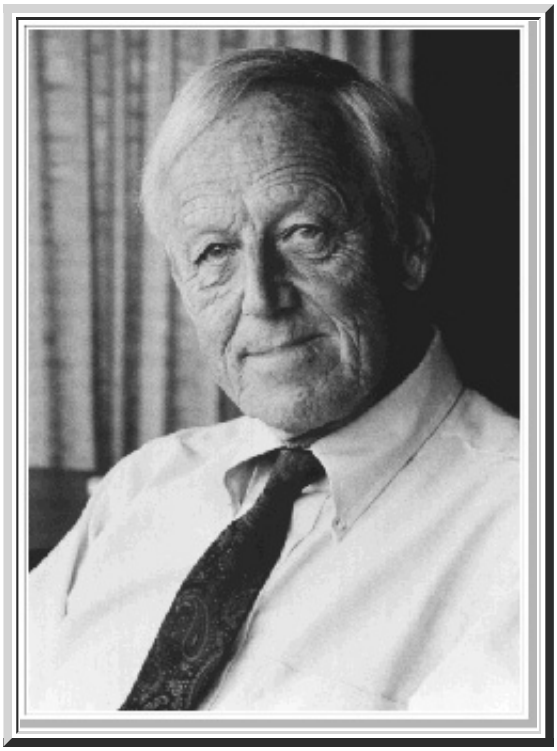
Hannes Alfvén (1908-1995)



Photograph of Prof. Hannes Alfvén, courtesy of
the Royal Institute of Technology, Stockholm.

Hannes Alfvén, winner of the 1970 Nobel Prize in Physics,acknowledged as one of creative and intuitive intellect's of the 20th century, died peacefully Sunday evening, April 2, 1995 in Stockholm, Sweden. He was 86 years old.
In the world of specialized science, Alfvén was an enigma. Regarded as a heretic by many physicists, Alfvén made contributions to physics that are today being applied in the development of particle beam accelerators, controlled thermonuclear fusion, hypersonic flight, rocket propulsion, and the braking of reentering space vehicles. At the same time, applications of his research in space science include explanations of the Van Allen radiation belt, the reduction of the earth's magnetic field during magnetic storms, the magnetosphere (a protective plasma envelope surrounding the earth), the formation of comet tails, the formation of the solar system, the dynamics of plasmas in our galaxy, and the fundamental nature of the universe itself.
Alfvén was the first to predict (in 1963) the large scale filamentary structure of the universe, a discovery that confounded astrophysicists in 1991 and added to the woes of Big Bang cosmology. Hannes Alfvén has played a central role in the development of several modern fields of physics, including plasma physics, the physics of charged particle beams, and interplanetary and magnetospheric physics. He is also usually regarded as the father of the branch of plasma physics known as magnetohydrodynamics.

In addition, Alfvén's contributions to astrophysics have been as important as his contributions to physics. His postulation in 1937 of a galactic magnetic field forms the basis today for one of the fastest growing areas of research in astrophysics - Cosmic Magnetism. In 1950, together with his colleague N. Herlofson, Alfvén was the first to identify nonthermal radiation from astronomical sources as synchrotron radiation, which is produced by fast-moving electrons in the presence of magnetic fields. The recognition that the synchrotron mechanism of radiation is important in celestial objects has been one of the most fruitful developments in astrophysics, as nearly all the radiation recorded by radio telescopes derive from this mechanism.

In spite of these fundamental contributions to physics and astrophysics, Alfvén, who retired his posts of professor of electrical engineering at the University of California at San Diego and professor of plasma physics at the Royal Institute of Technology in Stockholm in 1991, was still viewed as a heretic by many in those very fields. Alfvén's theories in astrophysics and plasma physics have usually gained acceptance only two or three decades after their publication. Characteristically and also concomitant with his 80th birthday in 1988, Alfvén was awarded the most prestigious prize of the American

Geophysical Union, the Bowie medal, for his work three decades earlier on comets and plasmas in the solar system. Disputed for 30 years, many of his theories about the solar system were only vindicated as late as the 1980's through measurements of cometary and planetary magnetospheres by artificial satellites and space probes.

Alfvén's lifetime achievements earned him worldwide recognition- including the Gold Medal of the Royal Astronomical Society (1967), the Nobel Prize in physics (1970), the Gold Medal of the Franklin Institute (1971), and the Lomonosov Medal of the USSR Academy of Sciences (1971). Several academies and institutes claimed his name in their membership rosters: the Institute of Electrical and Electronics Engineers (life fellow), the European Physical Society, the Royal Swedish Academy, the Swedish Academy of Engineering Sciences, the American Academy of Arts and Sciences, and the Yugoslav Academy of Sciences. Alfvén also was one of the very few scientists who are foreign members of both the U.S. and Soviet Academies of Sciences.

Although Alfvén received these singular honors from many parts of the world -and a rash of scientific journals scheduled special issues in honor of his 80th birthday- for much of his career Alfvén's ideas were dismissed or treated with condescension. He was often forced to publish his papers in obscure journals; and his work was continuously disputed for many years by the most renowned senior scientist in space physics, the British-American geophysicist Sydney Chapman. Even among physicists today there is little awareness of Alfvén's many contributions to fields of physics where his ideas are used without recognition of who conceived them.

Attempting to explain the resistance to his ideas, Alfvén pointed to the increasing specialization of science during this century. "We should remember that there was once a discipline called natural philosophy," he said in 1986. "Unfortunately, this discipline seems not to exist today. It has been renamed science, but science of today is in danger of losing much of the natural philosophy aspect." Among the causes of this transition, Alfvén believed, are territorial dominance, greed, and fear of the unknown. "Scientists tend to resist interdisciplinary inquiries into their own territory. In many instances, such parochialism is founded on the fear that intrusion from other disciplines would compete unfairly for limited financial resources and thus diminish their own opportunity for research."

Education

Hannes Olof Gosta Alfvén was born on May 30, 1908, in Norrkorping, Sweden. He received his doctor's degree from the University of Uppsala in 1934. His thesis was entitled "Investigations of the Ultra-short Electromagnetic Waves." The same year Alfvén was appointed a docent in physics at both the University of Uppsala and the Nobel Institute for Physics in Stockholm. In1940 he became professor of electromagnetic theory and electrical measurements at the Royal Institute of Technology in Stockholm, and in 1945 he was elected to a newly created Chair of Electronics at the same institute which was converted to a Chair of Plasma Physics in 1963.

In 1967 Alfvén issued a stinging condemnation of Sweden's nuclear research program, protesting what he considered to be insufficient funds for projects on peaceful uses of thermonuclear energy, and he left, saying, "My work is no longer desired in this country." He was immediately offered chairs in both the Soviet Union and the United States. After two months in the Soviet Union, he moved to America, testing the professorial waters in the departments of electrical engineering at two universities in Southern California, the University of California at San Diego in La Jolla and the University of Southern California. Having made his peace with the Swedish government soon after he left, Alfvén

spent the remainder of this life alternating between California and Sweden; October to March in La Jolla and April to September in Stockholm.

Alfvén's approach to physics

Alfvén's approach to physics was based on insight and intuition. He was quick to understand how nature works and he was able to place new observations into a framework larger than that required to explain the observations themselves. For example, in the early 1930's, cosmic rays were commonly thought to be gamma rays filling the entire universe. However, when they were discovered to be charged particles, Alfvén offered in 1937 the novel suggestion that the galaxy contained a large-scale magnetic field and that the cosmic rays moved in spiral orbits within the galaxy, owing to the forces exerted by the magnetic field. He argued that there could be a magnetic field pervading the entire galaxy if plasma was spread throughout the galaxy. This plasma could carry the electrical currents that would then create the galactic magnetic field.

Such a hypothesis, based on a great leap of creative intuition but without grounding in apparent rational thought or inference, left Alfvén's proposal open to much criticism; his theory was dismissed on the grounds that interstellar space was known to be a vacuum and that it certainly could not support the electrical currents and particle beams he was proposing. But Alfvén had started the scientific community thinking about an idea that was to become very fashionable in the 1980's and 1990's.

Alfvén's discovery of hydromagnetic waves is another example of an original idea having a far-reaching impact on multidisciplinary science. On purely physical grounds, Alfvén concluded that an electromagnetic wave could propagate through a highly conducting medium, such as the ionized gas of the sun, or in plasmas anywhere. However, in 1942 when Alfvén published his discovery, Maxwell's theory of electromagnetism was a well-established edifice, a subject for textbook pedagogy and engineering applications. It was "well known" that electromagnetic waves could penetrate only a very short distance into a conductor and that, as the resistance of a conductor became smaller and smaller, the depth of penetration by an electromagnetic wave would go to zero. Thus, with an ideal electrical conductor, there could be no penetration of electromagnetic radiation. But Alfvén was proposing a form of electromagnetic wave that could propagate in a perfect conductor with no attenuation or reflection. Alfvén's discovery was generally dismissed with such remarks as "if such waves were possible, Maxwell himself would have discovered them."
His work was not recognized as both correct and significant until six years later, when he gave several lectures on hydrodynamic waves during his first visit to the United States. An oversimplified statement of what occurred has been provided by University of Arizona professor Alex Dessler, former editor of the prestigious journal, Geophysical Research Letters. "During Alfvén's visit he gave a lecture at the University of Chicago, which was attended by [Enrico] Fermi. As Alfvén described his work, Fermi nodded his head and said, 'Of course.' The next day the entire world of physics said. 'Oh. of course."'

Alfvén versus Chapman

Alfvén became active in interplanetary and magnetospheric physics at a time when a contrary viewpoint prevailed. Alfvén's views were consistent with those of the founder of magnetospheric physics, the great Norwegian scientist Kristian Birkeland. At the end of the nineteenth century Birkeland had laid out a compelling case-supported by theory, laboratory experiments, polar

expeditions, and a chain of magnetic-field "observatories" around the world -that electric currents flowing down along the earth's magnetic fields into the atmosphere were the cause of the aurora and polar magnetic disturbances.

However, in the decades following Birkeland's death in 1917, Chapman became the acknowledged leader in interplanetary and magnetospheric physics. Chapman proposed, in contradistinction to Birkeland's ideas, that currents were restricted to flow only in the ionosphere with no downflowing currents. Chapman's theory was so mathematically elegant that it gained wide acceptance over the Birkeland theory. Based on Chapman's theory, algebraic expressions of the ionospheric current system could, with complete mathematical rigor, be derived by any student of the subject. Birkeland's ideas might have faded completely had it not been for Hannes Alfvén, who became involved well after Chapman's ideas gained predominance. Alfvén kept insisting that Birkeland's current system made more sense because downflowing currents following the earth's magnetic field lines were required to drive most of the ionospheric currents. The issue was not settled until 1974, four years after Chapman's death, when earth satellites measured downflowing currents for the first time.

This story was typical of the difficulties Alfvén faced in his scientific career. Interplanetary space was commonly considered to be a good vacuum, disturbed only by occasional comets. This viewpoint was widely accepted because space "looked" that way, having been viewed only by using telescopes at optical wavelengths. In contrast, the electrical currents proposed by Alfvén generated a telltale signature only in the radio portions of the electromagnetic spectrum so they had not yet been observed. Thus Alfvén's proposal that there were electrical currents in space was received with great skepticism.

In 1939 Alfvén advanced a remarkable theory of magnetic storms and auroras that has widely influenced contemporary theories of plasma dynamics in the earth's magnetosphere. He used the notion of electric charges spiraling in magnetic fields to calculate the motions of electrons and ions. This method came to be universally adopted by plasma physicists and remained in use until the tedious task was assigned to computers in the mid-1970s. Yet in 1939, when Alfvén submitted the paper to the leading American journal Terrestrial Magnetism and Atmospheric Electricity, the paper was rejected on the ground that it did not agree with the theoretical calculations of Chapman and his colleagues. Alfvén was forced to publish this seminal paper in a Swedish-language journal not readily accessible to the worldwide scientific community. Restrictions such as this were imposed on several of Alfvén's other key articles as well.

It is usual in science that one or two major discoveries place their author in the rank of leading authorities with great influence and continuing funding commonly following. This was certainly not the case with Alfvén. At no time during his scientific career prior to winning the Nobel Prize was Alfvén generally recognized as a leading innovator by those in the scientific communities who were using his work.

Dessler has written of his own realization that Alfvén's contributions were being overlooked.

"When I entered the field of space physics in 1956, I recall that I fell in with the crowd believing, for example, that electric fields could not exist in the highly conducting plasma of space. It was three years later that I was shamed by S.Chandrasekhar into investigating Alfvén's work objectively. My degree of shock and surprise in finding Alfvén right and his critics wrong can hardly be described. I learned that a cosmic ray acceleration mechanism basically identical to the famous mechanism suggested by Fermi in 1949 had [previously] been put forth by Alfvén."

Alfvén and Astrophysics

Because his ideas often conflicted with the generally accepted or "standard" theories, Alfvén always had trouble with the peer review system, especially as practiced by Anglo-American astrophysical journals. "I have no trouble publishing in Soviet astrophysical journals," Alfvén once disclosed, "but my work is unacceptable to the American astrophysical journals." In fact, he never enjoyed the nearly automatic acceptance generally afforded senior scientists in scientific journals. "The peer review system is satisfactory during quiescent times, but not during a revolution in a discipline such as astrophysics, when the establishment seeks to preserve the status quo," explains Alfvén.
Part of the reason that Alfvén's work is neglected in astrophysics may be that Alfvén considered himself, first and foremost, an electrical power engineer and rather enjoyed the accusation of encroachment in astrophysics leveled by other cosmologists and theoreticians. Plasma physics has traditionally been neglected in astrophysics, Alfvén claimed. "Students using astrophysical textbooks remain essentially ignorant of even the existence of plasma concepts, despite the fact that some of them have been known for half a century," he argued. "The conclusion is that astrophysics is too important to be left in the hands of astrophysicists who have gotten their main knowledge from these textbooks. Earthbound and space telescope data must be treated by scientists who are familiar with laboratory and magnetospheric physics and circuit theory, and of course with modern plasma theory."

Alfvén VERSUS THE BIG BANG

For 30 years, based on plasma physics, Alfvén and his colleagues proposed an alternative cosmology to both the Steady State and the Big Bang cosmologies. While the Big Bang theory was preferred by most astrophysicists for nearly 30 years, it is being challenged by new observations, especially over the last decade. In particular, the discovery of coherent structures of galaxies hundreds of millions of light years in length and the large-scale streaming of superclusters of galaxies at velocities that may approach 1,000 kilometers per second present problems that are difficult, if not impossible, to reconcile with the Big Bang theory.

To Alfvén, the problems being raised were not surprising. "I have never thought that you could obtain the extremely clumpy, heterogeneous universe we have today, strongly affected by plasma processes, from the smooth, homogeneous one of the Big Bang, dominated by gravitation."

The problem with the Big Bang, Alfvén believed, is similar to that with Chapman's theories, which the scientific community accepted mistakenly for decades: Astrophysicists have tried too hard to extrapolate the origin of the universe from mathematical theories developed on the blackboard. The appeal of the Big Bang, said Alfvén, has been more ideological than scientific. When men think about the universe, there is always a conflict between the mythical approach and the empirical scientific approach. In myth, one tries to deduce how the gods must have created the world - what perfect principles must have been used."

To Alfvén, the Big Bang was a myth - a myth devised to explain creation. "I was there when Abbe Georges Lemaitre first proposed this theory," he recalled. Lemaitre was, at the time, both a member of the Catholic hierarchy and an accomplished scientist. He said in private that this theory was a way to reconcile science with St. Thomas Aquinas' theological dictum of creatio ex nihilo or creation out of nothing.

But if there was no Big Bang, how -and when- did the universe begin? "There is no rational reason to doubt that the universe has existed indefinitely, for an infinite time," Alfvén explained. "It is only myth that attempts to say how the universe came to be, either four thousand or twenty billion years ago."

"Since religion intrinsically rejects empirical methods, there should never be any attempt to reconcile scientific theories with religion he said. An infinitely old universe, always evolving, may not, he admited, be compatible with the Book of Genesis. However, religions such as Buddhism get along without having any explicit creation mythology and are in no way contradicted by a universe without a beginning or end. Creatio ex nihilo, even as religious doctrine, only dates to around AD 200" he noted. The key is not to confuse myth and empirical results, or religion and science."

Alfvén admited that his plasma universe theory may take a long time to penetrate the popular consciousness. "After all," he asserted to a group of physicists, "most people today still believe, perhaps unconsciously, in the heliocentric universe." The group, at first incredulous, quickly nods in agreement as Alfvén continueed, "every newspaper in the land has a section on astrology, yet few have anything at all on astronomy."

PERSONAL AND PUBLIC LIFE

In counterpoint to his often turbulent scientific career, Hannes Alfvén's home life was quiescent, a tranquility that has been attributed to his wife of 67 years, Kirsten, who preceded him in death. They raised five children: a son who is a physician and four daughters, one a writer well-known in Sweden and one a lawyer.

Besides his scientific papers, Alfvén wrote popular science books, sometimes with his wife. These include Worlds-Antiworlds: Antimatter in Cosmology (1966), and The Great Computer: A Vision (1968). The latter book, written under the pen name Olof Johannesson, describes how increasingly sophisticated computers gain control first over government, then the earth. Alfvén's distrust of computers is long-standing, and only recently, when plasma simulations on supercomputers started reproducing the noise measured in real physical systems, did he take an interest in this aspect of analysis. Other popular books include Atom, Man, and the Universe: A Long Chain of Complications (1969) and Living on the Third Planet (1972).

Alfvén strongly identified with a variety of social issues. He was, for example, an activist in the worldwide disarmament movement, having served as president of the Pugwash Conference on Science and World Affairs. In addition, his son is the Swedish Secretary of the Physicians for Social Responsibility. Alfvén enjoyed studying the history of science and oriental philosophy and religion.

He was known for his sense of humor and for having an anecdote for every occasion. Alfvén enjoyed travelling, especially to exotic lands such as Sri Lanka, the Fiji Islands, and the Amazon River. He claimed residence according to the equinoxes -vernal to autumnal in Europe and autumnal to vernal in North America. He was fluent in English, German, and French, and nearly so in Russian; and spoke some Spanish and some Chinese. He remained physically active until the last four years of his life. Even at age 82 he would entertain visitors with wine at his apartment in La Jolla, hurrying them to the beach at sundown in hopes of catching a glimpse of the green flash" the phenomenon that sometimes occurs as the sun drops below the ocean horizon.

Anthony L. Peratt, 'Dean of the Plasma Dissidents', *The World & I*, May 1988, pp. 190-197.