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Khayyām: Ghiyāth al-Dīn Abū al-Fatḥ ʿUmar ibn Ibrāhīm al-Khayyāmī al-Nīshāpūrī

Behnaz Hashemipour

Alternate name

Omar Khayyām

Born **Nīshāpūr, Khurāsān, (Iran), 18 May 1048**

Died **Nīshāpūr Khurāsān, (Iran)**, ***circa*** **1123**

Better known in the West as ʿUmar Khayyām, Khayyām was one of the most prominent scholars of medieval times, with remarkable contributions in the fields of mathematics and astronomy. His worldwide fame today mainly comes from a number of quatrains attributed to him that have tended to overshadow his brilliant scientific achievements. Besides his ingenious achievements in mathematics, Khayyām is said to have supervised or actively taken part in the formulation and compilation of a solar calendar that potentially surpasses all calendar systems ever composed in precision and exactness – a legacy alive today in his native Iran. Khayyām's contributions to astronomy should be viewed within the context of his efforts to compile this calendar.

Nīshāpūr was known for its great learning centers and its prominent scholars. Khayyām studied the sciences of the day in his native town and is said to have mastered all branches of knowledge in early youth. Khayyām soon rose to prominence in Khurāsān, the political center of the powerful Saljūq dynasty that ruled over a vast empire extending from the borders of China to the Mediterranean. As the leading scientist, philosopher, and astronomer of his day, he enjoyed the support and patronage of the Saljūq court.

With the ascent of Jalāl al-Dīn Malik Shāh to the throne, in 1072, Isfahān was chosen as the new capital of the Saljūq dynasty. Consequently, a group of prominent scientists and scholars from Khurāsān, among them Khayyām and **al-Muẓaffar al-Isfizārī**, were summoned to the court in the new capital to embark on two grand projects: the construction of an observatory and the compilation of a new calendar to replace the existing calendars. In addition to other deficiencies, these calendars had proved inefficient in monetary and administrative matters related to time-reckoning. No details have survived regarding the observatory and its site, except for brief notes saying that huge sums of money were spent on it and that it was very well equipped. However, one finds references made by **Naṣīr al-Dīn al-Ṭūsī**, **Quṭb al-Dīn al-Shīrāzī**, and others to a *Zīj-i Khayyām* or *Zīj-i Malikshāhī* (Astronomical handbooks of Khayyām or Malikshāh) that could possibly be one major outcome of the observatory.

By 1079, a solar calendar was developed that was named the "Jalālī" or "Malikī" calendar, thus carrying the name of the monarch who was the project's patron. The most remarkable feature of the new calendar was the correspondence of the beginning of the year (*Nowrūz* or new day) and the beginning of Aries, *i. e.*, where the Sun passing from the Southern Celestial Hemisphere to the Northern appears to cross the Celestial Equator, marking the beginning of spring or the vernal equinox. The Jalālī year was a true solar year that followed the astronomical seasons. The length of this year was the mean interval between two vernal equinoxes. Recent studies have underscored the advantage of the Jalālī calendar by demonstrating the superiority of the vernal equinox as a calendar regulator, arguing that the vernal equinox year length is much more consistent than other natural regulating points.

The second important feature of this calendar was the introduction for the first time of leap years using the rule of quinquennium (5-year periods for leap years). After a normal period of 7 quadrennia (4-year periods for leap years – in exceptional cases 6 or 8), there comes a quinquennia in which the extra day is added to the 5th and not the 4th year as usual. This produces patterns of 33-, 29- and 37-year cycles for 7, 6, and 8 quadrennia, respectively. As modern calculations have shown, this introduction of 5-year leap-days into the calendar has the potential, provided that a correct pattern is employed, of rendering the calendar quite accurate over relatively long time spans – indeed, more accurate than the modern Gregorian calendar. There is, however, a wide variety of opinions on the pattern (the number of times 29 or 37 cycles are combined with 33-year cycles) of leap years originally built into the Jalālī calendar, thus leaving its actual accuracy an open question to be investigated.

Khayyām's major role in the court of Malik-Shāh, as well as the historical testimony of prominent astronomers such as Ṭūsī, Shīrāzī, and **Nīsābūrī**, all associating the name of ʿUmar Khayyām with the Jalālī calendar, leaves little doubt of his leading role in the compilation of the Jalālī calendar. His prominence as a major astronomer of his time is also borne out by his critical notes on **Ibn al-Haytham**'s *Maqāla fī ḥarakat al-iltifāf* (Treatise on the winding motion). This work, which is discussed by Shīrāzī, demonstrates the fact that Khayyām had been engaged in quite complicated and difficult aspects of theoretical astronomy that involved the development of new models to replace the unwieldy latitude models of **Ptolemy**.

Khayyām's work in astronomy has been overshadowed by his outstanding achievements in mathematics, in which his genius and originality are best manifested. His contributions to the subject may well be considered some of the greatest during the entire Middle Ages. In particular, his treatise entitled *Risāla fī al-barāhīn ʿalā masāʾil al-jabr wa-ʾl-muqābala* (Treatise on the proofs of the problems of *al-jabr* and *al-muqābala*) is one of the most important algebraic treatises of the Middle Ages. He also dealt with the so-called parallel postulate and arrived at new propositions that were important steps in the development of non-Euclidean geometries. His work in the theory of numbers was also significant, eventually leading to the modern notion of real positive numbers that included irrational numbers.

Khayyām also wrote short treatises in other fields such as mechanics, hydrostatics, the theory of music, and meteorology. Through his work in ornamental geometry, he contributed to the construction of the north dome of the Great Mosque of Isfahān. He may have also served as a court physician.

Though little remains of his work in philosophy, Khayyām was a follower of **Ibn Sīnā** and much respected by his contemporaries for his work in this field. In a later work, he concludes that ultimate truth can be grasped only through mystical intuition. This perhaps gives some inkling of how to read his famous poetry, not all of which has been accepted as authentic by modern scholarship.

Khayyām seems to have spent the most fruitful scientific years of his life in Isfahān. But with the assassination of Malikshāh in 1092, he returned to Khurāsān, spending the rest of his life in Marw and Nīshāpūr. His death brought to an end a brilliant chapter in Iranian intellectual history.

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