FINAL REPORT

NASA GRANT NGR-06-003-201

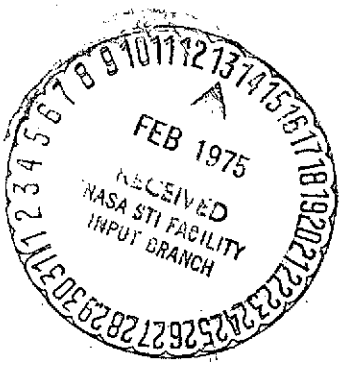
Analysis of Data from Satellite Experiments

Principal Investigator: Gary E. Thomas
Professor, Department of Astro-Geophysics
Fellow, Laboratory for Atmospheric and Space Physics
University of Colorado
Boulder, Colorado 80302

(NASA-CR-142057) ANALSYIS OF DATA FROM SATELLITE EXPERIMENTS Final Report, 1 Sep. 1973 - 1 Jul. 1974 (Colorado Univ.) 10 p HC $3.25 CSCL 03B

N75-16440

Unclas
G3/90 08952



PRECEDING PAGE BLANK NOT FILMED

ABSTRACT

This is a final report of activities carried out under NASA Grant NGR-06-003-201 from 1 September 1973 to 1 July 1974. The results are summarized from all analyses carried out on data from the OGO-5 and OGO-6 ultraviolet photometer experiments.

INTRODUCTION

The identical ultraviolet photometer experiments were carried on the eccentric orbiting OGO-5 spacecraft, launched in March 1968, and on the polar orbiting OGO-6 spacecraft, launched in June 1969. The experiments operated flawlessly and, because of the sophisticated electronic design, allowed signals to be processed accurately over a large dynamic range (see final Data Reports NAS 5-9307 and NAS 5-9327, on file in OGO office dated 12 September 1973). This report covers the scientific results gained from the post-mission data analysis efforts and, in particular, the period 1 September 1973 to 1 July 1974.

PRECEDING PAGE BLANK NOT FILMED

OGO-5

Because of its large apogee distance from earth (23 earth radii) this experiment was able to explore the outermost region of the hydrogen geocorona and to map for the first time the extraterrestrial Lyman alpha sky background. The following is a brief outline of the scientific achievements gained from the experiment.

1. Altitude distribution of the hydrogen geocorona.

This was mapped out to a distance of 80,000 km from earth (Ref. 1) where it became too weak to observe against the Lyman alpha sky background.

2. Sky distribution of the Lyman alpha sky background.

This was the most important achievement of this experiment, indeed perhaps of the entire OGO-5 mission. Together with the French scientists, we obtained a series of all-sky maps through an extraordinary set of spacecraft maneuvers ('spin-ups') carried out by personnel at the OGO Command and Tracking Group. A new solar system phenomenon, the "interstellar wind," was discovered. A field of interest was born which, over the past five years, has included some eighty scientific papers (Refs. 9 and 10). The initial results were reported in 1971 (Ref. 2). In 1972 at the Asilomar Conference on the Solar Wind, a special session was held in which the significance of the new

results were further discussed (Ref. 4). The final report for the spin-up data was recently given in Reference 5.

3. Temporal changes in the Lyman alpha sky background.

The discovery of a 27-day solar modulation in the extraterrestrial signal constituted final proof of the local nature of the radiation (Ref. 3). This allowed us to place an upper limit of 100 Rayleighs to the galactic emission, a result recently verified by Pioneer 10 measurements.

4. The Earth as a comet -- the 'geotail'.

In the past, theories were postulated that the outermost atmosphere of the earth would be drawn out into a comet-like tail by the influence of solar radiation pressure and the solar wind. However, this remained in doubt until OGO-5 measurements verified that such a phenomenon was indeed present (Ref. 3). Since then, two other investigations have also observed the 'geotail'.

5. Comet Bennett -- the bright comet of 1971.

By a fortuitous set of circumstances the OGO-5 photometer was able to make the most sensitive measurements ever carried out of the hydrogen coma and tail of a comet (Ref. 6). Those results revealed that the hydrogen cloud of comets was of gigantic proportions, more than 30 million kilometers

(0.1 a.u.) in extension. An analysis of these measurements provided a unique solar flux calibration (Refs. 6 and 7). Analysis also showed that the atoms were distributed in a non-Maxwellian mixture of velocities, indicating that the source of the hydrogen is probably the break-up of water molecules in the solar ultraviolet radiation field (Refs. 7 and 8).

OGO-6

1. The atomic oxygen airglow.

Measurements of the O I triplet at 1302.17, 1304.87, and 1306.04 A in the dayglow have for many years eluded analysis because of the very difficult task of theoretically modelling the emissions. We devoted a large effort to this task, and this has paid off to a great extent in the successful work on Mariner 6, 7, and 9 data (Refs. 11 and 12). We have recently applied these techniques to the OGO-6 oxygen airglow and have demonstreated the importance of both resonance scattering and photoelectron excitation. Furthermore, this analysis has shown that geomagnetic activity can seriously influence the oxygen dayglow (Ref. 17).

2. The hydrogen geocorona -- global variation.

Measurements of the 1216 A airglow between 400 and 1100 km have been recently analyzed to determine global variations of hydrogen density with solar and geomagnetic activity (Ref. 18). This study has shown that the escape flux of hydrogen due to the classical Jeans evaporation loss is probably not the only escape route of hydrogen. The presence of another, and perhaps dominant, upper atmospheric escape mechanism is suggested. This is probably due to the presence of hot ionospheric protons which create hot hydrogen atoms in a charge-exchange reaction. These energetic atoms escape the earth's gravitational field at a rate much higher than the thermal atoms.

3. Local time, latitudinal, and seasonal variations of hydrogen.

This analysis is not yet completed. However preliminary indications are that local time (diurnal) variations are weak at the high latitudes where OGO-6 preferentially samples the data. This is not inconsistent with earlier observations of a nighttime diurnal bulge at low latitudes. A latitudinal gradient of hydrogen from equator to pole also appears to be present. In addition, there is a strong suggestion of a permanent hydrogen bulge at low northerly latitudes. If verified, this finding would be consistent

with the recently-recognized tendency of the northern thermosphere to be cooler than the southern thermosphere.

4. Lyman alpha arcs at low latitudes.

The analysis is incomplete so far; however, there is no doubt that intense emissions (∿1 kilorayleigh) in the Lyman alpha spectral pass-band (1150 - 1225 A) regularly occur during passage over the equatorial regions. These arcs (observed in the zenith by OGO-6 and in the nadir in the light of Balmer-α by the French group) have no obvious connection with the well-known oxygen emissions in the tropical ultraviolet arcs. They may be associated with the decay of ring-current protons; however, the energy requirements are severe. Research is continuing into this problem.

CONCLUSIONS

The analysis of ultraviolet data from the OGO satellites has been very productive of new scientific results. New analysis tools (such as non-planar radiative transfer codes) have been developed which will be useful for forthcoming space missions. Future research into more restricted areas will produce additional benefits -- for example, the study of the detailed behavior of the hydrogen geocorona during a geomagnetic storm; and of the detailed morphology of the Lyman alpha equatorial arcs. The easy availability

of the OGO data at the NSSDC and at LASP also makes possible future specialized investigations at minimum effort and expense.

OGO BIBLIOGRAPHY

OGO-5

1. Thomas, G. E., Ultraviolet observations of atomic hydrogen and oxygen from the OGO satellites, Space Res., 10, 602, 1970.

2. Thomas, G. E., and R. F. Krassa, OGO-5 measurements of the Lyman alpha sky background, Astron. and Astrophys., 11, 218, 1971.

3. Thomas, G. E., and R. C. Bohlin, Lyman alpha measurements of neutral hydrogen in the outer geocorona and in interplanetary space, J. Geophys. Res., 77, 2752, 1972.

4. Thomas, G. E., Properties of nearby interstellar hydrogen deduced from Lyman alpha sky background measurements, Proc. Asilomar Solar Wind Conference, NASA SP-308, 668, 1972.

5. Thomas, G. E., and R. F. Krassa, OGO-5 measurements of the Lyman alpha sky background in 1970 and 1971, Astron. and Astrophys., 30, 223, 1974.

6. Keller, H. U., and G. E. Thomas, Determination of the solar Lyman alpha flux independent of calibration by UV observations of Comet Bennett, Astrophys. J., 186, L87, 1973.

7. Keller, H. U., and G. E. Thomas, A cometary hydrogen model: Comparison with OGO-5 measurements of Comet Bennett (1970 II), Astron. and Astrophys., 1975 (in press).

8. Keller, H. U., and G. E. Thomas, A high-velocity component of atomic hydrogen in Comet Bennett (1970 II), Proc. I.A.U. Symposium on Comets, 1975 (in press).

9. Thomas, G. E., The neutral interplanetary medium, Progress in Aeronautics and Astronautics, 1975 (in press).

10. Thomas, G. E., Interplanetary matter of non-solar origin, Rev. Geophys. Space Sci., 1975 (in press).

RADIATIVE TRANSFER STUDIES

11. Strickland, D. J., G. E. Thomas, and P. R. Sparks, Mariner 6 and 7 ultraviolet spectrometer experiment: Analysis of the O I 1304- and 1356-A emissions, J. Geophys. Res., 77, 4052, 1972.

12. Strickland, D. J., A. I. Stewart, C. A. Barth, C. W. Hord, and A. L. Lane, Mariner 9 ultraviolet spectrometer experiment: Mars atomic oxygen 1304-A emission, J. Geophys. Res., 78, 4547, 1973.

13. Sparks, P. R., and R. A. Goettge, Numerical integration techniques for the efficient calculation of airglow intensity, LASP Report, 1974.

14. Goettge, R. A., P. R. Sparks, and D. A. Luckey, A computation of the source function for spherical radiative transfer and complete frequency redistribution, LASP Report, 1974 (to be submitted for publication).

15. Sparks, P. R., Generalized renewal equations in reflexive spaces, Ph.D. thesis, University of Colorado, 1974.

16. Sparks, P. R., On the accurate calculation of the Chapman function, LASP Report, 1974 (to be submitted for publication).

OGO-6

17. Strickland, D. J., and G. E. Thomas, An analysis of 1304 A airglow data measured by the OGO-6 ultraviolet photometer experiment in 1969, Planet. Space Sci., 1975 (submitted for publication).

18. Thomas, G. E., and D. E. Anderson, Jr., Global atomic hydrogen density from Lyman alpha measurements from OGO-6, Planet. Space Sci., 1975 (submitted for publication).

19. Thomas, G. E., Lyman alpha arcs near the magnetic equator, J. Geophys. Res., 1975 (to be submitted for publication).

20. Thomas, G. E., Local time, latitudinal, and seasonal variations of atomic hydrogen in 1969 and 1970, J. Geophys. Res., 1975 (to be submitted for publication).