

VI. GEOPHYSICS

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A. PLASMA DIFFUSION IN A MAGNETIC FIELD

Complete results of experiments¹ on the diffusion of plasma of low-pressure arc discharges across a homogeneous magnetic field are now available.²

Further experiments are planned. Argon and Helium-Mercury discharges in homogeneous longitudinal fields to 25 kilogauss will be studied to obtain data on turbulent plasmas. Initial measurements will include determination of axial electric field and radial potential drop as a function of magnetic field. Spectral analysis and correlations of the RF noise and light fluctuations of the turbulent discharge will be performed by later experiments.

W. D. Halverson

References

1. W. D. Halverson, Plasma diffusion in a magnetic field, Quarterly Progress Report No. 75, Research Laboratory of Electronics, M. I. T., October 15, 1964, p. 31.
2. W. D. Halverson, Study of Plasma Columns in a Longitudinal Magnetic Field, Sc. D. Thesis, Department of Geology and Geophysics, M. I. T., January 1965.

B. OBSERVATIONS OF THE UPPER ATMOSPHERE BY OPTICAL RADAR IN ALASKA AND SWEDEN DURING THE SUMMER 1964 (Part II)

By invitation of the Geophysical Institute of the University of Alaska, and the Institute of Meteorology of the University of Stockholm, two optical radar devices were taken to Alaska and Sweden during the summer of 1964 to perform observations of the upper atmosphere at latitudes where noctilucent clouds might be visible. Some results were reported in Quarterly Progress Report No. 76 (pages 43-46).

Because optical radar observations require a dark sky background in order to maximize the signal-to-noise ratio, the unit in Sweden was mobile so that observations could be started at lower latitudes where there are longer periods of darkness. It was also of special interest to make observations during those nights when rocket experiments were being carried out at Kronogard, Sweden. These experiments, designed to measure temperature and wind velocity at the mesopause and to sample the particulate content of the noctilucent clouds, were carried out jointly by scientists of the Swedish Space Committee, the National Aeronautics and Space Administration, and the U.S. Air Force Cambridge Research Laboratories.

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Visibility conditions were less than satisfactory much of the time in Alaska, as well as in Sweden. Precipitation was not uncommon and cirrus clouds or lower clouds were often present. On July 15, 1964, in Sweden, a very strong noctilucent cloud display was visible overhead and to the South, but the apparatus was not operational. On some other occasions, noctilucent clouds were seen low on the horizon, that is, at a distance of several hundred kilometers. All of our measurements were obtained when noctilucent clouds were not visible overhead. At our locations, during that period of time, we visually observed noctilucent clouds on the following nights:

- 5-6 August, Torsta
- 6-7 August, Torsta (strong display)
- 7 August, College
- 7-8 August, Torsta (strong display)
- 9-10 August, Torsta
- 10-11 August, Torsta
- 15-16 August, Torsta
- 16-17 August, Torsta

It is possible that on occasions noctilucent clouds may have been present, but were not observable from our location because of local visibility conditions.

The intensity of the echoes for a thin layer of homogeneously distributed scatterers, expressed as n_R , the expected number of photoelectrons per transmitted pulse emitted at the photodetector cathode, can be computed with the aid of the following expression:

$$n_R = \frac{\eta\lambda}{hc} W_t A_r k_r k_t k_a^2 \frac{HN\sigma}{4\pi R^2},$$

where W_t is the transmitted energy per pulse, A_r is the collecting area of the receiving telescope, k_r and k_t are the efficiencies of the receiving and transmitting systems, k_a is the atmospheric transmission, H is the geometrical depth of the layer, $N\sigma$ is the average radar cross section of the scatterers per unit volume, R is the distance, λ is the wavelength, η is the quantum efficiency of the photocathode, h is Planck's constant, and c is the speed of light. The product $HN\sigma$ is defined as the optical thickness of the layer. Because of the difficulty in measuring some of the parameters in the equation, we have calibrated the sensitivity of the apparatus by assuming that the echoes from heights of 40-60 km were produced by a model molecular atmosphere. This calibration was used to estimate the optical thickness of the layers above 60 km. It should be pointed out that the assumption of a dust-free atmosphere in the 40-60 km interval may lead to an underestimate of the optical thickness of these higher layers. On the other hand, our photoelectron counting procedure may be subject to a reduced counting efficiency at lower

heights, which would result in an overestimate of the optical thickness of the upper layers. While these and other systematic instrumental uncertainties may modify the results to a certain extent, the system does provide us with the capability of obtaining a quantitative measure of the optical thickness of scattering layers in the upper atmosphere.

The important source of noise is the sky background which varies throughout the night and from night to night. In order to illustrate the nature of this variability, Fig. VI-1 has been constructed to show, for a typical night, the solar depression angle and the intensity of the sky background as a function of time. The intensity of the background is displayed as the average number of photoelectrons emitted in a 66- μ sec interval (equivalent to a resolution in distance of 10 km). The scatter in the points is due presumably to the occasional presence of thin cirrus clouds that increase the brightness of the background. Since the noise background increases very rapidly when the solar depression angle is less than 7°-8°, a very short interval of time is available for observations at high latitudes.

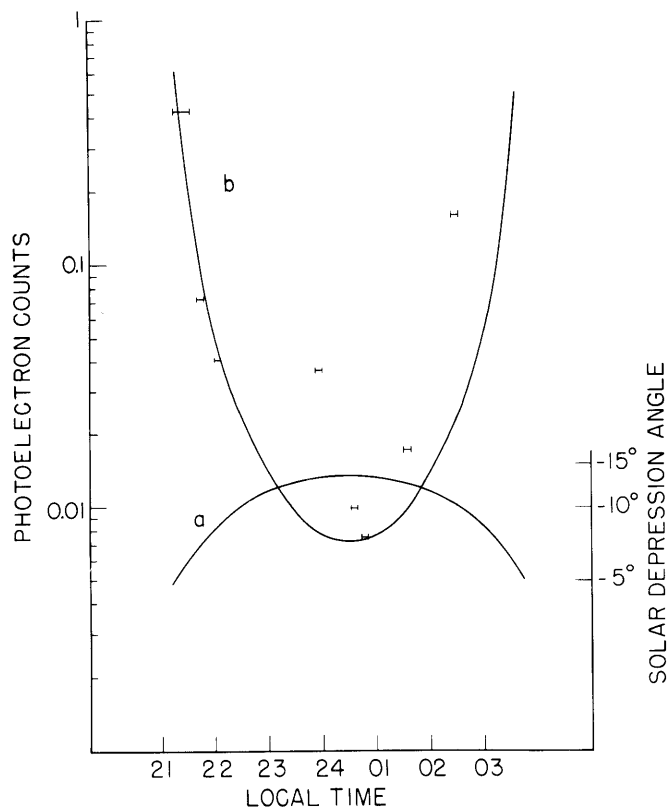


Fig. VI-1. Time variation of (a) solar depression angle, and (b) intensity of sky background for 16-17 August 1964 at Torsta, Sweden.

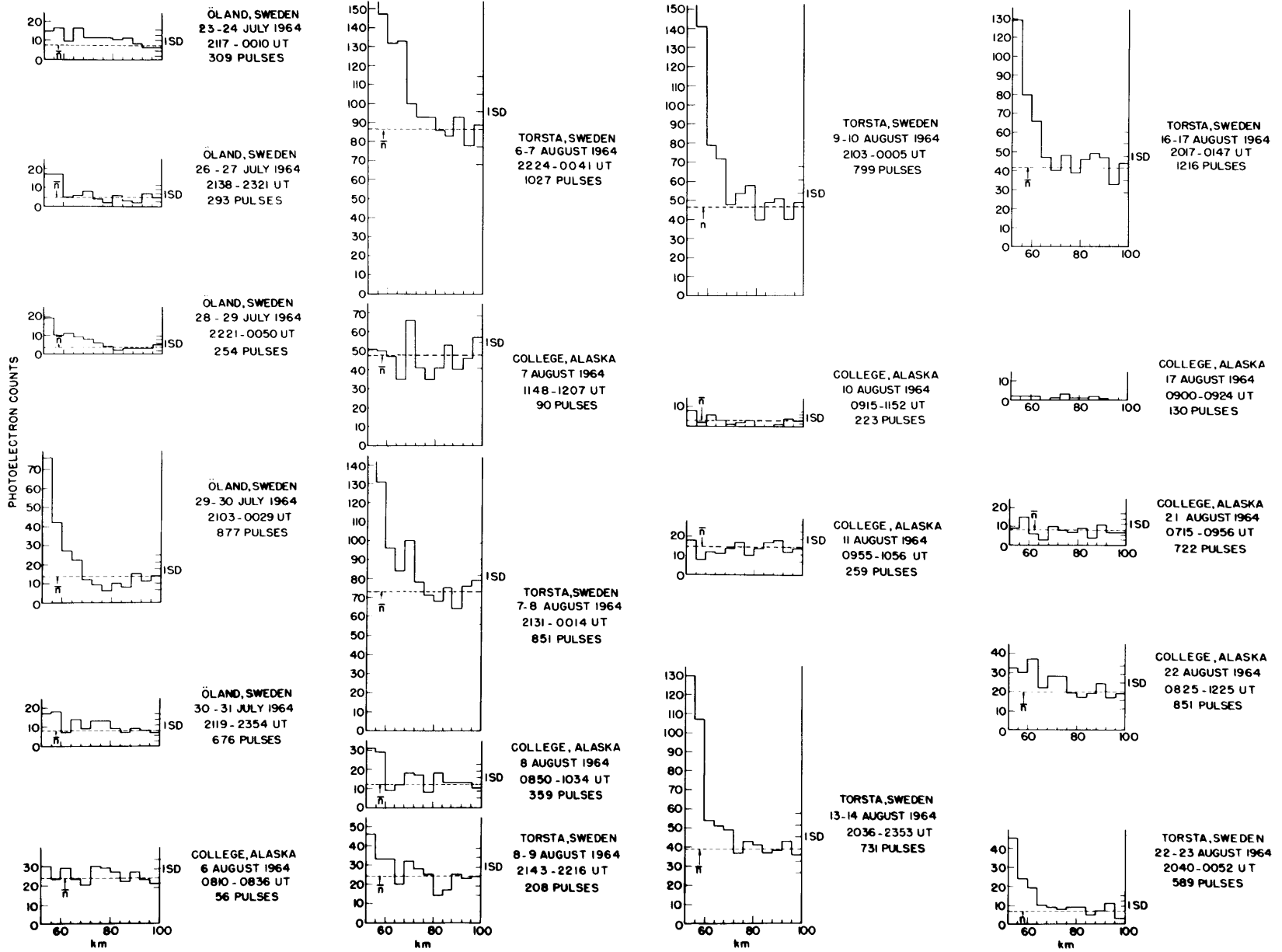


Fig. VI-2. Summary of observation for summer 1964.

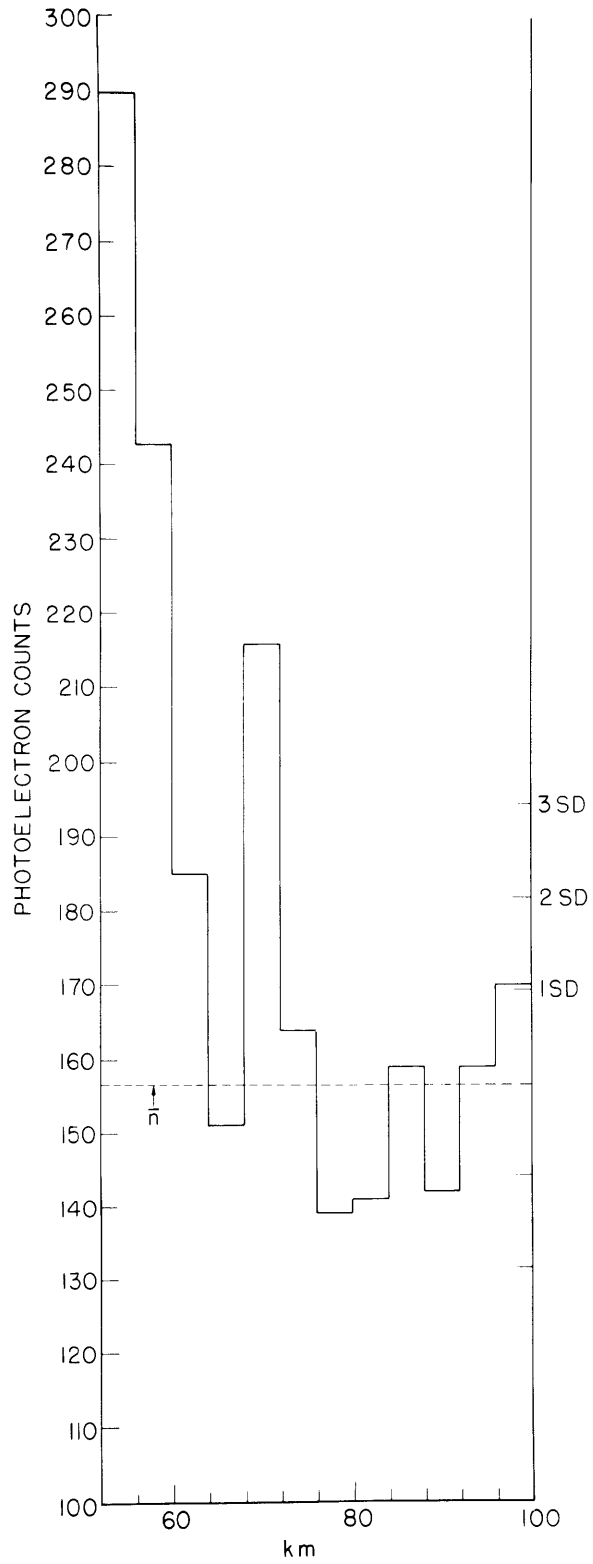


Fig. VI-3. Summary of observations obtained on 7, 7-8, 8, and 8-9 August 1964.

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Figure VI-2 is a summary of all observations performed. For each night, the total number of photoelectrons accumulated in intervals of 4-km width from 52 km to 100 km is indicated, as well as the total number of pulses radiated and the Universal Time when the observations were made. The average noise level, \bar{n} , is taken as the average of the measurements between 88 km and 100 km. A measure of the statistical fluctuations, $\sqrt{\bar{n}}$, is also indicated and is taken to be equivalent to the standard deviation of the measurement. Although we have a great number of traces with records from 100 km to 200 km, these will not be presented at this time. We point out, however, that these records do not show echoes of intensity comparable to those obtained in the summer of 1963 at those heights. The data presented in Fig. VI-2 indicate the presence of relatively strong echoes from an altitude of 68-72 km at both the Swedish and Alaskan locations on the nights of 7, 7-8, 8, 8-9 August, 1964. Note that we visually observed noctilucent clouds at both locations on the nights of 7 and 7-8 August. In order to gain statistical evidence that a scattering layer was present at that altitude, the observations for those four consecutive nights were averaged and the optical cross sections computed. The result is presented in Fig. VI-3. The optical thickness of this layer is estimated at $10^{-5} \pm 2 \times 10^{-6}$. Some measurements were also obtained on the night of 16-17 August in Torsta during a noctilucent cloud display. The partial count obtained from 0057 to 0147 U. T. has already been reported.¹ The data obtained during this time interval suggest the presence of scattering layers at altitudes of 60-64 km and 80-88 km. No comparable echoes were received during the earlier part of the night. This thickness of these layers is estimated to be 2×10^{-5} with a standard deviation of 1×10^{-5} for the 60-64 km layer, and 4×10^{-5} with a standard deviation of 2×10^{-5} for the 80-88 km layer.

Although these measurements are admittedly of a preliminary type, they indicate a value of the optical thickness for the noctilucent clouds substantially larger than that reported by Ludlam² and closer to the value suggested by Deirmendijan.³

G. Fiocco, G. W. Grams, K. Urbanek, R. J. Breeding

References

1. G. Fiocco, G. Grams, K. Urbanek, and R. J. Breeding, Quarterly Progress Report No. 77, Research Laboratory of Electronics, M.I.T., January 15, 1965, p. 45 (Fig. VI-3).
2. F. H. Ludlam, Noctilucent clouds, *Tellus* 9, 341-364 (1957).
3. D. Deirmendijan, Detection of Mesospheric Clouds from a Satellite, Proc. First International Symposium on Rocket and Satellite Meteorology, edited by H. Wexler and J. E. Caskey, Jr. (North-Holland Publishing Co., Amsterdam), pp. 406-411.