

II he taught Italian students at an international camp near Lausanne. After 1946 Fano lectured in the United States and Italy. In 1911 he married Rosetta Cassin; two sons became professors in the United States.

Fano worked mainly in projective and algebraic geometry of n -space S_n . Early studies deal with line geometry and linear differential equations with algebraic coefficients; he also pioneered in finite geometry. Later work is on algebraic and especially cubic surfaces, as well as on manifolds with a continuous group of Cremona transformations. He showed the existence of irrational involutions in three-space S_3 , i.e., of "unirational" manifolds not birationally representable on S_3 . He also studied birational contact transformations and non-Euclidean and non-Archimedean geometries.

BIBLIOGRAPHY

I. ORIGINAL WORKS. Among Fano's many textbooks are *Lezioni di geometria descrittiva* (Turin, 1914; 3rd ed., 1925) and *Lezioni di geometria analitica e proiettiva* (Turin, 1930; 3rd ed., 1958), written with A. Terracini. Two of his articles appeared in *Encyclopädie der mathematischen Wissenschaften* (Leipzig, 1898–1935): "Gegensatz von synthetischer und analytischer Geometrie in seiner historischen Entwicklung im XIX. Jahrhundert," in III (Leipzig, 1907), 221–288; and "Kontinuierliche geometrische Gruppen," *ibid.*, 289–388.

II. SECONDARY LITERATURE. See A. Terracini, "Gino Fano," in *Bollettino dell'Unione matematica italiana*, 3rd ser., 7 (1952), 485–490; and "Gino Fano, 1871–1952, cenni commemorativi," in *Atti dell'Accademia delle scienze* (Turin), classe di scienze fisiche, 87 (1953), 350–360. A bibliography, compiled by the editorial board, is in *Rendiconti del Seminario matematico, Università e politecnico di Torino*, 9 (1950), on pp. 33–45 of this issue dedicated to Fano (with portrait).

DIRK J. STRUIK

AL-FĀRĀBĪ, ABŪ NAṢR MUḤAMMAD IBN MUḤAMMAD IBN ṬARKHĀN IBN AWZALAGH (Latin *Alf[h]arabius*, *Abunazar*, among other forms) (*b.* Wasīj, district of Fārāb, ca. 870; *d.* Damascus, 950), *philosophy, music*.

The district of Fārāb—on both sides of the middle Jaxartes (now the Syr Darya) at the mouth of its tributary, the Aris—was conquered and Islamized by the Samanids in 839–840, and al-Fārābī's grandfather may have been a pagan convert. His father is said to have been an army officer of noble Persian descent, apparently in the service of the Samanid emirs, who claimed descent from the old Sassanid emperors of

Persia and patronized the emerging New Persian literature; but the family almost certainly spoke Sogdian or a Turkic dialect and exhibited Turkish manners and habits of dress. Al-Fārābī probably commenced his study of Islamic sciences (mainly law—the residents of Fārāb followed the legal school of al-Shāfi'ī) and music at Bukhara before going to Marv, where he seems to have begun his study of logic with the Syriac-speaking Nestorian Christian Yūḥannā ibn Ḥaylān, who was to continue teaching him in Baghdad and perhaps in Haran and whom he later acknowledged as his main teacher.

In the caliphate of al-Mu'taḍid (892–902) both teacher and disciple went to Baghdad. Ibn Ḥaylān devoted himself to his religious duties, either monastic administration or theological instruction in Nestorian monasteries. Al-Fārābī was his only prominent student in logic and philosophy, and his only Muslim student. The complete silence of Arabic sources about Ibn Ḥaylān in any connection except as the teacher of al-Fārābī; Ibn Ḥaylān's isolation from the intellectual life of Baghdad, where Arabic was the main language of instruction in philosophy; and the report that al-Fārābī arrived at Baghdad knowing Turkish and a number of other languages but not Arabic (that is, he did not know Arabic well enough to study philosophy in that language) all indicate that he must have studied with Ibn Ḥaylān in Syriac or Greek or both. It is unlikely that the language of instruction (which included elaborate commentaries on Aristotle's *Organon*) could have been in any of the Turkic dialects, in Sogdian, or even in New Persian. In Baghdad, al-Fārābī set about perfecting his knowledge of Arabic (including the study of advanced Arabic grammar) in about 900 with the well-known philologist Ibn al-Sarrāj, in exchange for lessons in logic and music; he mastered it so well that his writings became a model of simple and clear Arabic philosophic prose. His newly acquired knowledge of Arabic enabled him to participate more fully in the philosophic circles in Baghdad (he is said to have attended the lecture courses of his older contemporary, the Nestorian Christian Mattā ibn Yūnus) and to make fuller use of the extensive body of scientific literature that existed in that language.

In the caliphate of al-Muktafī (902–908) or early in the caliphate of al-Muqtadir (908–932), al-Fārābī left Baghdad to continue his studies in Constantinople. Apparently he traveled first to Haran in the company of Ibn Ḥaylān. "After this [that is, after completing the study of Aristotle's *Posterior Analytics* with Ibn Ḥaylān] he traveled to the land of the Greeks and stayed in their land for eight years until he completed [the study of the] science[s] and learned the

entire philosophic syllabus." This report is quoted by al-Khaṭṭābī (931–998) from al-Fārābī's own account of his studies. Al-Fārābī's linguistic interests, his contacts with the Syriac- and Greek-speaking teachers in Baghdad who could have provided him with the incentive and necessary information for the trip, and the relative ease with which a determined Muslim scholar (for example, the historian al-Mas'ūdī) could visit Constantinople during this period make it difficult to doubt the authenticity of the report, which helps to explain a number of facets of al-Fārābī's works and thought, such as his access to certain traditions and texts and the character of his Platonism. Al-Fārābī's works, in turn, can now provide us with a better understanding of the course of philosophic studies at the University of Constantinople in the period between Photius and Michael Psellus.

Sometime between 910 and 920 al-Fārābī returned to Baghdad to spend more than two decades teaching and writing, which established his reputation as the foremost Muslim philosopher and the greatest philosophic authority after Aristotle. His teacher Ibn Ḥaylān died in Baghdad sometime before 932. Although al-Fārābī must have had a number of students who later spread his works and teachings in Persia and Syria, his only students who are known by name are the prominent Jacobite Christian theologian and philosopher Yaḥyā ibn 'Adī, who headed an active but hardly brilliant philosophic school in Baghdad until his death in 975, and his brother Ibrāhīm, who was still with al-Fārābī in Aleppo shortly before the latter's death. Al-Fārābī's true disciples, however, were men like Ibn Sīnā, Ibn Rushd, and Maimonides, and his influence persisted in the learned tradition of the study of and commentary on Aristotle and Plato in Arabic, Hebrew, and Latin.

While defending the claims of philosophy and the philosophic way of life, al-Fārābī carefully avoided the theological, sectarian, and political controversies that raged in Baghdad during this period. He was not a member of the religious or scribal class. He must have had a number of friends among the many officers from his native land who formed the elite corps of the army and occupied high positions as bodyguards of the caliphs. Through them he probably came in contact with the prominent scribes and viziers who patronized the philosophic sciences, such as Ibn al-Furāt, 'Alī ibn 'Īsā, and Ibn Muqlah. He wrote his major work on music at the request of Abū Ja'far al-Karkhī, who became vizier in 936. This work was of great importance in the history of music theory and science. It is treated in the next section of the article.

It is unlikely that, at the age of seventy, al-Fārābī

would have chosen to leave Baghdad merely in search of additional fame. By 942 the internal political confusion and the threat to the safety and well-being of the city's inhabitants had become extremely grave. The caliph, his viziers, and his bodyguard were so menaced by the rebellion of a former tax collector from the south that the caliph fled and took refuge with the Ḥamdānid prince of Mosul. Al-Fārābī departed to an area which, in 942, seemed more peaceful and was governed by a dynasty more congenial to him than the Ḥamdānids of Mosul. The Ikhshīdids, who ruled Egypt and Syria, were originally army officers from Farghānah, not far from al-Fārābī's birthplace in central Asia; and the Nubian slave Kāfūr, who held the power as regent, was a liberal patron of the arts. Al-Fārābī stayed in Damascus for about two years (during which he perhaps visited Aleppo) and then went to Egypt, no doubt driven there by the conflict in Syria between the Ikhshīdids and the Ḥamdānids, which was to last until 947. In the meantime, the Ḥamdānid prince Sayf al-Dawlah occupied Aleppo and Damascus and began to surround himself with a circle of learned men, whom he supported liberally. About a year before his death, al-Fārābī left Egypt to join Sayf al-Dawlah's circle. When he died in Damascus in 950, the prince and his courtiers performed the funeral prayers for him. He was buried outside the southern, or minor, gate of the city.

Al-Fārābī believed that science (that is, philosophy) had reached its highest development in the Socratic tradition, as embodied in the writings of Plato and Aristotle, their Greek commentators, and others who developed or made independent contributions to the natural and mathematical sciences. This tradition, which had declined in its original home and the spirit or purpose of which had become extinct or confused, must now find a new home in the civilization of Islam, wherein a new tradition of learning had been developing for more than two centuries; must reassert its claim as the supreme wisdom available to man; must infuse the new learning with critical understanding of its foundations and a sense of harmony, order, and purpose; and must clarify the principles and presuppositions of man's view of himself and the natural whole of which he is a part. Al-Fārābī's effort to recover, explain, defend, and reestablish this view of science as the highest stage of human wisdom took into account the gulf that separated the cultural environment of Greek science from the new Islamic environment in such matters as language, political and legal traditions, and characteristic habits of thought, and especially the pervasive impact of the revealed religions on the character and direction of political

life and scientific thought. With persistence and skill, he set about teaching others what must have been the core of his own experience: the reconversion of man and his thought to the natural understanding, as distinguished from the multiplicity of customs, legal and political opinions, and religious beliefs.

Al-Fārābī's teaching activity followed an elaborate philosophic syllabus developed on a number of levels and based on the writings of Aristotle, a number of Platonic dialogues, and the works of Hippocrates and Galen, Euclid and Ptolemy, Plotinus and Porphyry, and the Greek commentators of the schools of Athens and Alexandria.

It began with introductory accounts of the opinions and writings of these authors, comprehensive accounts of the organization of the sciences, and epitomes of individual works. These were followed by a group of paraphrases of individual works, glosses on special difficulties in them, and expositions of particular themes. These led, finally, to a smaller group of lengthy commentaries in which the basic works of Aristotle were explored in great detail, taking into account the contributions, criticisms, and comments of earlier commentators.

Although al-Fārābī wrote commentaries on Euclid's *Elements* and Ptolemy's *Almagest*, the mathematical art to which he devoted particular attention was music. He wrote extensively on its history, theory, and instruments; and it is significant that his chosen art was the practice of music rather than medicine. Unlike the expository and didactic style of his mathematical writings, his specialized writings on natural science are for the most part polemical: against Galen's interpretations of Aristotle's views on the parts of animals; against John Philoponus' criticism of Aristotle's views on the eternity of the world and movement; against the physician al-Rāzī's views on matter, time, place, and atoms; against the theologian Ibn al-Rāwandī's account of dialectic, which was the method used by the theologians in natural science; against the doctrines of the theologians in general concerning atoms and vacuum; and finally against the scientific claims of astrology and alchemy. Judged from two of these writings which have been edited and studied (*On Vacuum* and *Against John Philoponus*), al-Fārābī's intention was not primarily to defend the doctrines of Aristotle against his critics, but rather to clarify the questions at issue, to ascertain the assumptions, coherence, and relevance of the arguments against Aristotle's natural science, and to determine whether they are based on genuine differences between Aristotle and his opponents or merely on a misunderstanding or misinterpretation of Aristotle, overconfidence in the theoretical implications

of certain experiments, or eagerness to support a religious doctrine. Al-Fārābī's openness regarding the foundations of Aristotle's natural science was restrained, however, because of his awareness of the decline of scientific learning since Aristotle's time and the overwhelming odds against free scientific inquiry in the new religious environment.

Al-Fārābī's departure from Aristotle is explicit in his writings on political science, which are inspired by a comprehensive view of Plato's philosophy and modeled after the *Republic* and the *Laws*. The intention of these works is both theoretical and practical. The theoretical intention emerges as al-Fārābī brings together the views of Plato and Aristotle and attempts to harmonize them without removing the underlying polarity between their two philosophies, leaving the reader with the conviction that the residual disagreement between the two leading philosophers may constitute the fundamental unresolved questions of science. The practical intention is expressed through the construction of constitutions proposed for cities whose institutions, doctrines, and practices are meant to promote, support, or at least not inhibit the development of scientific inquiry.

[A full bibliography follows the section below.]

MUHSIN MAHDI

AL-FĀRĀBĪ: Music.

Apart from a brief section in the *Iḥṣā' al-ʿulūm* (*Enumeration of the Sciences*), which provided medieval European theorists with one or two definitions but is otherwise of little interest, only one of al-Fārābī's musicological works has been edited, *Kitāb al-mūsīqā al-kabīr*. This is, however, probably the greatest Arabic treatise on music, and in it al-Fārābī not only demonstrates his mastery over the corpus of theory inherited from the Greeks but also justifies his reputation as an executant musician by giving a comprehensive account of some of the main features of contemporary practice.

For his methodology and definitions (set forth in the introduction) al-Fārābī draws upon the techniques of Greek philosophical inquiry. As for subject matter, however, some aspects with which the Greeks were concerned, such as ethical theories, receive scant attention, and the cosmological implications that had been of considerable interest to al-Kindī are ignored. The main theoretical section of the work begins with the physics of sound. Here al-Fārābī follows Aristotle—not uncritically, but nevertheless without any great originality: it was left to the late tenth-century Ikhwān al-Ṣafā' (Brethren of Purity) to introduce the concept of the spherical propagation of sound (which