The Great 'Umar Khayyam

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Iran is the land of poetry. The tradition has continued for at least one millennium without a break. Names such as Ḥāfiz, Saʿdī, Firdawsī, Rūmī and Khayyām are known around the world. Ḥāfiz’ collected poems may be found in any Iranian house, beside the holy Koran. The poetic legacies of Saʿdī, Firdawsī and Rūmī are known for their special fragrance and also their very large volume. In this history, Khayyām has a special position, for besides composing several hundred famous quatrains (rubă ʿyāāt) that reflect his philosophical inclinations, he was also an eminent mathematician and astronomer.

Khayyām lived in the late 11th and early 12th century. In Iran he is mainly known for his quatrains; the scientist Khayyām was not introduced until 1938 when the late Prof. Gh.-H. Mosaheb published the original Arabic text of Khayyām’s treatise on algebra with an abridged Persian translation and introduction (second edition 1960). In the West, he was known as a mathematician as early as 1742 when G. Meerman mentioned Khayyām’s algebra (preserved in manuscript no. 199 in the library of Leiden University) in the introduction to his textbook on differential calculus, whereas the poet Khayyām became known in the West mainly through Edward FitzGerald’s translation in verse of Khayyām’s quatrains, first published in 1859 (almost 120 years later).

Khayyām’s philosophical inclination consists of a variety of tendencies from atheism, pessimism, nihilism and skepticism to Epicureanism. His quatrains reflect his perplexity regarding the purpose of man’s life and his nostalgia for the glory of ancient Iran. He encourages his reader to drink wine to alleviate philosophical and social sufferings.

Such teachings of course could be dangerous for their direct incompatibility with dominant religious orthodoxy. This is why we read a lot of criticism of Khayyām in the writings of later authors such as Najm al-Dīn Rāzī who, in his Miṣrād al-ʿibād, attacks Khayyām for his blasphemous beliefs. For the same reason, Khayyām’s contemporaries such as ʿArūzī (author of Chahār-maqāla) and Abu ʿl-Ḥasan Bayhaqī (author of Tārikh-i Bayhaqī) do not mention his quatrains. It is only about 50 years
after Khayyâm’s death that his poetry is mentioned, by ʻImād al-Dīn Kātīb Isfahānī in his Kharīdat al-qāṣr.

Some authors have tried to solve the so called “inconsistency” between the characteristics of the knowledgeable Khayyâm and the Epicurean teachings of the composer of quatrains, by claiming that there were two independent Khayyâms. But the arguments for this are weak, and there is some evidence that Khayyâm was just one person, the poet and the scientist.

In the first place, in the introduction to his algebraic treatise, Khayyâm complains of the social ambience in which he cannot easily pursue his mathematical research. Here we can recognize the pessimistic and critical tone of the poet Khayyâm:

> I was unable to devote myself to the learning of this al-jabr and the continued concentration upon it, because of the obstacles in the vagaries of Time which hindered me; for we have been deprived of all people of knowledge save for a group, small in number, with many troubles, whose concern in life is to snatch the opportunity, when Time is asleep, to devote themselves meanwhile to the investigation and perfection of a science; for the majority of people who imitate philosophers confuse the true with the false, and they do nothing but deceive and pretend knowledge, and they do not use what they know of the sciences except for base and material purposes; and if they see a certain person seeking for the right and preferring the truth, doing his best to refute the false and untrue and leaving aside hypocrisy and deceit, they make a fool of him and mock him.

Khayyâm’s quatrains present complete and perfect messages in a very concise form, which remind us the brevity of mathematical statements and may be compared with Japanese haikus. There are references to the celestial bodies or constellations such as the Pleiades and Taurus in his poetry, and a decided declaration that he puts no faith in astrology. In one of his quatrains, Khayyâm says that he wishes to drink wine in order to extinguish the meddling of his curious mind. Mathematical research that could engage his mind might have a similar effect, offering well-organized and certain mathematical facts as an escape from the suffering caused by his own philosophical pessimism and social annoyances.

In the English translation of his quatrains, there is one quatrain in which he refers to his work on calendar reform:

> Ah, but my computations people say, Reduced the year to better reckoning? Nay, (Have squared the year to human compass, eh?)
'Twas only striking from the calendar
Unborn tomorrow and dead yesterday.

This quatrain is quoted by two renowned historians of mathematics, D.J. Struik and J.L. Berggren, however I have not been able to identify the corresponding Persian quatrain. FitzGerald might have included this based on his knowledge of Khayyâm’s role in calendar reform.

In another quatrain, he says:

وادئ سر زلف دلتل اوزیزی به

It’s better to escape from lessons and sciences,
To be entangled in the locks of the loved-one’s hair...

This implies that the poet was already involved in science. These and other evidences show that in spite of attempts to acquit the scientist Khayyâm of atheism and drinking wine, there is one Khayyâm, who seeks a spiritual refuge in wine and in the search for philosophical and mathematical truth.

There are thousands of books and articles containing editions, translations and analyses of Khayyâm’s life, beliefs and works. Among them, I want to mention the works of two Iranian authors that represent major political, philosophical and literary trends in Iran. The first author, Taqî Erani, was sent to Germany, like many other young and talented Iranians, for higher academic studies in the reign of the first king of the Pahlavi dynasty, Reza Shah. Many of these students were shocked by the contrast between what they had seen in the underdeveloped Iran of their time and what they could see in Europe. This shock influenced their careers and led to an intellectual reaction on their part. Taqi Erani was first attracted by fascist pan-Aryan teachings, but later became an influential Marxist. He was later murdered in hospital. He contributed to the publication of an edition of Khayyâm’s quatrains and Khayyâm’s treatise on finding the proportions of gold and silver in an alloy, published in Berlin in 1925. He later published an edition of the Arabic text of Khayyâm’s commentary on Euclid’s Elements, in Tehran in 1936, using manuscript no. 199 from the Leiden University Library, which Friedrich Rosen had taken to Berlin, and which Erani copied there in 1925.

The other figure is Šâdiq Hidâyat, the most internationally renowned of Iranian novelists, whose works have been translated into several languages (including Dutch). Like Erani, he was sent to Europe to continue his studies. He had close contacts with Iranian leftists but his deep pessimism never allowed him to join the movement actively. Like Khayyâm, he was nostalgic for the glory of ancient Iran. Hidâyat published an edition of
Khayyām’s quatrains preceded by a description of Khayyām’s beliefs. Hidāyat committed suicide in Paris in 1951 and was buried in Perlachaise cemetery.


In this work, Khayyām provides a brilliant classification of the algebraic equations which shows his highly ordered approach. George Sarton, in his Introduction to the history of science, regards it as one of the highest achievements of the Islamic period in mathematics. Khayyām only considered positive coefficients and the solutions to the equations. He discussed the 6 types of linear and quadratic equations, already mentioned by al-Khwārazmī, and continued with 19 types of cubic equations, 5 of which can be reduced to linear and quadratic equations. Of the 14 remaining types, two had been solved before Khayyām, and he solved the remaining 12 types by the intersection of conic sections. His methods were geometrical, but he desired a pure numerical solution to cubic equations and hoped that this might be achieved in the future. In the early 15th century another Iranian mathematician, Ghiyāth al-Dīn Jamshīd Kāshānī (al-Kāshī), devised an iterative method for finding the numerical value of the roots of cubic equations, with any desired accuracy. In the mid-16th century, G. Cardano provided a strict analytic formula for the solution of cubic equations.

Another algebraic treatise by Khayyām, Treatise on the division of a quadrant, preserved in a manuscript kept in the Central Library of the University of Tehran, was first published in Tehran (1960) with a Persian translation. English, Russian and French translations of this short Arabic treatise are also published. In this treatise, Khayyām seeks a method of dividing a quadrant in such a way that certain relations between the line segments are satisfied. He reduces the problem to a cubic equation which he solves using conic sections. Later it turned out that this construction problem is closely related to a geometrical tiling design found in manuscript MS 169 in BN (Paris).

Khayyām’s commentary on Euclid’s Elements, “Explanation of the difficulties in Euclid’s postulates” consists of three chapters: I) on Euclid’s famous postulate on parallel lines, II) on ratios and proportions, III) on composite ratios. In the first chapter, Khayyām refutes the attempts by his predecessors to prove the parallel postulate and presents his own proof. He tries to prove that in any birectangular isosceles quadrangle, the two
remaining angles are also right. To do so, he shows that if we suppose them to be acute or obtuse, the hypotheses lead to inconsistency. His hypotheses of the remaining angles being acute or obtuse correspond to the first theorems of non-Euclidean geometries of Lobatchevsky and Riemann. Khayyám’s birectangular isosceles quadrangle was later used in the works of the 19th century Italian mathematician G. G. Saccheri. Although it later became clear that the efforts of Khayyám and other mathematicians before and after him were mathematical dead ends, such endeavors were important in the final developments of geometry.

In the next two chapters, Khayyám concentrates on the exact definition and nature of the concept ratio. This treatise has been widely studied and translated, also into Spanish.

In his treatise on algebra, Khayyám refers to his treatise on proving the validity of the Indian methods for extracting square roots and cube roots. Khayyám adds that he has generalized these methods for extracting roots of higher orders. This means that he was aware of the coefficients of binomial expansion. The earliest source of this subject is from Karaji (10th century) quoted by Samuel Maghrībī (12th century). This work of Khayyám has not yet been found. The contents list at the beginning of codex no. 199 in the University of Leiden library mentions a treatise on Mushkilāt al-hisāb (the difficulties of arithmetic) by ‘Umar Khayyám, which might be a copy of this work, but unfortunately, the treatise is not included there. A manuscript of this work is reported to exist in Munich, but scholars’ attempts to locate it have failed.

Khayyám was a member of the group of astronomers who carried out astronomical observations in Isfahan, on Malikshâh’s orders, which were compiled in the Zīj-i Malikshiḥā. This group also improved the Iranian solar calendar which had experienced a shift due to the neglect of intercalation after the Arab invasion in the 7th century. The Zīj has not survived and the exact nature of the calendar reform and Khayyám’s role in it are unclear. This has led to long and hard debates in this regard, and the final word remains to be said. However, it is certain that the group decided to define the Iranian New Year (Nowrūz) based on an actual astronomical criterion (the sun entering the astronomical sign Aries at the vernal equinox) rather than arithmetical or tabular criteria. This guarantees keeping Nowrūz at the vernal equinox forever. This brilliant method is applied in the present Iranian calendar. I will conclude with a quatrain composed in Nishapur (Khayyám’s native city) some nine centuries after Khayyám, by Dr. Shafī’ī Kadkanī. It tells us the fate that awaits people like Khayyám, then or now:

**BETWEEN TAVERN AND MADRASA: ‘UMAR KHAYYÁM THE SCIENTIST**
Any person whose qualities go beyond the standards of his time,
Must suffer the torture of loneliness;
He will be accused of being a materialist, atheist and blasphemous,
Also an enemy of the people and a seditious person.