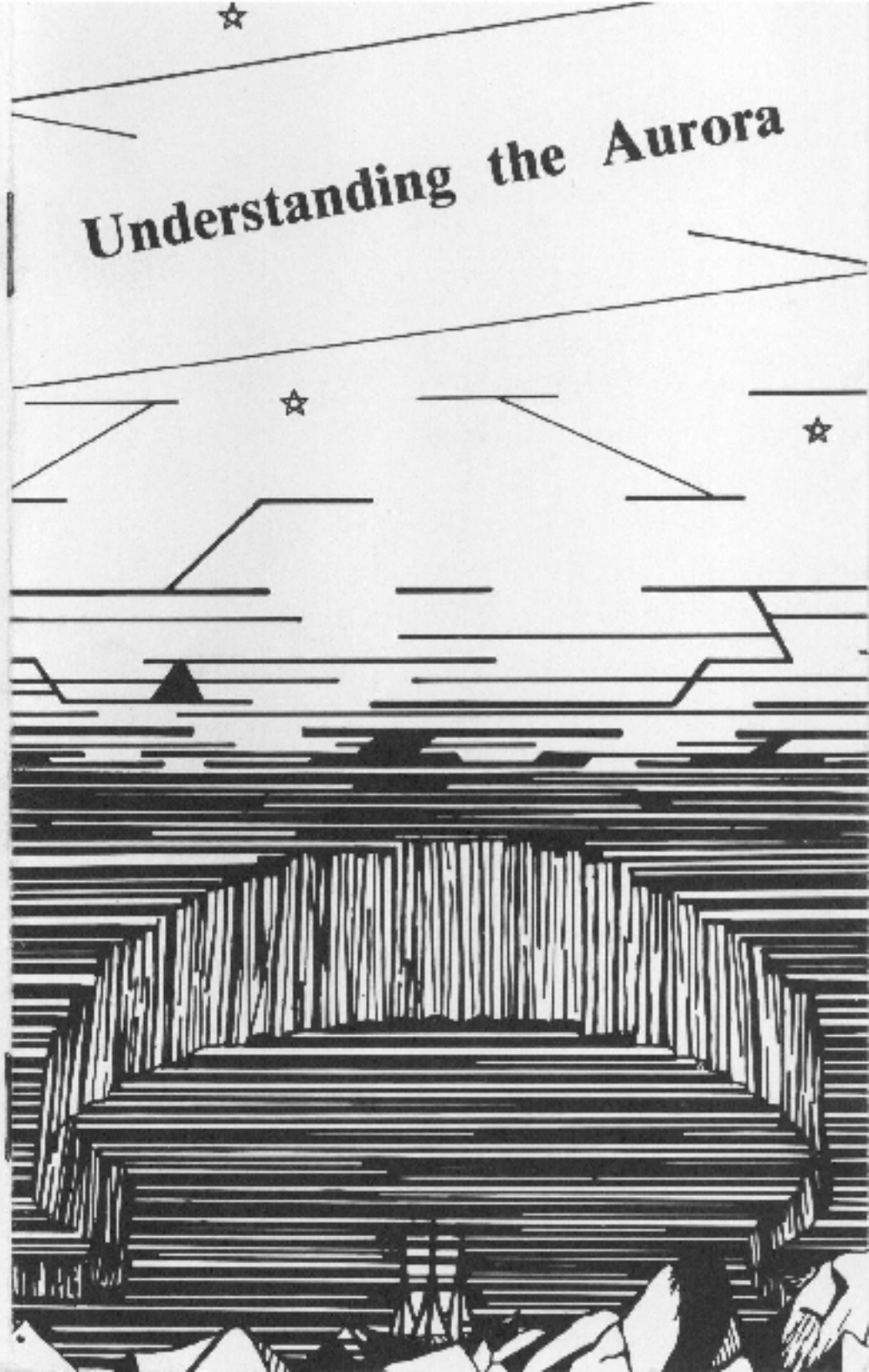
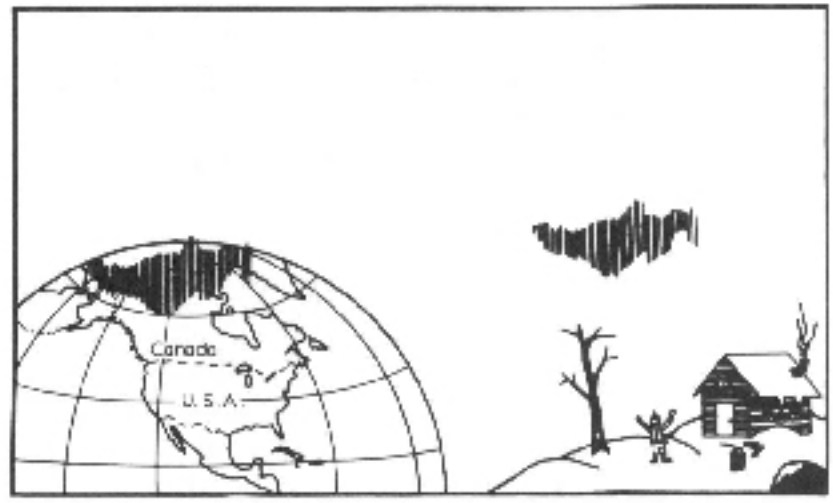
# Understanding the Aurora

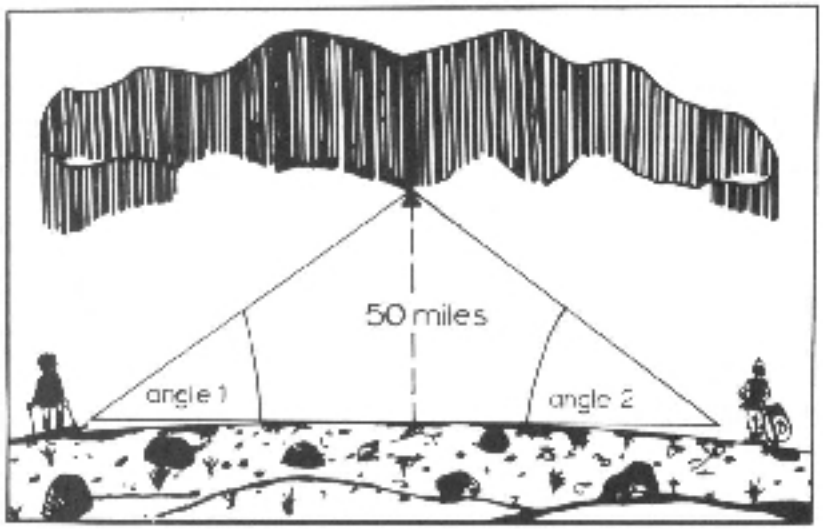


## What Is the Aurora?

The aurora, also known as the northern lights, is light coming from high above the earth that can be seen during the night in the polar regions. At times, the aurora appears to be only a few feet above our heads, but actually, it is never less than fifty miles (80 kilometers) above the earth. People used to believe that the aurora was the sun's light reflected from ice on the Arctic Ocean or from ice crystals in the atmosphere. Today we know that the aurora is actually light created where we see it in the sky. A typical aurora may be sixty or seventy miles above the earth and several hundred miles long.



## How High Is the Aurora?

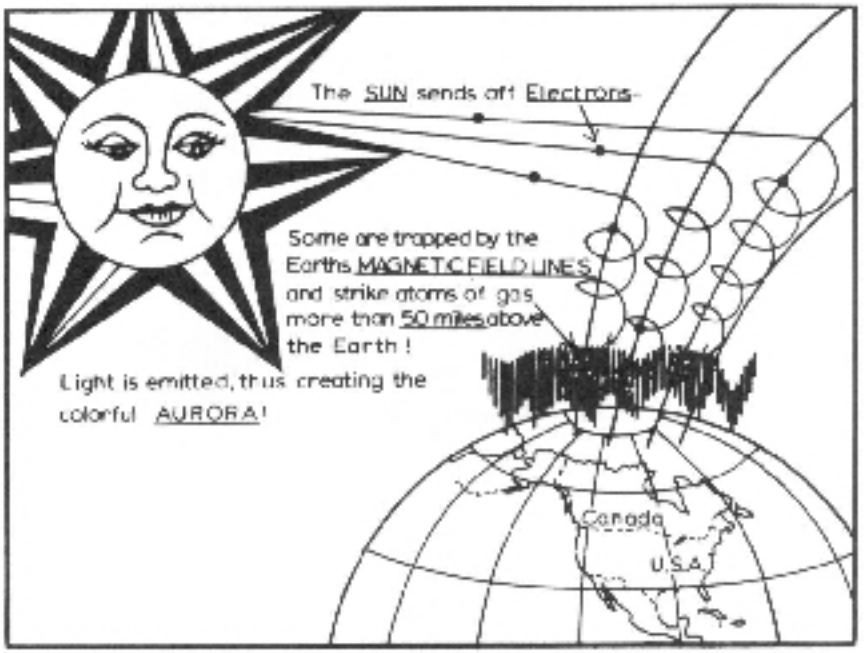



For a long time people thought the aurora was just above the clouds. In 1910, Carl Störmer in Norway made the first accurate measurements of the aurora. Using a process called "triangulation," Dr. Störmer and an assistant found that the aurora was at least 50 miles (80 kilometers) above the earth.

To do this, Störmer and his assistant positioned themselves several miles apart. By telephone, they agreed on a particular point of the aurora to measure. This point and the positions of the two people formed a triangle. At the same moment, they measured the angles formed from each of their positions to that point of the aurora. By knowing these angles (angles 1 and 2 of the drawing above), and the distance between each other, they could find the distance of the aurora from the earth.



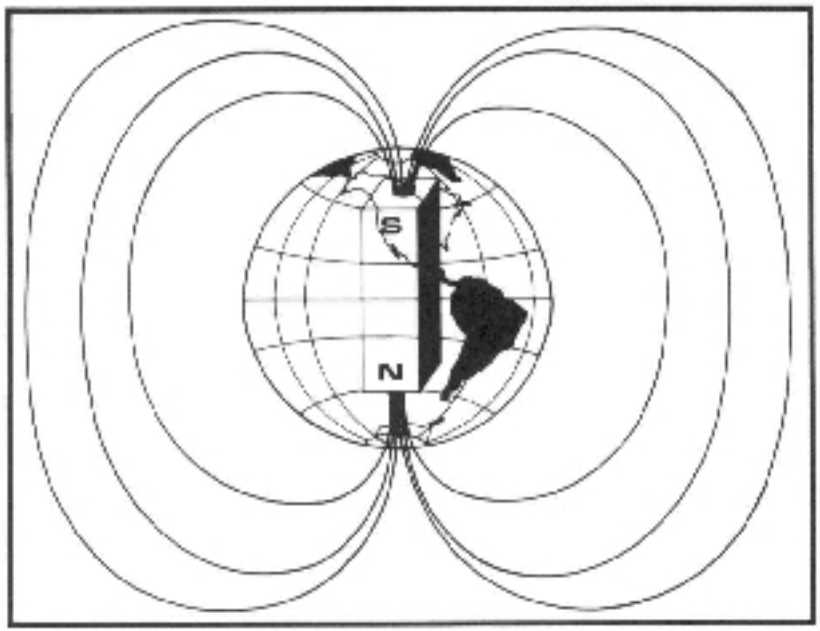
## The Source of the Aurora: the Sun




The sun is a ball of very hot gases. These gases are so hot that some of the atoms blow away as part of what we call the "solar wind." Electrons stripped from the outer shells of these atoms also make up much of the solar wind. It takes the solar wind about three days to travel the 93 million miles between the sun and the earth. When the electrons reach the earth, they are trapped by the earth's magnetic field. They travel along magnetic field lines in a cork-screw fashion into the earth's atmosphere where they emit light, creating the aurora.

## The Earth's Magnetic Field

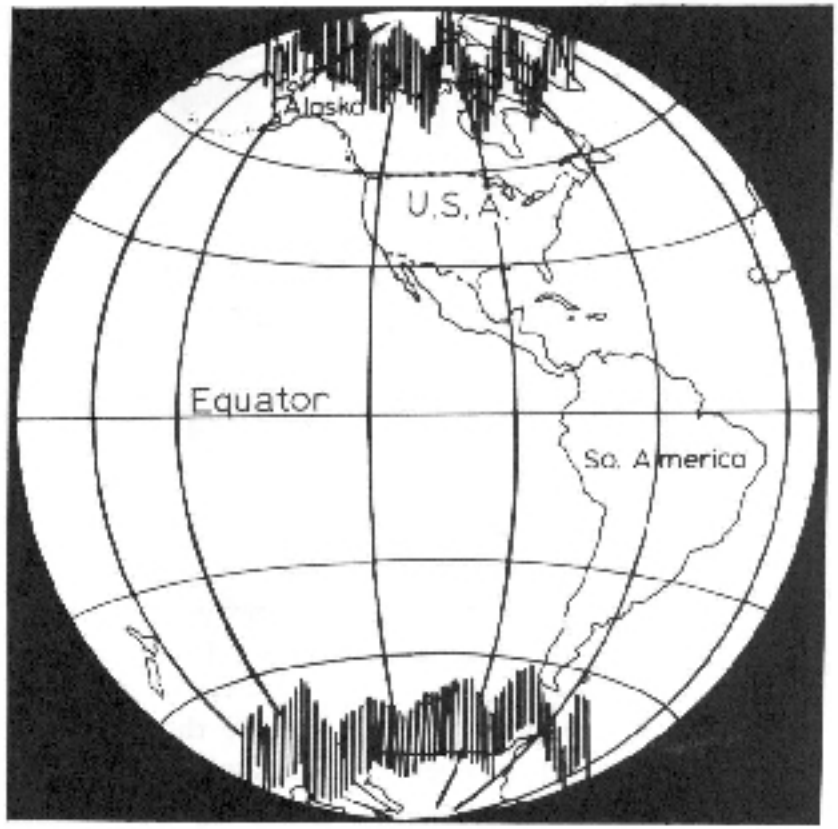
The earth has a magnetic field that is shaped as if a large bar magnet ran throught the center of the earth, as shown in this figure. The magnetic field controls the location of the aurora by guiding electrons into the earth's atmosphere near the geomagnetic poles. These tiny particles can bounce back and forth along the magnetic field lines from the north to the south in a few seconds, creating similar and simultaneous auroras in the north and south polar areas.

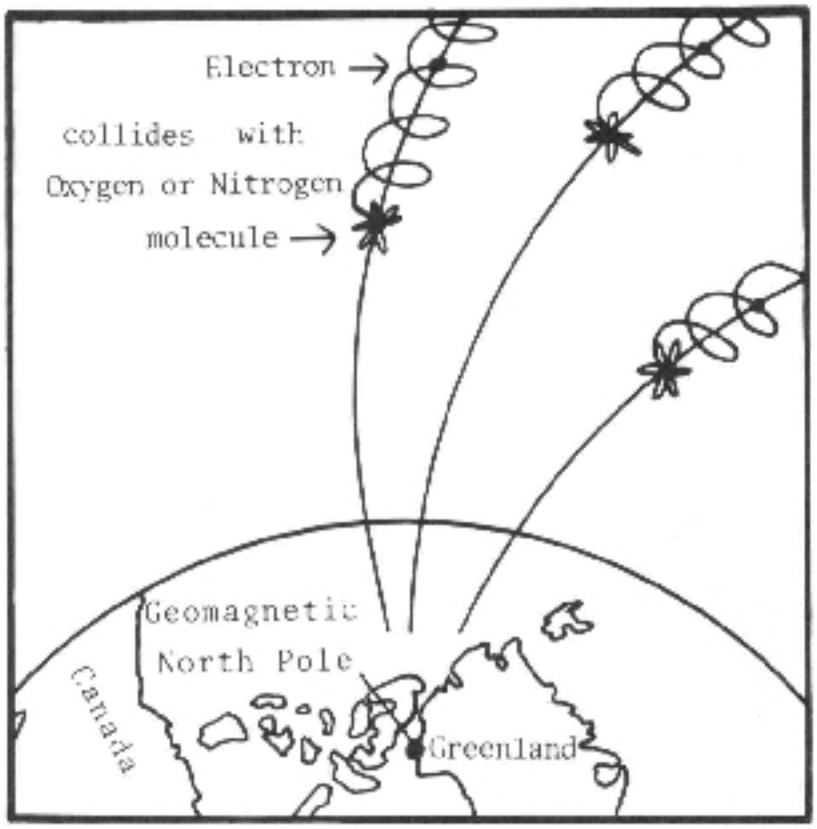





## Are There Two Auroras?

Yes, there is an aurora in both polar areas. Most of the time the aurora in the south and the aurora in the north are exactly alike and move around in the same way at the same time. The northern aurora is "aurora borealis" meaning dawn of the north. The southern aurora is "aurora australis," meaning dawn of the south.





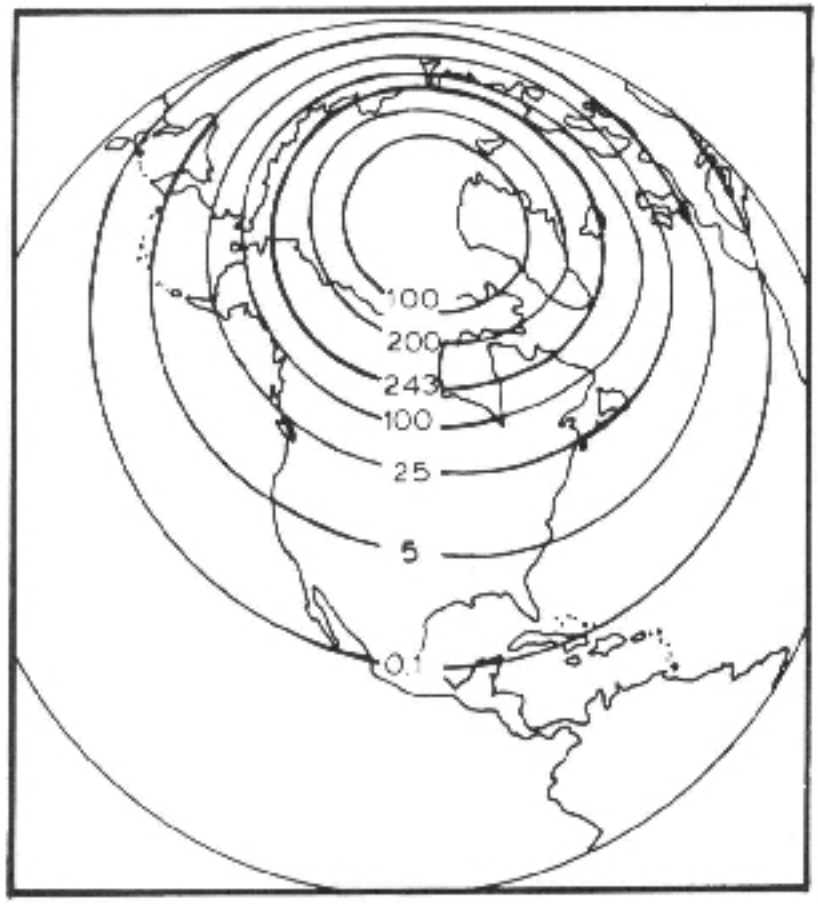

**How the Auroral Light Is Created**

Electrons trapped by the earth's magnetic field travel along the invisible field lines from space into the earth's atmosphere. When the electrons reach an altitude of 200 miles above the earth, they begin to hit the oxygen and nitrogen molecules of the very thin air. When an electron strikes an oxygen molecule, pale green light is given off and when nitrogen is struck, red light is created.



**Electrons in the Aurora**

The electrons are very tiny and bump into molecules hundreds of times as they come down toward earth. Each time an electron bumps into a molecule, a small flash of light is created. At the same time, the electron slows down a little. Finally, by the time the electron reaches 50 miles above the earth, it has used up its energy. It takes billons of electrons to create enough light in the sky for us to see even the smallest part of an auroral display.

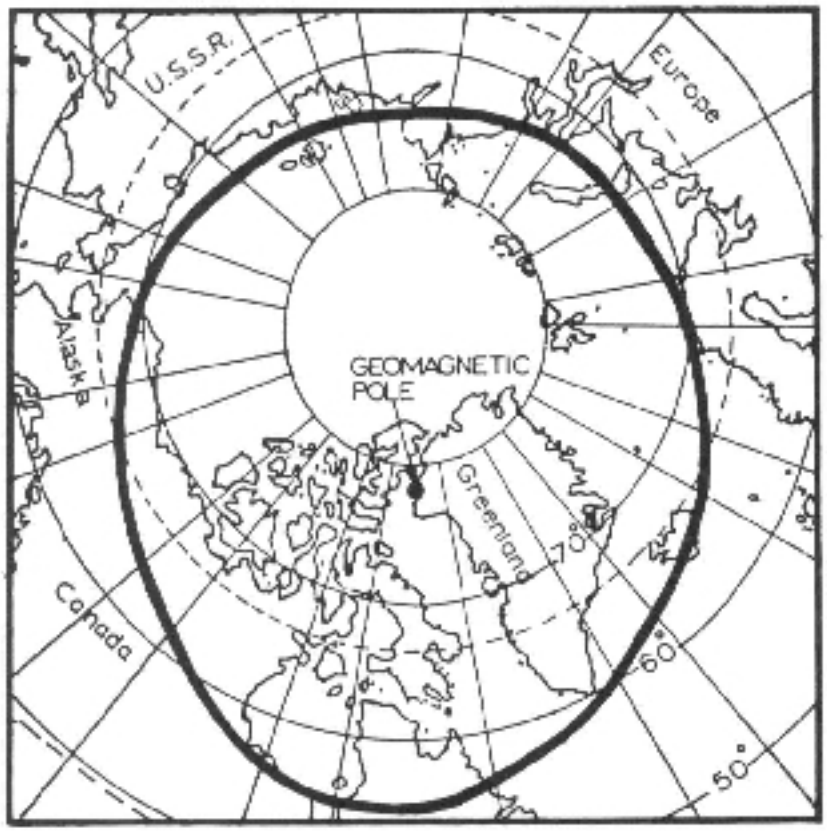





**Where Can People See the Aurora?**

Alaska is not the only place people can see the aurora borealis. The lines on this map show how many nights a year on the average it is possible to see the aurora from different places. Note that in the middle of the United States, people could see the aurora five nights a year. However, they would have to watch all night every night and the sky would have to be clear in order for them to see the aurora that frequently.

Note that in Alaska, people can see auroras on as few as 25 nights a year or as many as 243 nights a year, depending on where they are. Notice also that the number of nights the aurora can be seen increases as you travel from the equator north, reaching a maximum of 243 nights a year on a line that runs through the middle of Alaska. North of that line the number of auroras that can be seen each year decreases again. The line around the earth where the auroras can be seen most frequently is called the "auroral zone."



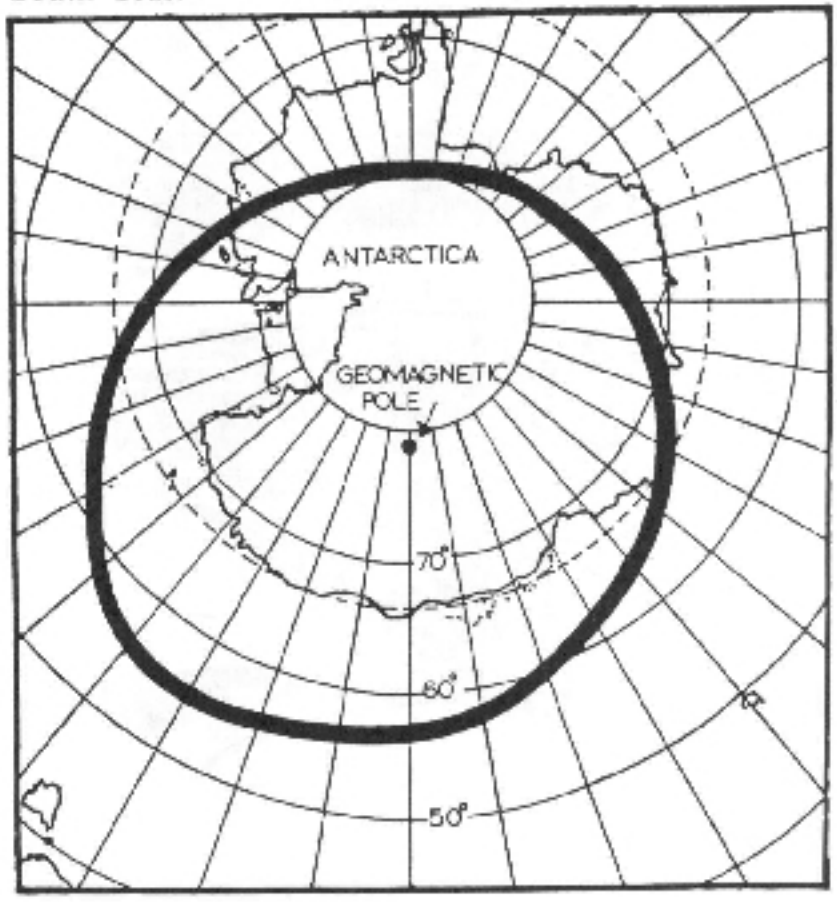

**The Northern Auroral Zone**

Seen from above the north pole, the auroral zone stretches across Alaska and northern Canada, the southern tip of Greenland and Iceland, the northern coast of Norway and part of the U.S.S.R. The northern aurora zone is centered at the north geomagnetic pole, not the geographic north pole.



**The Southern Auroral Zone**

The southern auroral zone passes partly over Antarctica and partly over the South Pacific Ocean. Like the northern auroral zone, the southern auroral zone is also centered at the geomagnetic pole. Aurora australis is not seen from inhabited areas. Africa, South America and Australia are too far from the south pole to have auroral displays. Because of this, aurora australis was not discovered until 1773 when the famous English explorer, Captain James Cook, saw the aurora during one of his voyages in the South Seas.



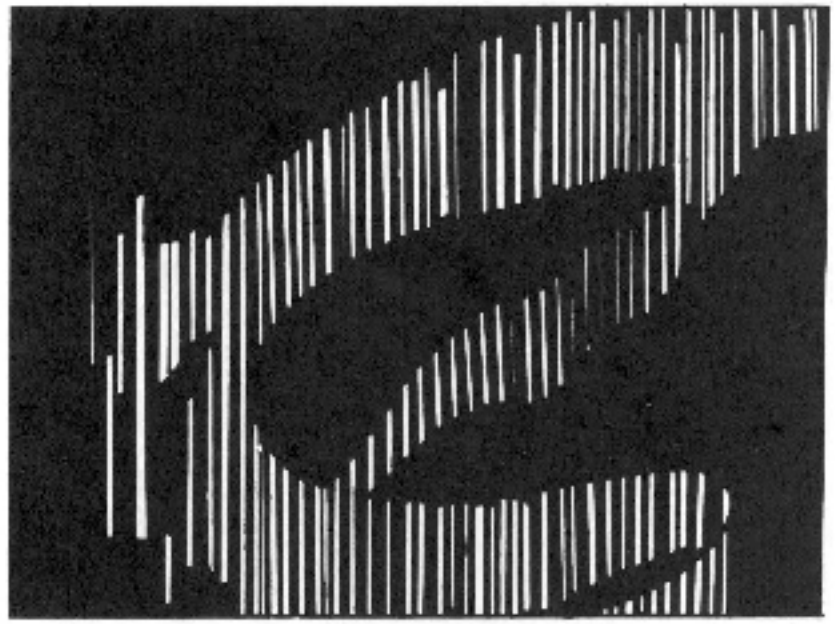
## The Aurora in Early Evening

When the Aurora is seen in the early evening, between seven and ten o'clock, it often has the form of a long, uniform strip of light stretching from one horizon to the other. This strip of light is called an "arc" because just as an arc is a portion of a circle, this early evening auroral form, if extended, would follow the auroral zone and encircle the earth.

Usually these early evening arcs seem to hang quietly in the sky. For this reason, they are called "quiet arcs." Sometimes quiet arcs will last for several hours.



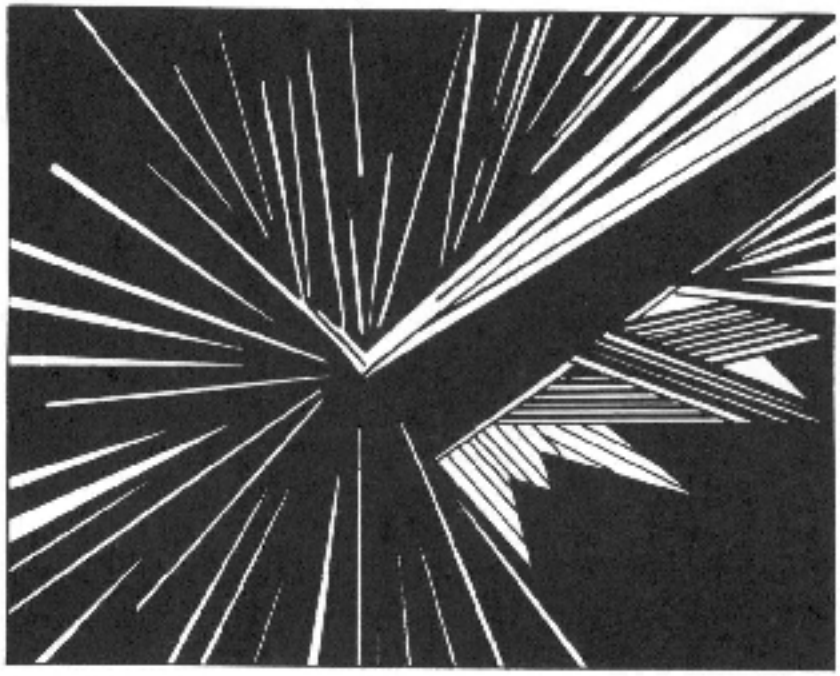

## Late Evening Aurora



**Rayed Bands**

Later in the evening, the auroral forms become more active. The quiet arc develops vertical bars of light called "rays" which line up with the earth's magnetic field lines. Then the arc begins to wave around, moving many miles in just a few seconds. After awhile the quiet arc breakes up into "rayed bands" which appear to be broken-up rayed arcs twisting all around the sky. Up until this time, the aurora has had a pale green color. Now red often appears on the bottom of the dancing rays and on the front edge of the bands as they move around in the sky.

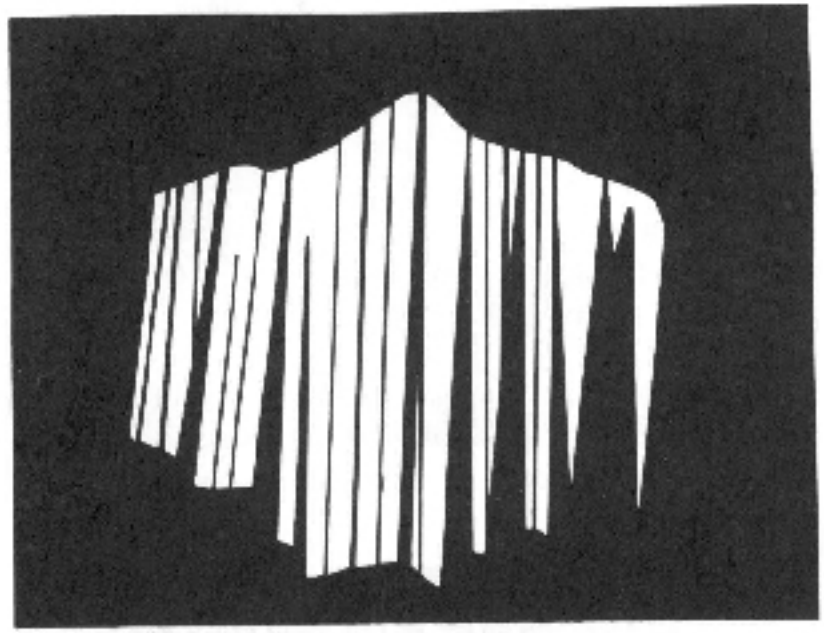
Sometimes a rayed band will be seen straight overhead. When this happens, it is possible to look up and see the rays in the band spreading out in all directions from a central point. This form is called a "corona." The corona is an optical illusion similar to the effect created when looking down long, straight railroad tracks. Sometimes the rays in a rayed band are over a hundred miles in length from top to bottom, and the effect of looking at many parallel rays from the bottom makes them appear as if they come together, although they actually do not.



**Corona**







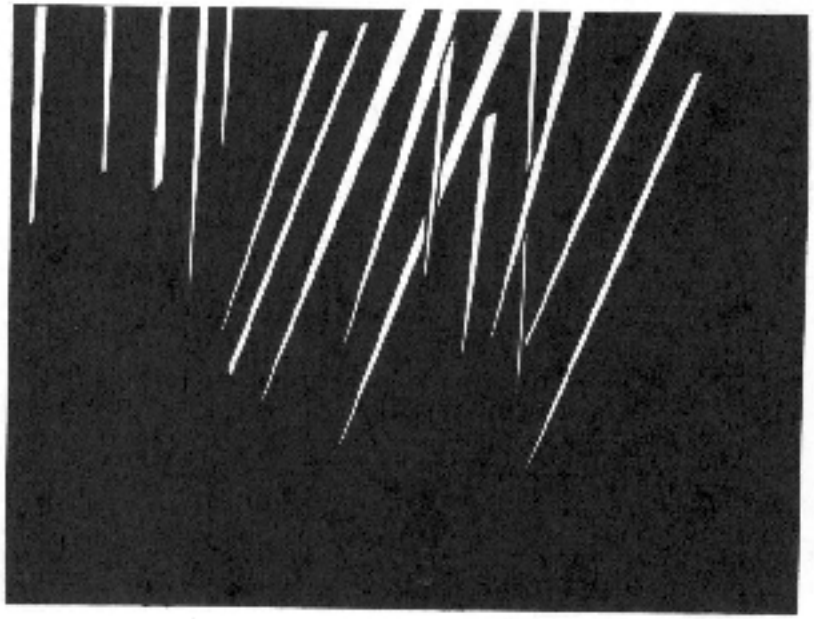
**Patches**

Often after midnight, the aurora becomes quite different. After being very active and filling the entire sky, the aurora seems to almost go away, except for a pale green color throughout the sky. Then, slowly, patches of light start to appear. These patches often look like puffs of smoke or the fluffy clouds seen in midsummer. Patches usually blink on and off in a regular pattern ranging from one or two seconds up to half a minute. They are called "pulsating aurora."

**Predawn Aurora**

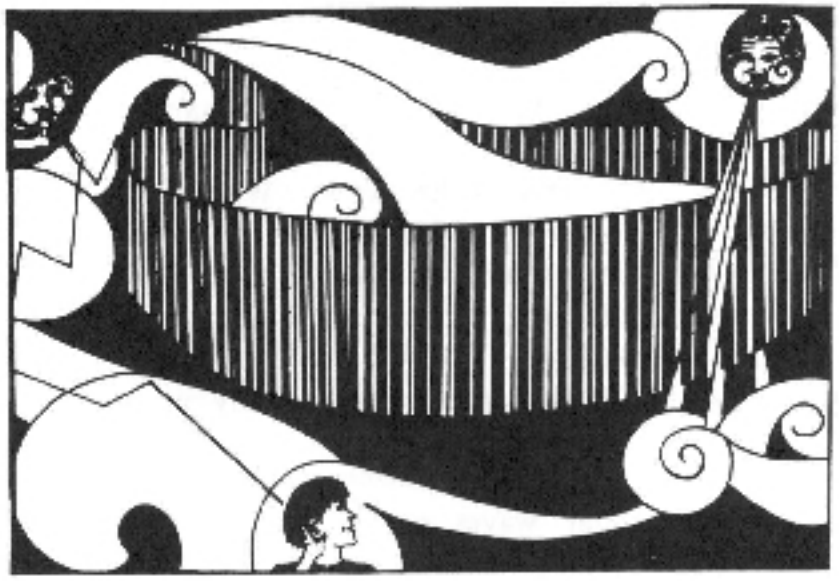
Sometimes toward morning, after a night of very active aurora and after the patches have disappeared, long auroral rays will appear. These rays are not part of an arc or band, but appear as single, isolated columns of light. In bright daylight, the aurora can no longer be seen because the sky is brighter than the aurora. Also the aurora moves far to the north during the day so that it could be seen only in uninhabited areas even if were visible.

From May to early August, the night sky in Alaska is too bright to see the aurora, but people in the "lower 48" often see auroral displays during summer nights.



**Rays**





**Can the Aurora be Heard?**

For thousands of years, and even today, people have reported hearing the aurora. Several different sounds have been reported, but most are described as a very quiet swish or a faint crackling. The sounds have usually been heard during the time rayed bands or a corona move rapidly overhead.

Scientists are puzzled by these reports because the air fifty miles above the earth is much too thin to carry sound. Yet people continue describing these sounds. All attempts to make recordings have failed.

## Why Do We Study the Aurora?

These beautiful patterns of light have aroused curiosity since the first human became aware of them. The questions "What is the aurora? Why does it move and change color?" and others have been asked and "explained" in legends for thousands of years. It is only natural that scientists should wonder as well. The results of auroral studies have indicated that understanding these processes has many practical applications.

Radio and radar waves are frequently distorted or absorbed during high auroral activity. The discharge of electrons can give false commands to satellites orbiting in the area of the aurora. At least one satellite has been lost due to such false commands. Solar storms produce surges of electric current in power lines that can result in power failures.

It is estimated that 99.9% of the universe is in a plasma state—that is gas which is so hot that its atoms become electrically charged. Therefore, understanding plasma is basic to almost every aspect of astronomy. Plasma produced by the aurora is the only natural plasma that can be studied easily with instruments flown on rockets. By studying auroral plasma one may also be able to solve some problems which have frustrated scientists in their attempts to achieve controlled thermonuclear fusion, one on the most potentially valuable sources of energy for the future.



## Glossary

**arc** An arc is a portion of a circle. Since the aurora encircles the auroral zone, the very quiet auroral forms we see stretching across the sky are called "auroral arcs." They are the visible portion of this large circle.

**aurora** The Latin word for the pale light of dawn before the sun comes up.

**australis** The Latin word for "of the south."

**borealis** The Latin word for "of the north."

**geo-** A prefix meaning "of the earth."

**geographic** Referring to surface features on the earth.

**geomagnetic** Pertaining to the earth's magnetism.

**geomagnetic field** The area within the earth's magnetic force.

**magnetic field lines** The theoretical lines of magnetic force surrounding a magnet.

**optical illusion** An effect where what we believe we see is not true.

## Additional Materials

TRAVELING EXHIBIT. A traveling exhibit of color posters explaining the aurora is available through the University of Alaska Museum. Arrangements can be made by contacting the Director, University of Alaska Museum, University of Alaska, Fairbanks, Alaska, 99775-1200, or phoning 474-7505.

SLIDES. The Geophysical Institute has prepared for sale to the public, four sets of five 35 mm slides each of various auroral forms. They are available at $2.00 a set or $8.00 for all twenty slides by writing to Business Office, Geophysical Institute, University of Alaska, Fairbanks, AK 99775-0800.

WRITTEN MATERIALS. Understanding the aurora has been a recent development. Older reference materials, and even some recent publications, contain incorrect information. The materials listed below are recommended.

"The aurora: an electrical discharge process around the earth" by Dr. Syun Akasofu, in *Endeavor*, New series Volume 2, No. 1, Pergamon Press, 1978, pages 7-12. Reprints available at no charge by writing to Director, Geophysical Institute.

"The aurora," Dr. Syun Akasofu, *Scientific American*, December, 1965, pages 54-62.

"Probing the mysteries of the aurora," by Dr. T. Neil Davis, in *Britannica Yearbook of the Future*, Encyclopedia Britannica, Inc., 1974, pages 144-157.



*Auroral Borealis—The Amazing Northern Lights*, Dr. Syun Akasofu, *Alaska Geographic*, 1979, 95 pages. This abundantly illustrated monograph is a blend of legends, history, and science surrounding the aurora. Copies are available at $7.95 per copy plus $.75 for postage by writing to Director, Geophysical Institute.

FILMS. These films are available on temporary loan from Media Services Library, Room 331, Rasmuson Library, University of Alaska, Fairbanks, Alaska 99775-1120.

"Lights in the Northern Sky." This film was made in Alaska as part of the project producing this pamphlet. The film explains the processes by which the aurora is created through interviews and explanations by Alaskan scientists researching the aurora. Made in 1975.

"Challenge of Unanswered Questions." This film was made in Alaska and explains the aurora from the viewpoint of a young graduate student studying the aurora.

VIDEOTAPE. A 27-minute videotape presentation of the best displays of the aurora borealis we observed during the 1985-1986 year in Fairbanks, Alaska. To the images we have added excerpts from the orchestral sound track of the Symphony in URSA MAJOR, composed by University of Alaska Professor Gordon Wright and performed by the Fairbanks Symphony Orchestra. Available in ½-inch (VHS or BETAMAX II) formats for $35, plus $3 shipping and handling charge. Also available in P.A.L. or S.E.C.A.M. for $35 plus $5 foreign shipping.

**About this Pamphlet**

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