This low value of $[H_2O_2]_{ss}$ explains why photolysis of that product, which would serve as an additional source of OH, is unimportant in these experiments. At lower OH concentrations, as in the experiments with added CO, H_2O_2 will reach higher concentrations. However, no effects attributable to H_2O_2 have been observed in the experiments.

WILLIAM B. DEMORE
Jet Propulsion Laboratory, Pasadena, California 91103

References and Notes

1. See, for example, A. E. Barrington, Ed., *Proceedings of the Survey Conference* (Climatic Impact Assessment Program, Department of Transportation, Washington, D.C., 1972).
2. R. G. W. Norrish and R. P. Wayne, *Proc. Roy. Soc. London Ser. A* **288**, 361 (1965); W. D. McGrath and R. G. W. Norrish, *ibid.* **254**, 317 (1960); *Nature* **182**, 235 (1958).
3. W. B. DeMore, *J. Chem. Phys.* **46**, 813 (1967).
4. K. R. Langley and W. D. McGrath, *Planet. Space Sci.* **19**, 413 (1971).
5. R. N. Coltharp, S. D. Worley, A. E. Potter, *Appl. Opt.* **10**, 1786 (1971).
6. F. Kaufman, *Ann. Geophys.* **20**, 106 (1964).
7. The filter consists of a 2-cm path of O_2 at 1 atm, cooled to about $-5°C$. The steady-state absorbance of O_3 is more than 4.0.
8. C. J. Hochanadel, J. A. Ghormley, P. J. Ogren, *J. Chem. Phys.* **56**, 4426 (1972).
9. W. E. Wilson, Jr., *J. Phys. Chem. Ref. Data* **1**, 535 (1972).
10. J. Anderson and F. Kaufman, *Chem. Phys. Lett.*, in press.
11. N. R. Greiner, *J. Phys. Chem.* **72**, 406 (1968).
12. This report presents the results of one phase of research carried out at the Jet Propulsion Laboratory, California Institute of Technology, under NASA contract NAS7-100. I am grateful to N. Davidson and H. Ford for helpful conversations and to F. Kaufman for the disclosure of recent results concerning reaction 1.

4 December 1972; revised 20 February 1973

Magnetospheric Dayside Cusp: A Topside View of Its 6300-Angstrom Atomic Oxygen Emission

Abstract. *An interference filter photometer on the ISIS-II spacecraft generates global maps of the atomic oxygen emission at 6300 angstroms from the ionosphere. The most prominent feature observed is a band of permanent red aurora on the dayside of the earth, centered on magnetic noon at about 78 degrees magnetic (invariant) latitude, brighter than the quiet-time nightside aurora.*

Our knowledge of the detailed characteristics of the earth's magnetosphere has rapidly increased in recent years. One important aspect now receiving attention is the dayside cusp. This name has been given to the magnetic neutral point on the dayside, a demarcation dividing the magnetic field lines which turn equatorward and close on the dayside from those which stream over the pole into the tail of the magnetosphere. It appears that solar plasma can enter the magnetosphere unimpeded at this point, flowing down to ionospheric levels. Using all-sky camera data from a number of stations, Feldstein (*1*) constructed an "instantaneous" auroral distribution pattern now called the auroral oval, and showed that it closed on the dayside at about 79° magnetic invariant latitude. Soon afterward, satellites carrying detectors of low-energy electrons detected a region of "soft" precipitation on the dayside (*2*). Later particle observations (*3*) identified this precipitation with the dayside neutral point or cusp, and Hoffman and Berko (*4*) related their particle observations to the ground-based observation of discrete auroral forms. Since dayside auroras can be observed at local noon, albeit in rather inaccessible geographical regions, a series of aircraft observations were carried out (*5–8*). Heikkila *et al.* (*9*) have provided a detailed documentation of the relevant particle and optical characteristics. The precipitation consists of isotropic 100-ev electrons and 300-ev to 3-kev protons. The protons are considered to identify the cusp most sharply, which occurs between about 79° and 81° invariant latitude, depending on the level of activity. It is recognized that the cusp extends well to both sides of local noon, but the existing knowledge of its longitudinal extent has been built up from a number of satellite passes made at different times.

This is a report of an optical observation of the entire dayside cusp region, taken in "snapshot" fashion during a single pass with the second international satellite for ionospheric studies, ISIS-II. The spacecraft was launched on 1 April 1971 into a near-circular near-polar orbit at a nominal altitude of 1400 km. The instrumentation is similar to that of ISIS-I (*10*), but one of the new instruments aboard is the red line photometer (*11*), designed to measure the global distribution of the 6300-Å emission of atomic oxygen, OI. The photometer looks perpendicular to the spacecraft spin axis with two optical axes, 180° apart, characterized by spectral bandwidths of about 10 and 88 Å. The two optical channels can share the same photomultiplier and electronics, since when one channel views the earth the other scans the dark sky. The spin-stabilized spacecraft has a rotation period of about 18 seconds, during which the spacecraft moves approximately 120 km. The photometer has a field of view of 2.5° angular diameter or 60 km when looking vertically downward on the earth. With the spin axis in the orbit plane, the combined rotation and orbital motion generates a raster-like scan across the earth, generating maps in both wavelength channels. These can be combined to extract the white light background and so to generate a global map in the 6300-Å emission.

On 14 December 1971, the spacecraft spin axis had been maneuvered by magnetic torquing to within 30° of the orbit plane and a declination of −10°; the orbit plane was then close to the noon-midnight meridian. This provided very favorable viewing conditions for the auroral oval in the dark northern polar cap. The purpose of this report is to present the polar map obtained from 05:18 to 05:40 U.T. in a single pass by using the ground stations at Resolute Bay, Northwest Territories, and Ottawa, Canada; practically the entire auroral oval is visible, and particularly the 6300-Å emission from the dayside cusp. The value of the observation is that it makes available an essentially instantaneous picture of a region that has dynamic characteristics.

The data are presented in Fig. 1 in the form of a spin map (*12*), generated by the computer line printer. In this map, one line of print corresponds to one rotation of the spacecraft; the two scans of different bandwidths obtained from subsequent half-rotations have been combined to present the extracted 6300-Å emission as single scans in which the intensity is represented by the density of the symbol used. The leading limb of the emission is forced to coincide with the left edge of the page and the trailing limb falls where it occurs, somewhere inside the right edge. That limb is evident in Fig. 1 owing to the enhancement of tangential viewing; a simple cosine correction is applied to the data, but this correction is inadequate right at the limb, for several reasons. The dayside cusp appears as a pronounced band of intensity indicated by the overprinted symbols just below the top of the map, from roughly spin 5 to spin 20. The brighter patch in the extreme upper right corner is a region of twilight on the earth. The nightside auroral oval can also be weakly seen, as zeros and asterisks at about spin 45 in the center of the map. The noon-midnight meridian runs approximately vertically through the center of the map, so that following the nightside aurora around to the left brings one to the evening side, where the emission appears to connect smoothly with the dayside precipitation. But the emission is too weak from 18 to 20 hours for this to be certain. On the morning side the emission is too close to the limb to define the degree of continuity there.

Near the bottom of Fig. 1, near spin 65, the blank region indicates a sudden intensity drop. This intensity edge corresponds to a solar depression angle of 10° at the magnetic conjugate point, and results from the cessation of conjugate point photoelectrons, which precipitate all night long at high latitudes during the solstice. This and some earlier observations of this phenomenon with ISIS-II have been published (*13*).

In Fig. 2 some intensity contours from the actual number map corresponding to Fig. 1 have been plotted in the coordinates of geographic latitude and local time, by using the geometry of an expanded earth corresponding to an assumed emission height of 250 km. The invariant latitude contours for 80°, 75°, and 70° have been plotted, as well as certain other parameters. The cusp defined by the most intense 6300-Å emission lies very close to 78° invariant. In the evening sector, the

Fig. 1. Spin map of the 6300-Å emission obtained on orbit 3257, 14 December 1971, from 05:18 to 05:40 U.T. Each line of print corresponds to one scan across the earth and the intensities are indicated by the blackness of the symbols. The leading limb of the earth is aligned with the left edge; the trailing limb can be seen about two columns in from the right. The dayside cusp is apparent at the top at about spin 10, while the nightside aurora can be seen going down to about spin 45.

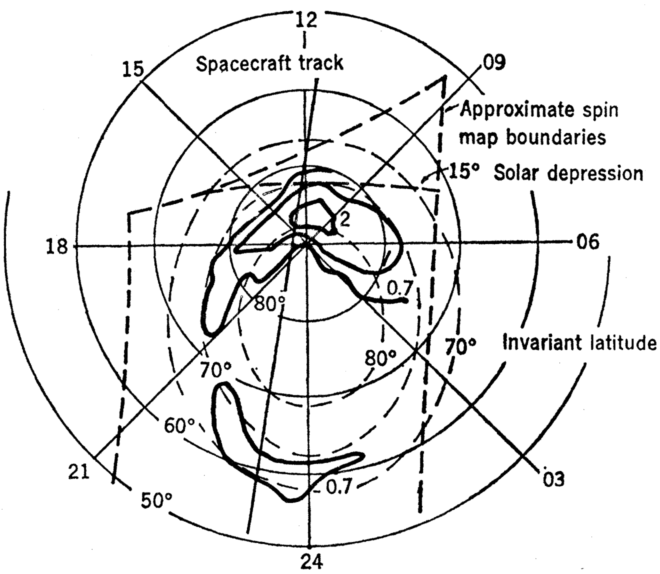

Fig. 2. Intensity contours for 6300-Å emission plotted on coordinates of geographic latitude and local time. The intensities shown are in kilorayleighs. Also shown (dashed) are some invariant latitude contours, the spin map boundaries, the 15° solar depression angle line, and the spacecraft track. Data from orbit 3257, 14 December 1971; 05:18 to 05:40 U.T.

cusp-associated emission has come down to nearly 75° invariant and thus does appear to define an oval consistent with the nightside aurora, which is very weak but is defined by a 0.7-kilorayleigh contour reaching down to 60° invariant latitude.

The excitation mechanism of the 6300-Å emission is an interesting problem in itself. The incoming 100-ev electrons (*5*) excite ^1D atomic oxygen with considerable efficiency, but secondary processes will also be important. High electron temperatures exist in the dayside cusp, at least at spacecraft altitudes (*14*), and hot ambient electrons may produce a significant fraction of the emission. Dissociative recombination of O_2^+ would also be important. Comparisons with other data from the spacecraft will permit a detailed interpretation.

The relationship of the data presented here with the optical data previously collected is not altogether clear. The satellite observation suggests a rather smoothly varying intensity distribution extending over roughly 10° of latitude. In black-and-white all-sky camera photographs (*5–7, 15*) the auroras are seen as very narrow, discrete, rayed, and rapidly varying (*6*). They must also be rather bright, and it is possible that such structured forms were absent when the spin map was obtained, since Anger (*16*) detected fairly low levels of 3914-Å emission with an auroral scanning photometer (*17*). Korosheva (*18*) observed a more homogeneous arc extending around the dayside, at about 75° invariant latitude. But other evidence indicates that these discrete auroras are enriched in the 6300-Å emission. Akasofu photographed them in color, and they appear red (*9*). Starkov (*19*) measured their most probable height as 150 km, which would make them somewhat enriched in 6300 Å. Whalen *et al.* (*7*) used a combination of all-sky camera photographs and scanning photometers to show that there was a continuous 6300-Å background surrounding the discrete auroras, having a sharply peaked latitude distribution, much as described here, except that their reported intensity was only 100 rayleighs (with 30 and 8 rayleighs of 5577-Å and 4278-Å emission, respectively). Strömman *et al.* (*20*) made photometric ground-based measurements at Ny-Alesund, Spitzbergen, which clearly show the cusp emission as a 6300-Å phenomenon. Feldstein and Starkov (*21*) may have provided the clue to this mystery. They maintain that the dayside aurora consists of rays and bands in quiet times, which are distinctly different in form from the morning and evening arcs that move in from both sides toward the noon sector, never quite reaching it, as the activity level increases. Whether these rayed structures are superimposed on a continuous background, or whether they are so uniformly distributed as to appear as a continuous distribution, remains to be resolved.

G. G. Shepherd
F. W. Thirkettle
Centre for Research in Experimental Space Science, York University, Ontario, Toronto, Canada

References and Notes

1. Y. I. Feldstein, *Geomagn. Aeron. USSR* **3**, 183 (1963); *Planet. Space Sci.* **14**, 121 (1966).
2. J. L. Burch *J. Geophys. Res.* **73**, 3585 (1968); R. D. Sharp, D. L. Carr, R. G. Johnson, *ibid.* **74**, 4618 (1969).
3. W. J. Heikkila and J. D. Winningham, *ibid.* **76**, 883 (1971); L. A. Frank and K. L. Ackerson, *ibid.*, p. 3612.
4. R. A. Hoffman and F. W. Berko, *ibid.*, p. 2967.
5. J. Buchau, J. A. Whalen, S.-I. Akasofu, *J. Atmos. Terr. Phys.* **31**, 1021 (1969).
6. G. J. Romick and N. B. Brown, *J. Geophys. Res.* **76**, 8420 (1971).
7. J. A. Whalen, J. Buchau, R. A. Wagner, *J. Atmos. Terr. Phys.* **33**, 661 (1971).
8. R. H. Eather and S. B. Mende, *J. Geophys. Res.* **76**, 1746 (1971).
9. W. J. Heikkila, J. D. Winningham, R. H. Eather, S.-I. Akasofu, *ibid.* **77**, 4100 (1972).
10. J. H. Whitteker, L. H. Brace, J. R. Burrows, T. R. Hartz, W. J. Heikkila, R. C. Sagalyn, D. M. Thomas, *ibid.*, p. 6121.
11. G. G. Shepherd, T. Fancott, J. McNally, K. S. Kerr, *Appl. Opt.*, in press.
12. G. G. Shepherd *et al.*, *Planet. Space Sci.*, in press.
13. G. G. Shepherd, L Brace, J. H. Whitteker, *J. Geophys. Res.*, in press.
14. L. H. Brace, *Trans. Amer. Geophys. Union* **53**, 473 (1972).
15. S.-I. Akasofu, *J. Geophys. Res.* **77**, 244 (1972).
16. C. D. Anger, private communication.
17. ———, T. Fancott, J. McNally, H. S. Kerr, *Appl. Opt.*, in press.
18. O. V. Korosheva, *Geomagn. Aeron. USSR* **3**, 294 (1963).
19. G. V. Starkov, *ibid.* **8**, 28 (1968).
20. J. R. Strömman, B. N. Maehlum, J. K. Olesen, *Planet. Space Sci.* **19**, 540 (1971).
21. Y. I. Feldstein and G. V. Starkov, *ibid.* **15**, 209 (1967).
22. Operational support of the spacecraft is provided by the Communications Research Centre, Ottawa, and the National Aeronautics and Space Administration. Financial support for this research was provided by the National Research Council of Canada.

7 February 1973

Early Hominid Humerus from East Rudolf, Kenya

Abstract. *A fossil hominid humerus discovered in 1970 by the expedition to East Rudolf, Kenya, led by R. E. F. Leakey is examined in comparison with a large series of extant hominoids. This comparison as well as a multiple discriminant analysis shows the uniqueness of the fossil among the hominoids.*

During the 1970 season the expedition led by R. E. F. Leakey to the fossil beds east of Lake Rudolf discovered a well-preserved hominid humerus (*1*). The fossil is missing the proximal end but is otherwise in remarkably good condition considering its age of between 1 and 2 million years (*2*). It derives from the upper half of the "Lower Unit" of locality B, Ileret. A description has already been published (*3*).

This fossil humerus is very important to the reconstruction of the locomotor,