occupancy factors for O(16) and O(17): in fact, the O(16) water molecule (whose occupancy factor is 0.65) appears firmly linked to the N(1) ammonium ion (bond length, 3.095 Å), whereas the O(17) water molecule (whose occupancy factor is 0.35) appears more loosely bound to the N(2) ammonium ion (bond length, 3.374 Å).

The structural formula for ammonioborite is: $(NH_4)_3B_{15}O_{20}(OH)_8 \cdot 4H_2O$, with four such formula units per unit cell.

The infinite chains found in larderellite $NH_4B_5O_7(OH)_2 \cdot H_2O$ (*11*) can be regarded as the polymerization product of the trimeric polyions $[B_{15}O_{20}(OH)_8]^{3-}$, according to the schematic reaction:

$$n[B_{15}O_{20}(OH)_8]^{3-} = [B_5O_7(OH)_2]_{3n}^{-3n} + nH_2O$$

Bond lengths in the polyion are given in Fig. 2: in ammonioborite the average B–O distance in the triangles is 1.366 Å and in the tetrahedra is 1.473 Å; these values correspond to those found in larderellite (1.373 Å and 1.466 Å, respectively) and in $\beta = NH_4B_5O_6(OH)_4 \cdot 2H_2O$ (*12*) (1.364 Å and 1.479 Å, respectively) and are in excellent agreement with the values found by several workers in other borates (*13*).

As regards the B–O bonds in the triangles, there are significant differences between those involving oxygen atoms linked to two boron atoms in the trigonal state (mean bond length, 1.391 Å) and those involving oxygen atoms linked to only one boron in the trigonal state (mean bond length, 1.347 Å). Such differences can be explained in terms of differences in π-bond order (*14*).

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Magnetoglow: A New Geophysical Resource

Abstract. *Evidence has been found that the earth is immersed in a large volume of glowing helium ions. This ionic glow, at 304 angstroms, is similar to the geocoronal hydrogen glow in that it extends to very high altitudes, but it is unique in that it is largely confined to the closed field line portion of the magnetosphere. Because of its magnetic containment, this ionic radiation is called the "magnetoglow." Observations of the magnetoglow from inside and outside the magnetospheric cavity promise to provide a valuable means of studying the structural dynamics of the magnetosphere.*

In August 1967, two far ultraviolet photometers with thin-film filters were flown aboard an Aerobee rocket into the night sky (*1*). The major portion of the signal from the indium filter photometer (770- to 1080-Å passband) was identified as solar Lyman-β radiation resonantly backscattered from the hydrogen geocorona. The aluminum filter instrument (150- to 800-Å passband) measured radiation that was absorbed mainly between 160 and 140 km in altitude. This absorption characteristic is similar to that for He+ (304 Å) radiation (*2*). However, the wide bandwidth of the aluminum filter, the large view angle of the collimator, small light leaks through the thin film, and high background noise in the photomultiplier detector rendered it impossible to identify positively the radiation as 304 Å and to exclude the possibility that some of the signal within the detector passband may have been due to 584-Å photons resonantly scattered by the neutral helium within the earth's atmosphere.

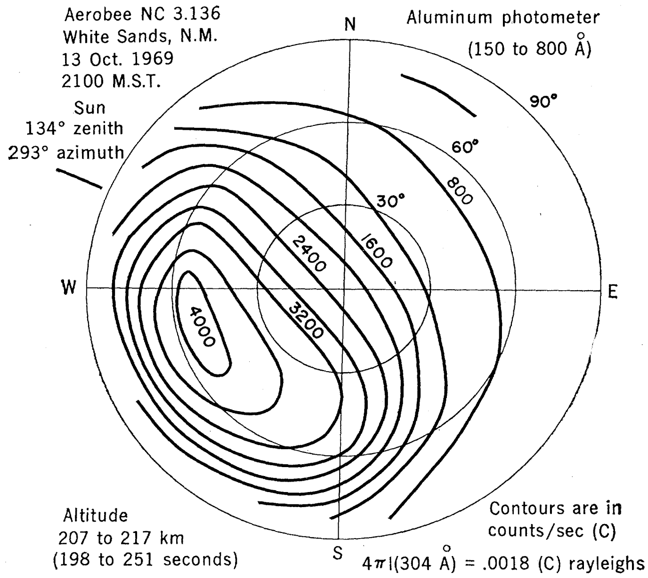
On 13 October 1969, new photometers, which were insensitive to visible light, which used low-noise Channeltron detectors, and each of which had a 0.1-steradian field of view, were flown into the night sky above White Sands, New Mexico. An additional photometer with an aluminum-carbon thin-film filter (150- to 400-Å passband) flew this time in order to isolate the 304-Å from the 584-Å nightglow. The existence of He+ (304 Å) radiation was substantiated by the fact that the signal from both the aluminum and aluminum-carbon photometers followed each other closely both in phase and amplitude excursions. Within the limits of experimental error, subtraction of the aluminum-carbon signal from that of the aluminum photometer left a noisy signal from which we could not identify a nightglow at 584 Å.

Figure 1 shows isophotes of He+ (304 Å) intensity from the night sky hemisphere centered on the zenith above the rocket. The data are derived from the aluminum filter photometer as the rolling rocket scanned the sky from above 207-km altitude. No atmospheric attenuation corrections have been made to the data in Fig. 1. No He+ (304 Å) albedo was observed below the optical horizon.

For contrast, Fig. 2 displays the hydrogen Lyman-α (1216 Å) night sky radiation measured with a magnesium fluoride filter photometer above 178 km on the same rocket flight. Scattered from the neutral hydrogen geocorona, the Lyman-α radiation is most intense in the general direction of the sun, which at the time lay 44 deg below the horizontal.

From the many rocket and satellite observations of hydrogen Lyman-α radiation (*3*), it has been concluded that the earth's blanket of neutral hydrogen has an optical thickness greater than 1 —that is, on the average, each photon is scattered more than once before it reaches the lower atmosphere where it is absorbed by molecular oxygen. Thus, when viewed from inside the "thick" hydrogen geocorona, nonuniformities in the initially scattered Lyman-α radiation pattern are diffused by the subsequent scattering process. Figure 2 shows a Lyman-α intensity variaiton of less than 2 : 1 over the night sky.

On the other hand, the intensity of the He+ (304 Å) radiation (Fig. 1) is



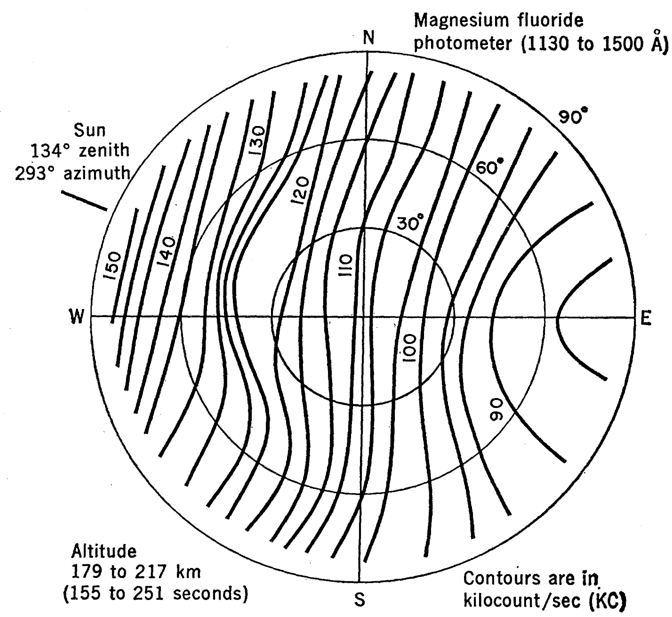


Fig. 1 (left). First "picture" of the magnetoglow taken in solar 304-Å ultraviolet light scattered by helium ions in the earth's magnetosphere as seen when the rocket was at an altitude of between 207 and 217 km. The isophotes are plotted on the zenith-centered upper hemisphere of the night sky. The bright spot centered in the southwest quadrant, when corrected for atmospheric attenuation, moves to the western horizon and reflects both the position of the sun and the concentration of helium ions in the mid and equatorial latitudes. Fig. 2 (right). Isophote plot of hydrogen Lyman-α (1216 Å) geocorona from the same flight that observed the magnetoglow.

highly nonuniform with a well-defined maximum that is not in the solar direction. This high degree of nonuniformity suggests a close earth origin for the 304-Å photons, rather than a distant source such as might occur from charge exchange reactions between solar wind He^{++} and interplanetary hydrogen (*4*). It also suggests an optically thin source—namely, the extensive low-density cloud of helium ions in the earth's upper ionosphere.

In contrast to the thick hydrogen geocorona, the earth's ionized helium blanket has an optical thickness of less than 0.1. This He^{+} cloud is made observable by solar 304-Å photons that are scattered by the portion of the cloud that falls outside the earth's shadow. Once scattered earthward into the night atmosphere, the 304-Å photons are not likely to be rediverted from their paths toward the 150-km altitude region where they are absorbed, thereby producing ionization in the night ionosphere. Because of the dominance of single scattering paths, the intensity of the scattered solar 304-Å radiation is related directly to the illuminated columnar content of helium ions in the earth's magnetosphere. The solar radiation resonantly scattered from the magnetospheric helium ions we call the "magnetoglow."

Satellite mass spectrometers have found that, from altitudes of 2,000 to 25,000 km, the ionic content of the earth's magnetosphere consists mainly of protons with about a 1 percent fraction of helium ions (*5*, *6*). Thus, the singly charged helium ion, which is the only major high-altitude ion with an optical electron, is the tracer for ionization in the high ionosphere. The magnetoglow, in turn, becomes a new geophysical resource which lets us "see" the magnetosphere. By scanning the magnetoglow from low-altitude satellites, an overall two-dimensional picture of the magnetosphere is obtained. The intensity variations observed reflect density nonuniformities in the scattering

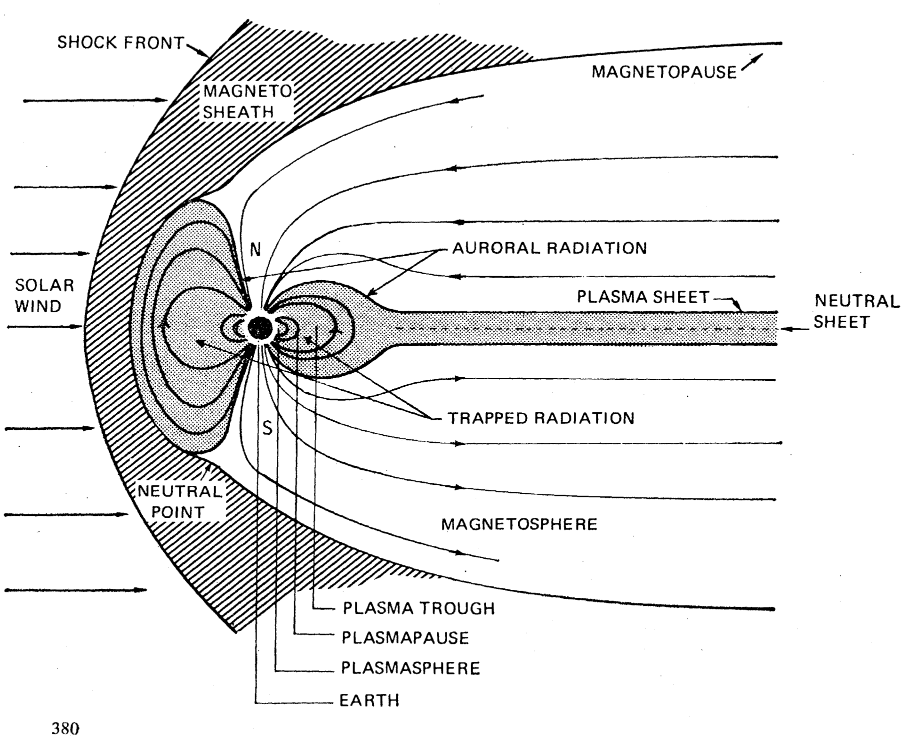


Fig. 3. Model of the earth's magnetic field shown in the plane of the sun-earth line and the geomagnetic axis (*11*). The drawing is approximately to scale. Shape of a given region may change with solar activity. Most of the helium ions from which the magnetoglow originates are confined within the plasmasphere (the gray area).

ions. By comparing a time sequence of such pictures, motion of inhomogeneities could be seen. A study of such motions and of variations in magnetoglow intensity should provide new insight into magnetospheric phenomena. The data should be interpretable in terms of the state of the earth's magnetic field in its integrated ionization content. The situation is analogous to that of an observer inside a comet. The observer sees a glow in all directions. Variations in the glow tell him about the content of the matter in the line of sight but not about its distribution along this direction.

The perspective is altered, however, as the altitude of the observing satellite is increased. Comparison of pictures obtained at different altitudes provides a three-dimensional picture of the magnetoglow. If the observation altitude is increased to beyond the magnetosphere boundary, the situation is similar to that of an observer on earth looking at a comet in space. By viewing the magnetoglow from such a position, a comprehensive picture of the earth's ionization entrapped in the magnetic field lines (Fig. 3) and buffeted by the solar wind might be obtained.

The relationship of the magnetoglow intensity in rayleighs (R) to the total column content of helium ions (N) in an optically thin layer is given by Brandt and Chamberlain (*7*) as

$$R = N(\pi F_\nu)\frac{\pi e^2}{mc} f\, 10^{-6}$$

where (πF_ν) is the flux per unit frequency interval at the solar 304-Å emission line center, and f is the oscillator strength. If we assume that the equivalent solar line width is 0.1 Å, that the line intensity is 4.6×10^9 photons cm^{-2} sec^{-1} (*8*), and that $f = 0.416$, the above expression reduces to $N = (6.4 \times 10^{10})R$. This implies that, for the zenith magnetoglow intensity observed, there were about 2×10^{11} helium ions per square centimeter of column illuminated by the sun. At the time of flight, about 0.5 earth radius of the overhead atmosphere fell within the earth shadow. Because the measurements of Taylor *et al.* (*5*) and Hoffman (*9*) suggest lower concentrations of helium ions, it would be useful to investigate the solar 304-Å emission line profile so that the intensity of the magnetoglow might be correlated absolutely with the magnetospheric helium ion content.

The minimum detectable level of magnetoglow depends on the signal-to-noise ratio of the detector and the background radiation falling within the instrument bandpass. The present detectors have a broad passband and an instrumental noise level of about 1 count per second. Thus a helium column content of 10^9 ions per square centimeter could be "seen" in magnetoglow. For the magnetoglow measurement shown in Fig. 1, most of the intensity is of plasmaspheric origin. However, it is within the capability of the existing instrument to view dense plasma outside the plasmasphere of the kind reported by Chappell *et al.* (*10*). It is also possible that the extended earth magnetotail possesses a sufficient helium ion content to be visible in magnetoglow.

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Sulfur Dioxide Emissions from Power Plants: Their Effect on Air Quality

Abstract. *A modeling study of atmospheric diffusion indicates that emission from power plants contributed only a modest percentage of the yearly average concentration of sulfur dioxide at ground level in the most polluted areas of Cook County, Illinois, during 1968.*

Sulfur dioxide is one of the major air pollutants in industrial cities in the eastern United States. Since 30 to 80 percent (*1*) of the sulfur dioxide emissions in these cities may come from electric power plants that burn fossil fuels, it has been said that curbing emissions from power plants would considerably alleviate the sulfur dioxide pollution problem. We report a modeling study of atmospheric diffusion which indicates that emissions from power plants contributed only a modest percentage of the yearly average concentration of SO_2 at ground level in the most polluted areas of Cook County, Illinois, during 1968.

The Air Quality Display Model (AQDM) developed by the National Air Pollution Control Administration (NAPCA) (*2*) was used to simulate the air quality of Cook County, Illinois. The AQDM is based on a Gaussian diffusion equation which describes the diffusion of a plume as it is transported from a continuously emitting source. The model computes the expected annual average concentrations at ground level at specified receptor points, which result from both point and area sources, as well as the percent of the concentration contributed by each contaminant at the receptor points ascribable to each source. We feel that the AQDM represents a useful first approximation to the physical situation in areas with level topography.

To exercise the AQDM, we first established a grid of receptor points which was overlaid on a map of Cook County. With an inventory of emissions for 1968 compiled by NAPCA, we entered the location and strengths of point and area sources of SO_2. The meteorological data required to execute the AQDM were obtained from the National Weather Records Center in Asheville, North Carolina, and the measured annual average concentrations of SO_2 for 1968 which were necessary to calibrate the model were taken from data compiled by the city of Chicago. Then the model was used to calculate SO_2 concentrations for the Cook County areas (Fig. 1). These calculated concentrations provide a reasonable representation of the air quality around Cook County, partly because the predictions of the AQDM are adjusted to be consistent with observed