Abstract The Ultraviolet Imager on the Viking Spacecraft provides global images of aurora in both night and day hemispheres at rates of up to three per minute. First results summarized in this and a set of eight companion papers reveal new aspects of the patterns and dynamics of the aurora, including eastward as well as westward expanding substorm intensifications, but very little evidence of bulk equatorward expansions during some substorms, resulting in the formation of an intense eye-shaped bulge containing diffuse aurora and north-south aligned arc segments; substorm-like intensifications at the point where transpolar arcs join the nightside oval; rapid small scale auroral brightenings, or "hot spots" over a wide range of local times; and very rapid changes in auroral forms in the noon sector.

Introduction

The processes which couple energy from the solar wind into the magnetosphere are complex and spread over large regions of space. It is difficult to evaluate these processes when relying entirely on the results from measurements made at single points in space or on earth. Because of this, investigators have been relying increasingly on global auroral images obtained from satellites to aid them in their study of the magnetosphere. Many of the processes of interest result in the energization or scattering of charged particles, causing them to precipitate into the upper atmosphere where they cause the emission of visible and UV radiation which can be detected optically. Regions of optical auroral emissions thus serve as tracers, identifying those field lines where particle energization or scattering of trapped particles is taking place.

The Ultraviolet Imager (UVI) on the Viking satellite, launched February 22, 1986 is the newest member of a series of global auroral imaging instruments which began with the monochromatic scanning photometer on ISIS-2 (Anger et al., 1973), accompanied shortly thereafter by white-light scanners of somewhat higher spatial resolution on the DMSP satellites (Rogers et al., 1974). The time between images was decreased from two hours to 12 minutes with the Dynamics Explorer imagers, (Frank et al., 1981) which began to explore global auroral dynamics in both the visible and vacuum ultraviolet wavelength regions. The range of possibilities for imaging in various UV auroral lines was subsequently demonstrated by the HILAT scanning spectrometer (Meng and Huffman, 1984).

With the UVI instrument a new realm of time resolution reaching to 20 seconds/image with sensitivity reaching to IBC-I and below (Valiance Jones et al., 1987) has been achieved along with imaging of global auroral patterns in both night and day hemispheres with a spatial resolution of 20-30 km. With this instrument we have been able to explore the temporal development of global auroral displays with considerably improved resolution while retaining the ability to resolve individual auroral structures. Details of the instrument design and characteristics are described in a companion paper (Anger et al., 1987).

Interactive control and real-time analysis of data from the instrument at the satellite ground station in Kiruna, Sweden, were an integral part of the instrument (and spacecraft) design concepts. Pointing direction, field of view size, and instrument gain can be altered on a time scale of seconds in response to what is seen by the UVI and other Viking instruments.

The purpose of this paper is to provide a general overview of the initial impressions and conclusions derived from several hundred hours of comfortable viewing of global auroral images as they arrived at our mountain-top receiving station in northern Sweden, followed up by more detailed and quantitative inspections of images and image sequences. We also wish to introduce and provide a context for the eight companion papers on UVI results included in this special Viking issue of GRL.

Summary of Observations

Following in list form are some of the more notable features of northern hemisphere auroras as seen by the UVI during the first eight months after launch. Many of these points will serve as a basis for statistical and quantitative tests to be applied to the full data set in the future and thus are subject to confirmation and refinement.

1. The presence of location-and form-dependent ratio changes in simultaneous images from the two cameras (Figure 1). These probably indicate variation in the energy spectrum of the precipitating particles responsible for the auroral emissions.

2. A fairly consistent pattern for the development of auroral intensifications and substorms, as illustrated in Figure 2 (Shepherd et al., 1987; Rostoker et al., 1987a, b; and Hones et al., 1987).

(a) The initial stage is an intensification which spreads east and/or west along the oval.

(b) The event may immediately, or later as a result of further intensifications, develop an expanding eye-shaped bulge due to poleward (and frequently equatorward) expansion of the active region. The bulge is filled with bright patchy forms usually with a general north-south alignment.

(c) After some minutes or tens of minutes the patchy forms within the bulge weaken leaving the bulge filled with intense diffuse aura. Discrete auroras tend to be concentrated near the poleward edge of the bulge, and the
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1. Simultaneous images of an auroral breakup obtained on 860326 at 143532 UT. The image on the left is from the camera sensitive to the Lyman-Birge-Hopfield bands of molecular nitrogen, and that on the right to the 1304/1356 Å emissions of atomic oxygen. The color scales vary from blue (minimum intensity) to red (saturated). The forms and structures in the two images are very similar, but the bright arc at the top left is brightest in LBH, while the breakup feature in the center-right is brightest in the OI 1304 emission.

2. The top of the bulge may "flatten" due to continued east-west expansion of the active region around the oval.

3. The absence of any consistent westward movement in surge structures.

4. The frequent, conspicuous presence of the afternoon auroral enhancement, even when the rest of the oval is quiet. It can be the most intense and dynamic feature in the oval (Lui et al., 1987).

5. The common occurrence of intensity enhancements at the point where polar arcs join the midnight sector (Figure 3). These intensified regions can have scale sizes and behavior similar to small substorms at least some of the time, but the existence of a polar arc is not a part of classical substorm models or theories (Murphree et al., 1987).

6. The occurrence of auroral brightenings and rapid changes in auroral structures at all local times, not exclusively in the midnight sector, including:
   a. At noon and in the late morning sector where dramatic changes in the entire structure frequently take place within a very few minutes (Figure 4).
   b. The frequent occurrence of short-lived "hot spots" (Lui et al., 1987), approximately 100 km across which develop rapidly, within less than a minute, to an intensity approximately double that of the surrounding aurora and then fade out after a few minutes.

7. The general absence of obvious large scale coherent time variations in the aurora between different local time sectors, the one obvious exception being in the late morning.

Fig 1. A series of nine successive images starting at 1750 UT on 861004 and showing the development of an auroral substorm. Universal times are shown on each image, and the midnight MLT meridian is shown on the first and fifth images. The oval can be seen extending around the magnetic pole. The substorm begins as an intensification at midnight which spreads west and east along the oval and then fades significantly by 1759 UT. A further intensification and poleward expansion then takes place forming an intense eye-shaped bulge.

Fig 2. A series of nine successive images starting at 1750 UT on 861004 and showing the development of an auroral substorm. Universal times are shown on each image, and the midnight MLT meridian is shown on the first and fifth images. The oval can be seen extending around the magnetic pole. The substorm begins as an intensification at midnight which spreads west and east along the oval and then fades significantly by 1759 UT. A further intensification and poleward expansion then takes place forming an intense eye-shaped bulge.
Fig 3. A sequence of 6 images (861019) showing snapshots of the auroral distribution over a 30 minute period. During this time period the aurora changes from being relatively quiet with weak polar arcs to a configuration with optical substorm characteristics. Even when the auroral distribution indicates substorm activity, a bright polar arc is still present.

Fig 4. A sequence showing the very rapid development of an extended set of arcs in the morning sector on 861015 between 2027 and 2030 UT. The noon MLT meridian is shown on the last image.
sector where rapid variations spanning several thousand kilometers can be observed.

8. Finally, and probably most significant of all, the dynamic stability and general continuity of the auroral oval, which represents either a remarkable overlap of separate magnetospheric regions or an apparent linkage of such disparate regions as the nighttime plasma sheet and the dayside cusp and all the boundary layers between them.

Discussion

At this point we have reached the end of the beginning of our Viking analysis. Future work will include intercomparison of our imager data with results from other instruments on Viking. Some striking correlations are already obvious from real-time observations made during a series of Viking campaigns. There are also some tantalizing aspects which we have not yet had the opportunity to investigate, the most intriguing of which are dayglow features which are present (or absent) in the data, and the distinct impression that there are long term variations (time scale of weeks) in the basic morphology of the aurora. Included in this is the inspection of the images for possible evidence of cometary "holes" as reported by Frank et al. (1986). We can report inspection of a small sample of 1304 A camera images has not revealed any obvious deep depressions in intensity, nor have we observed any obvious "holes" in our more extensive set of dayside LBH images. However, based on their reported optical characteristics, extensive analysis will need be done to determine whether the Viking UV data can support or deny the existence of this phenomenon.

It seems clear that the vacuum UV provides good imagery of auroras even in full sunlight and will probably furnish useful diagnostic information on particle energies, much as is the case with visible emissions. The technical difficulties of working in the UV are more than offset by the smaller size and structural simplicity of UV instruments due to reduced baffling requirements. This relative freedom from scattered light problems makes it possible to open up the instrument field of view so that effective use can be made of two dimensional array image sensors, which in turn provides dramatic improvements in spatial and temporal resolution. Further improvements appear to be possible, and the wealth of detail evident in our data probably means that such improvements will be warranted.

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C.D. Anger, L.L. Cogger, R. A. King, J. S. Murphy and D. Venkatesan, Department of Physics, University of Calgary, Calgary, Alberta, Canada, T2N 1N4

J. W. Haulet, Department of Elec. Eng., University of Calgary, Calgary, Alberta, Canada, T2N 1N4

F. Creutzberg, R.L. Gattinger, F.R. Harris, A. Vallance Jones and D.D. Wallis, Herzberg Institute, National Research Council, 100 Sussex Drive, Ottawa, Ontario, Canada, K1A 0R6


G. Gustafsson, Uppsala Ionospheric Observatory, 755 90 Uppsala, 1 Sweden

E.J. Llewellyn and D.J. McEwen, Department of Physics, University of Saskatchewan, Saskatoon, Saskatchewan, Canada S7N 0W0

J.C. McConnell and G.G. Shepherd, CRESS, York Univ., 4700 Keele Street, Downsview, Ontario Canada M3J 1P3

E.H. Richardson, Dominion Astrophysical Observatory, Victoria, B.C., Canada V8Z 3H8

G. Rostoker, Department of Physics, University of Alberta, Edmonton, Alberta, Canada T6G 2J1

G. Witt, Meteorological Institute, University of Stockholm, S17540 Stockholm, Sweden

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