu'ādh al-Jayyānī's theorems reached Europe through translations of Islamic mathematicians like al-Battānī and Jābir b. Aflaḥ (active in Seville, ca. 1150). As a result, it has been suggested that Ibn Mu'ādh al-Jayyānī's *Kitāb majhūlāt qisī al-kura* may have contributed in some way to the development of Latin trigonometry, specifically that of Regiomontanus (Bavaria, 1436 – Rome, 1476).[7]

This possibility can not be ruled out, as we know that this European mathematician used the works of Iberian astronomers such as the *Alfonsine Tables* sponsored by King Alfonso X of Castile, which were based on the *Toledan Tables* produced by Ṣā'id of Toledo (1029–1070) together with Ibn al-Zarqālluh and a group of astronomers also from al-Andalus.

[6] María-Victoria Villuendas, *La trigonometría europea en el siglo XI. Estudio de la obra de Ibn Mu'āḏ, El Kitāb maŷhūlāt*, Instituto de Historia de la Ciencia de la Real Academia de Buenas Letras, Barcelona, 1979. Julio Samsó, "Notas sobre la trigonometría esférica de Ibn Mu'āḏ", *Islamic Astronomy and Medieval Spain*, Variorum Collected Studies Series, Great Britain, 1994, article number VII.

[7] N.G. Hairetdinova, "On Spherical Trigonometry in the Medieval Near East and in Europe", *Historia Mathematica*, 13, 1986, 136–146.

The second book copied at the court of Alfonso X of Castile, the *Risāla fī maṭraḥ shu'ā'āt al-kawākib* (*Treatise on the projection of rays of the planets*),[8] is dedicated to two astrological themes: firstly, to the projection of the ray of a planet, the term that designates the determination of the degree on the ecliptic over which a planet addresses its influence, and, secondly, to the establishment of the twelve celestial houses.

The positions of "the four cardines" were established by the intersections of the circles of the sphere: house I (the point of intersection of the circle of the ecliptic with the circle of the Eastern horizon), house VII (the opposite point, placed at 180 degrees), house IV (the point of intersection of the ecliptic with the lower local meridian) and house X (the opposite point: the intersection of the ecliptic with the upper local meridian). In this manner, the ecliptic was divided in four quadrants inside which the rest of the celestial houses were to be established.

This last step, the establishment of houses between cardines, created a great diversity of mathematical computations. One of them is the "Equatorial method of fixed limits", which has the advantage of being applicable also to the projection of rays. In Latin Western science, the "Equatorial method of fixed limits" was known through Regiomontanus, but the first text giving evidence of this method is Ibn Mu'ādh al-Jayyānī's treatise.

A group of astronomers worked in Toledo for King al-Ma'mūn (1043–1075) under the leadership of Ṣā'id of Toledo. Among their members was the young Ibn al-Zarqālluh who would become the leader of an Andalusī Western astronomical tradition distinct from that of Eastern science, and with followers in al-Andalus such as al-Istijī (active in Toledo and Cuenca, eleventh century), and in the Maghrib such as al-Baqqār (active in Fez, ca. 1418). Although Ibn Mu'ādh al-Jayyānī was contemporary of the Toledan group, he was an independent scholar who had no relation with this school.

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[8] Josep Casulleras, "Ibn Muʿādh on the Astrological Rays", *Suhayl*, 4, 2004, 385–402. Josep Casulleras, "Mathematical Astrology in the Medieval Islamic West", *Zeitschrift für Geschichte der Arabisch-Islamischen Wissenschaften*, 18, 2008/2009, 241–268. Josep Casulleras, *La astrología de los matemáticos. La matemática aplicada a la astrología a través de la obra de Ibn Muʿāḏ de Jaén*, Publicacions i edicions de la Universitat de Barcelona, Barcelona, 2010. Hogendijk, "Applied Mathematics in Eleventh Century Al-Andalus: Ibn Muʿādh al-Jayyānī and his Computation of Astrological Houses and Aspects", 87–114.

Their studies focused on different fields: Ṣā'id of Toledo and Ibn al-Zarqālluh in astronomy, Ibn Mu'ādh al-Jayyānī in mathematics, and al-Istijī and al-Baqqār in astrology.

Even though medieval scientists were, at the same time, experts in astronomy, astrology and mathematics, we can say that their specializations influenced the way they approached scientific questions and led them to impose their own requisites and conditions on other fields. Indeed, Ibn Mu'ādh al-Jayyānī came in for criticism: from the field of astronomy and astrology, al-Istijī and al-Baqqār disapproved of his method for the projection of the rays of a planet with latitude[9] because they thought that it was a mathematical formulation that could never be transferred to the physical reality of the motions of the celestial bodies.

Although we do not know the full extent of its impact on the transmission of knowledge, there is no doubt that Ibn Mu'ādh al-Jayyānī's work spread over time in the science of the Latin West, as is shown by the translations and copies of his writings in all genres: astronomy in the *Liber de crepusculis matutino et vespertino* (*Book of the morning and evening twilights*) and the *Tabulae Jahen* (*Tables of Jaen*), mathematics in the *Kitāb majhūlāt qisī al-kura* (*Book of the unknown quantities of the arcs of the sphere*) and astrology in the *Risāla fī maṭraḥ shu'ā'āt al-kawākib* (*Treatise on the projection of rays of the planets*). In addition, in the *Libros del saber de astronomía* (*Books of the knowledge on astronomy*), a composition made at the court of King Alfonso X of Castile, Ibn Mu'ādh al-Jayyānī is quoted as a reference point in astrology.

In the science of the Islamic West, we see some contradictory signs: Ibn Mu'ādh al-Jayyānī's Astronomical Tables were followed and his astrological methods were known; however, his method for projecting the rays of a planet with latitude was rejected, and he does not feature in the book by Ṣā'id of Toledo[10] that lists scientists according to their nation. Perhaps his absence from the Andalusī astronomical tradition meant that, in some cases, his contributions were not recognized.

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[9] Montse Díaz-Fajardo, "Part Two of al-Baqqār's *Kitāb al-adwār*: the latitude of a planet in the calculation of astrological aspects", *Zeitschrift für Geschichte der Arabisch-Islamischen Wissenschaften*, 20/21, 2012/2014, 31–61.

[10] Régis Blachère, *Kitāb Ṭabaqāt al-umam (Livre des catégories des nations)*, Publications de l'Institut des Hautes Études Marocaines, Paris, tome XXVIII, 1935. Ḥ. Bū 'Alwān, Edition of *Ṣā'id al-Andalusī, Kitāb Ṭabaqāt al-umam*, Beirut, 1985.

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