Guest Editorial
The Golden Anniversary of "Magnetic Storms and the Aurorae"

(Dedicated to Hannes Alfvén in recognition of his 80 years)

IT was exactly a half-century ago that the paper "A Theory of Magnetic Storms and the Aurorae" by Hannes Alfvén was published in the *Proceedings of the Royal Swedish Academy of Sciences* (*Kungliga Svenska Vetenskapsakademiens Handlingar*, vol. 18, pp. 1–39, 1939). This remarkable paper contains concepts that continue to influence and guide modern space plasma physics. It was in this paper that Hannes Alfvén developed the guiding center approximation for determining the gross motion of charged particles trapped in a magnetic field and introduced the concept of a partial ring current formed from trapped radiation in the earth's magnetic field. (For a modern discussion of this paper, see "Magnetic Storms and the Aurorae: Comments and Annotations on a Paper by Hannes Alfvén" by A. J. Dessler and J. M. Wilcox [1].) Alfvén also expanded on the idea of electric currents flowing along geomagnetic field lines which was introduced at the turn of the century by the Norwegian scientist, Kristian Birkeland (see the paper on Birkeland by Alv Egeland in this Special Issue and also his paper (with E. Leer) in the IEEE TRANSACTIONS ON PLASMA SCIENCE First Special Issue on Space and Cosmic Plasma [2]). The existence of such field-aligned currents (now referred to as "Birkeland" currents) was not widely accepted and could not be positively identified from surface magnetic field observations, and they became a source of controversy and intense debate. For example, Alfvén's "Magnetic Storms and the Aurorae" paper was rejected for publication by the American journal *Terrestrial Magnetism and Atmospheric Electricity* on the grounds that it did not agree with the theoretical calculations of Sydney Chapman and his colleagues [3]. The advent of the space age, two decades after Alfvén's paper, provided the opportunity to acquire the data required to prove the existence of field-aligned Birkeland currents. These currents flow into and away from the auroral regions, as shown in Fig. 2, and are associated with a wide range of auroral phenomena. They are now regarded as an important element in the solar–terrestrial system, and many of the aurora, ionosphere, magnetosphere papers published in this Special Issue are related to Birkeland currents. Some of these papers report on observations obtained with Sweden's first satellite, called Viking, launched in February 1986. It is no surprise that Alfvén's home country should launch its first satellite to conduct studies of auroral phenomena such as the spectacular image shown in Fig. 3.

Fig. 1. Hannes Alfvén celebrates his 80th birthday at a party held in his honor at the Royal Institute of Technology, Stockholm, Sweden, on May 30, 1988.

In his theory of the origin of the solar system, Alfvén proposed that when a neutral gas streams through a plasma across magnetic field lines at sufficiently high velocity, a discharge-like process can occur in which the neutral gas begins to ionize rapidly [4]. The "Critical Ionization Velocity" (CIV) effect has been demonstrated in the laboratory, but the capability to investigate the details of this effect in space has only recently become available. A new area of space plasma physics has been spawned by Alfvén which is directed towards an understanding of this effect in space, and two papers here address this topic.

Alfvén regards the "space age" as being a revolution in science, comparable to the introduction of the telescope by Galileo. He has pointed out the ability of spacecraft to observe a wide range of physical parameters in comparison to the limited "visual light universe" based on surface telescopes. The papers in this issue provide an ex-

0093-3813/89/0400-0065$01.00

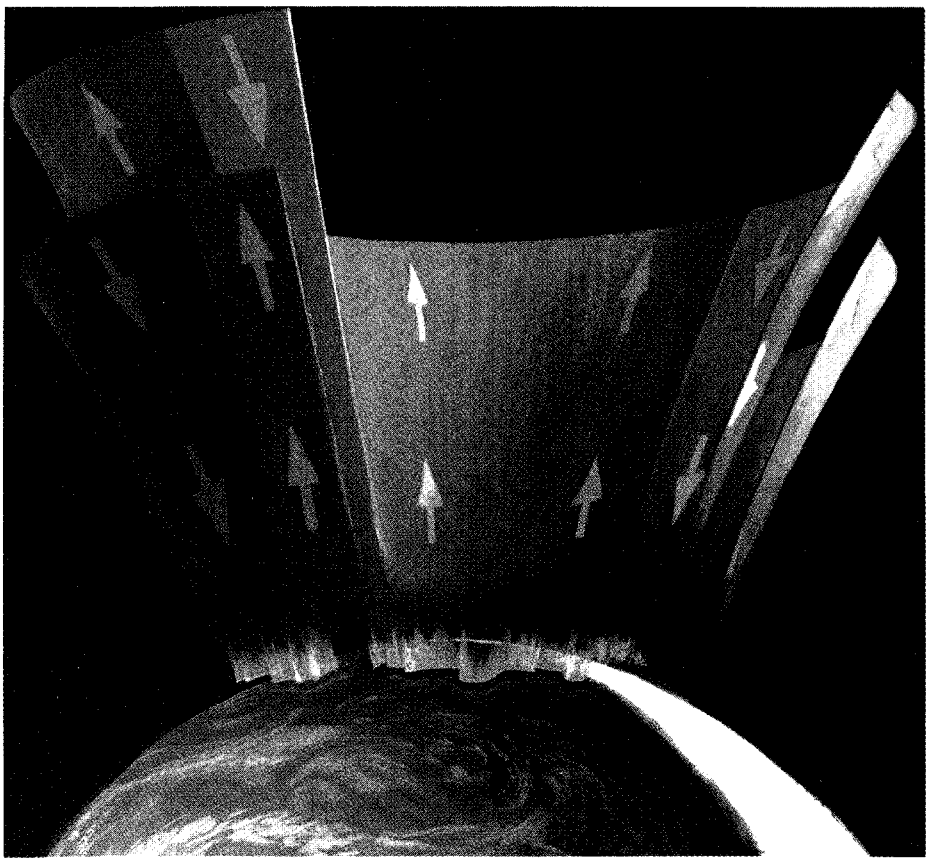

Fig. 2. Artists' depiction of Birkeland currents flowing into and out of the earth's atmosphere at high latitude. These currents, once the subject of intense debate, are routinely measured with satellites and have total magnitudes of millions of amperes. (Courtesy of S. G. Smith, Applied Physics Laboratory, The Johns Hopkins University.)

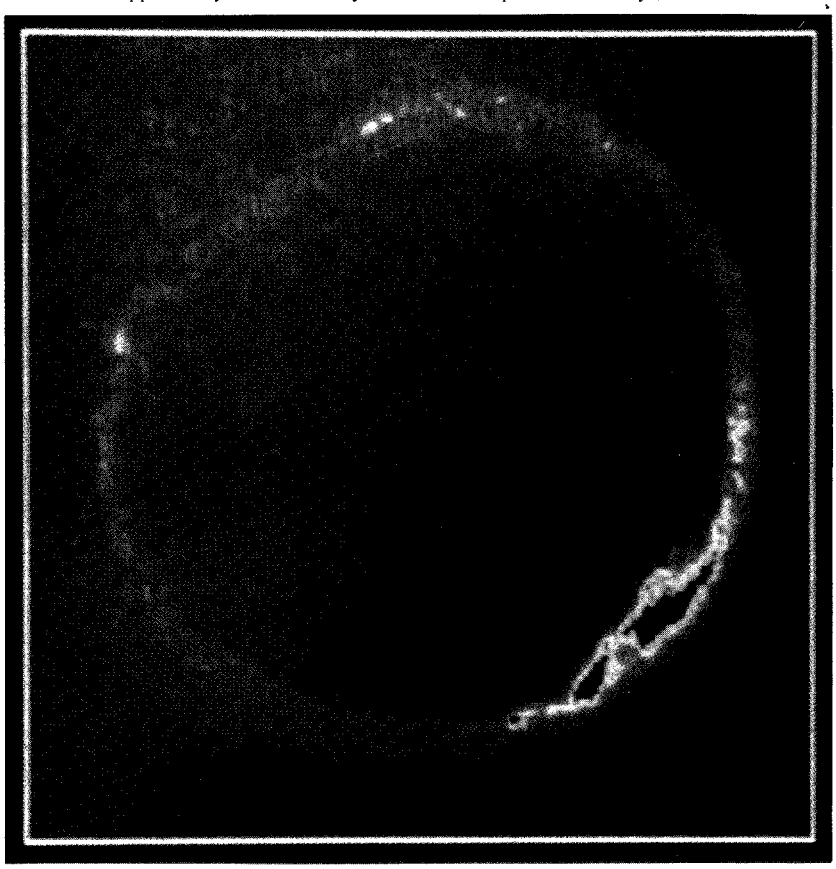

Fig. 3. A view of the earth's aurora obtained in UV light by the Viking satellite. (See the article by Murphree *et al.* in this Special Issue for more details of this instrument.) The auroral emissions completely encircle the geomagnetic pole, located approximately in the center, and are brightest near midnight, located in the lower right corner. The diameter of this auroral ring is about 5000 km.

panded view of the universe now available from spacecraft-borne instruments which can measure particles, plasma waves, magnetic fields, electric fields, and UV emission in our planet's plasma environment above its protective atmosphere and ionosphere. These studies have provided greater insights into solar–terrestrial and auroral processes, the distribution of electric fields and currents in the earth's magnetosphere, and the fascinating behavior of UV aurora viewed from outer space. But there is more to be understood, including such basic questions as the particle acceleration processes responsible for the aurora and the ultimate sources of the large-scale Birkeland currents.

Concomitant with the golden anniversary of the publication of "Magnetic Storms and the Aurorae" was the awarding to Alfvén the William Bowie Medal, the oldest and most prestigious award of the American Geophysical Union. Appropriately, this medal happened to be the 50th conferred by the Union. It should again come as no surprise that Alfvén has won the acclaims of geophysical, engineering, space science, and physical societies worldwide [5]–[7]. His pioneering work in "Magnetic Storms and the Aurorae" ushered in the field of charged particle-beam propagation and catapulted Kirchhoff's circuit laws and therefore electrical engineering towards the study of problems having dimensions eight orders of magnitude larger than those previously investigated in the laboratory, and nearly four orders of magnitude greater than those associated with the longest power distribution systems on Earth.

As was quoted in the Bowie Medal Citation, ". . . having gotten space physics straightened out, (Alfvén's) activities are now largely directed toward attacking some of the basic beliefs of the astrophysical science establishment. His style has not changed. He plays the role of the iconoclast smashing the most scared idols of the discipline. For example, he treats the well-regarded, popular theory of the formation of the universe in a "Big Bang" as a myth, nothing more" [8]. The papers in this Second Special Issue on Space and Cosmic Plasma are a tribute to Alfvén's deep insight and to his extraordinary vision.

THOMAS A. POTEMRA, *Guest Editor*
Applied Physics Laboratory
The Johns Hopkins University
Laurel, MD 20707

ANTHONY L. PERATT, *Guest Editor*
Los Alamos National Laboratory
Los Alamos, NM 87545

[1] A. J. Dessler and J. M. Wilcox, "Magnetic storms and the aurorae: Comments and annotations on a paper by Hannes Alfvén," *EOS*, vol. 50, pp. 180–194, 1970.
[2] A. Egeland and E. Leer, "Prof. Kr. Birkeland: His life and work," *IEEE Trans. Plasma Sci.*, vol. PS-14, pp.666–677, 1986.
[3] A. J. Dessler, *Science*, vol. 170, pp. 604–606, 1970.
[4] H. Alfvén, *On the Origin of the Solar System.* London: Oxford Univ. Press, 1954.
[5] A. L. Peratt and H. Hora, "Particle beams and basic phenomena in the plasma universe: A special issue in honor of the 80th birthday of Hannes Alfvén," *Laser and Particle Beams*, vol. 6, part 3, pp. 385–387, 1988.
[6] C. G. Fälthammar *et al.*, "Plasma and the universe," *Astrophys. Space Sci.*, vol. 144, parts 1 & 2, 1988.
[7] A. L. Peratt, "Dean of the plasma dissidents," *The World & I*, vol. 3, pp. 190–197, 1988.
[8] A. J. Dessler, presented at the Honors Ceremony of the Amer. Geophys. Union, 1988 Fall Meet. (San Francisco, CA). *EOS*, vol. 70, no. 1, pp. 9–10, 1989.

Thomas A. Potemra was born in Cleveland, OH, in 1938 and received the Ph.D. degree from Stanford University, Palo Alto, CA, in 1966.

He was a member of the technical staff of Bell Laboratories from 1960–62. He joined the Applied Physics Laboratory, Johns Hopkins University, Laurel, MD, in 1965.

During 1985–86 he worked on special assignment as a Senior Policy Analyst in the Office of Science and Technology Policy, Executive Office of the President. He is presently Supervisor of the Space Physics Group and conducts research on magnetospheric current systems. He is the Principal Investigator for numerous satellite magnetic field experiments and has served on several committees of the National Academy of Sciences and the American Geophysical Union. He is a member of the faculty of The Johns Hopkins University G. W. C. Whiting School of Engineering and has been a Guest Lecturer at the U.S. Naval Academy.