

Ambartsumian, Viktor Amazaspovich I

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b. Tbilisi, Georgia [Russian Empire], 18 September 1908; *d.* Byurakan, Armenia, 12 August 1996)

astrophysics, radiative transfer, principle of invariance, stellar dynamics, interstellar absorption, active galactic nuclei.

Recognized as one of the giants of twentieth-century astrophysics, Ambartsumian is best known for his pioneering work in three areas: (1) invariance principles as applied to the theory of radiative transfer; (2) inverse problems of astrophysics; and (3) the empirical approach to problems of the origin and evolution of stars and galaxies. An honorary or foreign member of twenty-eight national academies of sciences, Ambartsumian served as both vice president (1948–1955) and president (1961–1964) of the International Astronomical Union (IAU) and as president of the International Council of Scientific Unions (ICSU). Arguably Armenia's greatest scientist of modern times, Ambartsumian was born in the waning days of the Russian Empire. Coming of age after the 1917 Bolshevik Revolution, Ambartsumian would—as he created his own revolution in astrophysics—live a life that was shaped and directed by the Soviet system in which he lived. Reflecting this dichotomy, the present article is divided into discussions of the scientific and political aspects of Ambartsumian's life.

Early Years. Ambartsumian was born in Tbilisi, Georgia, which at the start of the twentieth century was the cosmopolitan hub of the Russian Empire's Transcaucasian territories. His father Amazasp Asaturovich Ambartsumian graduated from the Institute of Oriental Languages in Moscow and received a law degree from [St. Petersburg](#) University. A linguist who translated classic Greek literature into Armenian, Ambartsumian's father encouraged him from an early age to show an interest in knowledge in general and in science in particular. Viktor Ambartsumian displayed an aptitude for mathematics by age four and had become captivated by astronomy by age eleven. He gave talks on astronomy while still a student in [secondary school](#) and worked in the school observatory.

Following in his father's footsteps, Ambartsumian went to [St. Petersburg](#) (which had been renamed Leningrad) in 1924 and enrolled in the Department of Physics and Mathematics at Leningrad State University (LSU). There he met fellow student Nikolai Kozyrev, who quickly became Ambartsumian's close friend and professional collaborator. As Ambartsumian described in a 1987 interview, in Kozyrev he “found a comrade with whom I became friends because we had absolutely identical goals.” By 1925, Ambartsumian and Kozyrev were working together on problems of radiative transfer and were publishing papers in the *Astronomische Nachrichten*, *Zeitschrift für Physik*, *Monthly Notices of the Royal Astronomical Society*, and other major international journals of the day. The relationship between Ambartsumian and Kozyrev became so close that they were known by a single nickname: “the Ambars.”

Ambartsumian and Kozyrev also had a close friendship with fellow astronomy student Dmitrii Eropkin. In addition, this astronomical trio maintained a friendship with a group of LSU physics “musketees” that included Dmitrii Ivanenko, [George Gamow](#), Lev Landau, and Matvei Bronshtein. Ambartsumian and Kozyrev completed their studies at LSU in 1928 and went to Pulkovo

Observatory on the outskirts of Leningrad for graduate study under the astrophysicist Aristarkh A. Belopolskii.

Like Kozyrev, the physicist Ivanenko figured as a coauthor in Ambartsumian's early works. In particular, in the late 1920s, Ambartsumian and Ivanenko tackled the widespread assumption that atomic nuclei consist of protons and electrons. At a time when the neutron had yet to be discovered, most physicists presumed that the weight of a nucleus came entirely from protons. Moreover, if the charge of a nucleus was something other than would be expected from the number of protons, the nucleus must contain negatively charged electrons to offset the positively charged protons. In studying β decay, however, Ambartsumian and Ivanenko came to the conclusion that an electron is created spontaneously at the time it is ejected from an atom and could not, therefore, have been in the atom's nucleus. The 1930 paper by Ivanenko and Ambartsumian anticipated the discovery of the neutron by two years.

In 1929, Ambartsumian ventured into mathematics. [Werner Heisenberg](#) and Erwin Schrödinger had just published works in which questions of atomic spectra and atomic energy levels were posed as problems of the eigenvalues of several operators—that is, given an operator, find the eigenvalues and eigenfunctions. Ambartsumian turned this around to ask to what extent an atom's spectrum determines its structure. If the eigenvalues are known, is it not possible to first find the operator and then see how unambiguously the operator determines the functions and parameters entering into that operator? Ambartsumian could not

answer this question completely, but he did solve a special case in which he proved that among all vibrating strings only the homogeneous vibrating string has eigenvalues that are specific to it—that is, homogeneous vibrating strings have a spectrum of eigenvalues. Ambartsumian's paper on this, the theory of inverse spectral problems associated with Sturm-Liouville operators, was published in 1929 in the physics journal *Zeitschrift für Physik*, where it went largely unnoticed until it was discovered by mathematicians in the mid-1940s and became a significant research topic in the ensuing decades.

After completing his graduate work in 1931, Ambartsumian served as Pulkovo's Scientific Secretary in 1931 and 1932 while simultaneously working as a lecturer at LSU. During this time Ambartsumian traveled to Pulkovo's southern station in Simeis, Crimea, where he met and married Vera Fyodorovna, the niece of observatory director Grigorii Shain, with whom he would have four children.

In 1932, Ambartsumian published a paper in the *Monthly Notices of the Royal Astronomical Society* on the radiative equilibrium of planetary nebulae that would become a cornerstone of the modern theory of gaseous nebulae. In the following year Ambartsumian and Kozyrev published a work in which the masses of gas clouds ejected by novae were estimated for the first time.

Leaving Pulkovo in 1934, Ambartsumian returned to LSU and organized the [Soviet Union](#)'s first university department of astrophysics. (His first graduate student was Viktor V. Sobolev.) In 1935, when academic degrees were reintroduced into the educational system for the first time since the establishment of the Soviet state, Ambartsumian was awarded a doctoral degree based on his scientific work through that date.

In the mid-1930s, Ambartsumian turned his attention to inverse problems of astrophysics. English astrophysicist [Arthur Eddington](#) had posed the question of whether it is possible to determine the distribution of the space velocities of stars based on the distribution of radial velocities. Ambartsumian showed how this can be done, in the process carrying out the first ever numerical inversion of the Radon transform that today is the basis of tomography, the reconstruction of two-dimensional images from a set of one-dimensional projections and angles. The paper containing Ambartsumian's solution was submitted to the *Monthly Notices of the Royal Astronomical Society* by Eddington himself.

In 1938, Ambartsumian and his student Sh. G. Gordeladze studied bright dusty nebulae and the stars illuminating them. They concluded that such nebulae are illuminated only as a by-product of their accidental placement between the Earth and a bright star. Moreover, Ambartsumian and Gordeladze carried out computations showing that only about 0.05 percent of the galaxy's dust nebulae are illuminated in this manner by bright stars. From this they concluded that interstellar absorption has a patchy structure and that [interstellar matter](#) is in the form of clouds. [Subrahmanyan Chandrasekhar](#) later described Ambartsumian's approach to studying fluctuations in the brightness of the [Milky Way](#) as "marvelously elegant" (p. 3). In 1939, at the age of 31, Ambartsumian was elected a corresponding member of the Academy of Sciences of the USSR.

World War II and Beyond. [World War II](#) brought an abrupt change in Ambartsumian's career. With German forces approaching Leningrad in 1941, Ambartsumian organized the evacuation of much of Leningrad State University to a safe location beyond the Ural Mountains in Elabuga. There Ambartsumian established and headed the Elabuga branch of LSU, for which he was subsequently awarded an Order of Lenin.

Even during the war years, Ambartsumian continued his pioneering work in astrophysics, in 1943 developing and applying the invariance principle to the problem of

isotropic scattering in a semi-infinite, plane-parallel atmosphere. According to this principle, the reflective capability of a medium consisting of infinitesimally thin, parallel layers of nearly infinite optical depth does not change if a new layer with the same optical properties is added. Applying this principle, Ambartsumian developed a system of simple functional equations describing light scattering in a turbid medium. These equations found immediate application to problems of radiative transfer in the Sun and other stars, and they have since been applied in optics, mathematical physics, and a number of other fields. Chandrasekhar described the principle of invariance as "a theoretical innovation that is of the greatest significance" (1988, p. 3) and did much to develop Ambartsumian's innovation further.

As the war moved towards its end, in 1944 Ambartsumian moved his family to Yerevan, Armenia, where he helped to found the Armenian Academy of Sciences, serving first as vice president (1944–1947) and then as president (1947–1993). From that point forward, science in Armenia was synonymous with the name Ambartsumian.

In 1946, he founded Byurakan Observatory, Armenia's first major and as of 2007 still most important observatory for astrophysical research. He directed Byurakan through 1988 and continued as its honorary director thereafter. He simultaneously served as chairman of the Department of Astrophysics at Yerevan State University. In 1964 Ambartsumian founded the Armenian journal *Astrofizika*, serving as its editor in chief through 1987.

In 1947, he turned his attention to hot giant and supergiant stars (spectral classes O and B) and T Tauri variable stars, which were known to have a tendency to be found in groups. Ambartsumian studied the spatial velocities of these groups and discovered that they occupy limited spatial volume—that is, they are physical systems. He introduced the term stellar associations to describe these groupings. Analyzing the physical forces at work in these associations, Ambartsumian

determined that they are highly unstable and therefore will dissipate with time. Given that this dissipation has not yet occurred, the stars in these associations must be quite young—on the order of tens of millions of years. From this he concluded that star formation in the galaxy is an ongoing process and that stellar associations are the regions in which star formation is taking place. His discovery of stellar formations opened an entirely new field of astrophysical research.

In the 1950s, following the discovery of strong radio sources in external galaxies, Ambartsumian began studying clusters of galaxies and discovered that these too are unstable, thereby implying that galactic formation also is an ongoing process. In 1958, he gave a report to the Solvay Conference on Physics in Brussels in which he said that explosions in galactic nuclei cause large amounts of mass to be expelled. For these explosions to occur, galactic nuclei must contain bodies of huge mass and unknown nature. From this point forward Active Galactic Nuclei (AGN) became a key component in theories of galactic evolution. In the later twentieth century, AGNs came under direct observational study with the advent of space-borne x-ray observatories such as *Chandra*.

Teoreticheskaia Astrofizika, edited by Ambartsumian, was published in Russian in 1952 and became a bible for a generation of astrophysicists. It appeared in English translation in 1958 and epitomized to the world the high level of development that astrophysics had achieved in the [Soviet Union](#)—with much of the credit attributed to Ambartsumian. A member of the IAU from 1946 on, he served as its vice president from 1948 through 1955 and as its president from 1961 through 1964. He had become the most widely known and respected Soviet astrophysicist in the world. Between 1956 and 1960, he was awarded the Janssen Medal of the [French Academy](#) of Sciences, the Bruce Medal of the Astronomical Society of the Pacific, and the Gold Medal of the Royal Astronomical Society.

He remained active as an astrophysicist well into the 1990s as he continued to develop his work on inverse problems of astrophysics, the invariance principle, and stellar and galactic evolution. He raised the stature of the search for extraterrestrial intelligence (SETI) by hosting two SETI conferences, and Armenia became a magnet for foreign astrophysicists traveling to conferences and seminars organized by Ambartsumian at Byurakan. Internationally, he served two terms as president of the ICSU (1968–1972) and was a frequent speaker at IAU and other international seminars. He died on 12 August 1996, in Byurakan.

A Soviet Astrophysicist. Ambartsumian grew up through the turbulent years of [World War I](#), the Bolshevik Revolution, civil war, Lenin's [New Economic Policy](#) of the 1920s, and the rise of [Joseph Stalin](#). Like many if not most young educated Soviet men of his day, Ambartsumian was a patriot who believed his country was at the forefront of a great movement that would transform the world and improve the lot of mankind everywhere. Whereas his close friend and collaborator Nikolai Kozyrev would be rudely disabused of this notion in the late 1930s, all evidence indicates that Ambartsumian remained committed to the Soviet system to the end. His scientific genius combined with his political loyalty took him to the heights of the Soviet scientific establishment.

Ambartsumian was elected a corresponding member of the USSR Academy of Sciences in 1939 and joined the [Communist Party](#) in 1940. During those same years he published newspaper articles at LSU with titles such as “We Will Help the Finnish People Again Obtain Independence” and “We Will Fight for a Genuinely Scientific, Materialistic, World View.” In 1948, he was a member of the Central Committee of the [Communist Party](#) of the Armenian SSR, and beginning in 1950, he served as a deputy in the USSR Supreme Soviet. He was also a delegate to Communist Party congresses in the 1960s and 1970s. In 1953, he was elected a full member of the Academy of Sciences, and by 1955, he was a member of the Academy's presidium. A recipient of Lenin and Stalin prizes in 1946 and 1950, Ambartsumian himself served on the committee for Lenin and USSR State prizes in the period 1947 through 1972. He served as chairman of the Academy of Sciences' Astronomical Commission from 1944 to 1946 and chairman of the Commission on Cosmogony from 1952 through 1964. He was also a member of the editorial board of the Soviet Union's main astronomy journal, the *Astronomicheskii zhurnal*, from 1944 through 1979.

Ambartsumian was an ardent proponent of [dialectical materialism](#), that component of Marxist-Leninist ideology that concerns the philosophy of science, and he directly connected this philosophical view to his astrophysical interpretations. For example, Ambartsumian wrote that he was guided by the principles of [dialectical materialism](#) when he did his work that led to the determination that galactic nuclei contain bodies of huge mass. Indeed, his views on dialectical materialism as a guiding principle in scientific research spawned a school of followers that included the philosopher Vadim V. Kaziutinskii. Sometimes working together, Ambartsumian and Kaziutinskii wrote frequently on the subject of dialectical processes at work in the history and evolution of the universe.

Ambartsumian's towering authority as an astrophysicist combined with his position in the Soviet establishment made him arguably the most powerful Soviet astronomer of his day. He used his power to advance the cause of astrophysics throughout the Soviet Union in the postwar years when major new observatories with astrophysical capabilities were established. He also worked to advance the careers of V. V. Sobolev and other talented young Soviet astrophysicists. For his work to advance science in Armenia, a grateful nation proclaimed Ambartsumian a National Hero of Armenia in 1994.

The hierarchical nature of the Soviet system and, in particular, the Academy of Sciences meant that not all of Ambartsumian's colleagues were happy with his power and influence. Iosif Shklovskii, an astrophysicist no less talented than Ambartsumian, wrote with sad irony that the support of one or more of the “mafias” was needed for an otherwise outstanding scientist to be elected a member of the academy. In astronomy and astrophysics it was Ambartsumian who had the power to promote or block the election of individual candidates.

Finally, shadows from the 1930s followed Ambartsumian in hushed whispers throughout his career. While he was being elected a corresponding member of the Academy of Sciences in 1939, his close friend Kozyrev was languishing in an NKVD prison, on his way to serve a ten-year sentence in the labor camps of the Soviet Gulag. The Great Purges of 1936 through 1938 took a tremendous toll among astronomers and physicists. Although Kozyrev survived his imprisonment, Eropkin, Bronshtein, and many other of Ambartsumian's friends and colleagues from the early 1930s were executed outright or perished in the camps. Both within the Soviet Union and abroad, there were those who asked why these scientists perished while Ambartsumian flourished. Kozyrev's relations with Ambartsumian were strained for the remainder of his life, and in the West there were those who questioned whether Ambartsumian had played a role in unleashing the terror that swept away much of Pulkovo Observatory, including its director Boris Gerasimovich, in the late 1930s. A number of Gerasimovich's colleagues outside the Soviet Union were aware that his relations with Ambartsumian had been strained beyond the breaking point, and there were some who believed Ambartsumian had personally fanned the flames that led ultimately to Gerasimovich's execution in 1937.

Even after the fall of the Soviet Union and into the early 2000s, historians differ regarding Ambartsumian's role during the purges of the 1930s. Although some continue to see his role as negative, at least one has pointed to archival letters showing that Ambartsumian was himself terrified that he too was about to be arrested, and another historian has suggested that Gerasimovich's dislike of Ambartsumian may in fact have saved him. Whereas Ambartsumian's friends Kozyrev and Eropkin were still at Pulkovo when arrests began there in 1936, Ambartsumian had been dismissed by Gerasimovich two years earlier and was at LSU. This alone may have been sufficient to save Ambartsumian from the fate that befell his colleagues. Although his role from 1936 through 1938 may have been less than heroic, there is no hard evidence to suggest that he was guilty of anything more serious than surviving at a time when others did not.

Scientific Legacy. Viktor Ambartsumian left a legacy of personal scientific achievement that places him at the top ranks of twentieth-century astrophysics. Working within the Soviet system, he almost single-handedly created an infrastructure for astronomy and astrophysics in Armenia and kept the Soviet Union at the forefront of theoretical astrophysics. In the words of Chandrasekhar, "There can be no more than two or three astronomers in this century who can look back on a life so worthily devoted to the progress of astronomy."

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