THE CHALLENGE OF THE AURORA

Those of us who spend our winters at high latitudes enjoy viewing a spectacle available to relatively few people—the aurora borealis. We are privileged to get a good look at the aurora and also to have access to recent scientific discoveries made by the researchers here at the Geophysical Institute.

The aurora occurs year-round, but it can be seen by the human eye only when the sky is dark. The aurora that we see in the winter sky is actually light created when energetic electrons from outer space strike molecules in the upper atmosphere of the earth. The auroral electrons originally come from the sun as part of the solar wind, starting as a million-degree hot ionized gas, or plasma, and continuously streaming out of the sun and carrying embedded in it the interplanetary magnetic field. The solar wind flow compresses the earth’s own magnetic field into a comet-shaped envelope, the magnetosphere, with a cross section over 200,000 km in diameter and a million-kilometer long tail.

Part of the solar wind penetrates into the magnetosphere, where its electrically charged particles—electrons, protons, and heavier atomic nuclei—are trapped by the earth’s magnetic field. This huge particle reservoir occasionally is subjected to severe disturbances. During such events, electrons are “squeezed out” from the reservoir and accelerated toward both polar regions. At an altitude of about 350 kilometers, the precipitating electrons begin to strike oxygen and nitrogen molecules and auroral light is emitted. Each feature, each movement, and each color of the aurora is linked to some disturbance process far away from the earth; thus the magnificent auroral displays over Fairbanks are nothing less than a giant TV show of storms raging in outer space.

Since the creation of the Geophysical Institute by an Act of Congress in 1946, our scientists have played a crucial role in unraveling the mysteries of the aurora. Professor Syun-Ichi Akasofu has discovered magnetic and auroral substorms. These are rapid variations of the earth’s magnetic field, accompanied by pronounced increases in brightness as well as violent motion in auroras. A team of Geophysical Institute scientists headed by former Director Keith Mather demonstrated that auroras in the southern polar regions are mirror images of the auroras occurring simultaneously in the north (see photograph below). Many characteristic features of the aurora were discovered by our scientists with a special “all-sky” camera developed at the Institute and emplaced worldwide in many auroral observatories. Important advances continue to be made on the subject of auroral prediction (see last page). Recently, Professor Akasofu discovered how the interplanetary magnetic field acts as a “faucet” that lets solar wind energy into the magnetosphere, and Professor Lou-Chuang Lee and visiting scientist Zhu-Feng Fu achieved an important breakthrough in the understanding of how the solar wind regulates this transfer of energy and the perturbations that ultimately cause the aurora.

Juan G. Roederer
Director

Conjugate Aurora: Simultaneous photographs taken from cockpits of aircraft flying conjugate paths in the northern (left) and southern hemispheres.
The green color of most auroras is the result of the impact of incoming electrons on oxygen atoms near 110 km above the earth. When the stream of electrons is very intense it may penetrate below 100 km and create a green aura with a red lower border. All-red auroras, such as this one, are caused by a delayed emission of atomic oxygen produced by collisions with incoming slow electrons at high altitude (above 150 km). The all-red auroras occur relatively infrequently.

The form called the corona results when a rayed aurora is seen directly overhead. The rays appear to converge to a point that is the observer’s magnetic zenith.
Auroral arcs or bands are seen as long ribbons set on edge, often from horizon to horizon—1000 km or more long. Neil Davis and other researchers at the Geophysical Institute were able to measure arc widths both from the ground and from rockets in the 1970s. Eugene Wescott directed development of the rocket technique that involves injecting barium ions into the aurora.

Some auroral arcs contain rays which are aligned with the direction of the local geomagnetic field—nearly vertical over Alaska. The shape and structure of these rays were not known until Tom Hallinan of the Geophysical Institute used high-resolution TV cameras to study them.

Astronauts Don Lind and Bob Overmyer, after training at the U of A Poker Flat Research Range, photographed the aurora from Spacelab III in May 1985. This picture, taken at an altitude of 300 kilometers, shows the aurora near Antarctica. The irregular white band and the red "flame" make up the aurora. Tom Hallinan, Geophysical Institute, is the Principal Investigator.
PREDICTING AURORAS

The overall process of the aurora can be likened to the electric discharge caused by a gigantic but invisible dynamo—a generator that can produce up to one million megawatts (the power consumed by one billion electric irons). This generator is the product of the interaction of the solar wind with the magnetosphere; the power delivered is regulated mainly by the interplanetary magnetic field. Predicting the aurora requires an understanding of this mechanism and knowledge of how it is linked to disturbances on the sun.

Supported by grants from several sources, Geophysical Institute researchers led by Professor Syun-Ichi Akasofu have learned how to estimate the power output of the generator causing the aurora. Professor Joseph Kan recently received a grant from the National Science Foundation to continue studying the interaction of the solar wind with the earth's magnetosphere and ionosphere.

These studies are part of a continued effort to develop reliable schemes for the prediction of auroral activity. Since auroras disrupt—and can damage or seriously interfere with—electrical systems and communications networks, accurate predictions of auroral activity will be useful as warnings for the operators of powerlines and communications systems, including those necessary for national defense.

COLOR AURORA VIDEOTAPE

Using a recently acquired supersensitive TV camera, Geophysical Institute researchers Neal Brown, Tom Hallinan, and Dan Osborne have gathered spectacular views of the aurora at Poker Flat Research Range for the National Aeronautics and Space Administration and the National Science Foundation.

Because of the high accuracy of these videotapes, they are very useful in studies of the aurora, as well as being unusually true-to-life and beautiful representations of the northern lights in action. A selection of the video scenes has been edited and, with a sound track excerpt from Alaskan composer Gordon Wright's Symphony in Ursa Major, made available for sale to anyone who would like to see an aurora display at a convenient time and at room temperature.

The videotape costs $35 plus $2 U.S. postage for each Beta or VHS 24-minute tape; it is also available in PAL on VHS for $55 plus $5 overseas postage. Order by writing to Geophysical Institute (Attention: Sheila Finch), University of Alaska, Fairbanks, Alaska 99775-0800, or by calling (907) 474-7453.