GEOPHYSICAL INSTITUTE

of the

UNIVERSITY OF ALASKA

SPECTROPHOTOMETRY OF PLANETARY ATMOSPHERE FROM THE X-15 ROCKET AIRPLANE

Final Report

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I. HIGHLIGHTS

This grant originally covered a program for instruments to be flown on the X-15 rocket airplane. X-15's high-altitude flights were discontinued before work got well underway, and after consultation between the principal investigators and Dr. Maurice Dubin, NASA Headquarters, the objectives were changed to rocket studies of the aurora. First rockets launched under this grant were three Nike-Apaches fired from Ft. Churchill in November 1965. These were followed by three Nike-Tomahawks in December 1967 and February 1968 and two Nike-Tomahawks in February 1970, all from Ft. Churchill, Manitoba. Final rockets in the program were two Nike-Tomahawks launched from the University of Alaska's Poker Flat Rocket Facility, Chatanika, Alaska. In all, a total of seven Nike-Tomahawks and three Nike-Apaches were launched. A nose cone failure on the last Nike-Tomahawk launched wiped out all instrumentation and no data resulted from this flight. The other six Tomahawks gave essentially solid data with only minor gaps due to telemetry problems. On the Nike-Apache flights a considerable amount of data was lost as a result of malfunction of an ejectable door designed to protect the instruments during passage through dense atmosphere, but a considerable amount of data was also obtained. Objectives were to obtain data from typical auroral situations - quiet pre-breakup aurora, westward traveling surges, breakup aurora and quiet post-breakup aurora. All of these situations were covered, although only one rocket was fired into the actual breakup region and the breakup was atypical.

II. PUBLICATIONS

Murcray, W. B., An observation of the height-luminosity distribution of auroral Hβ emissions, Planet. Space Sci., 14, 812, 1966.

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Murcray, W. B., Spatial relationships of auroral OI and N_2^+ emissions, J. Geophys. Res., 72, 1053, 1967.

Murcray, W. B., Intensity ration of the 6300 and 5577 OI emissions in quiet aurora, Planet. Space Sci., 17, 1429, 1969.

Murcray, W. B., The ratio $\rho(5577)/\rho(N_2^+$ first neg) in the aurora, J. Geophys. Res., 74, 366, 1969.

III. RECOMMENDATIONS

Much of the analysis of these observations contained the implicit assumption that the atmosphere was stationary at higher altitudes, and that one could calculate an equilibrium between, for instance, ionization and recombination without taking into account the possibility that the ions produced in a given volume of space would be carried out of the region and recombine somewhere else. It was recognized that this might not be true, but until fairly recently there was no firm evidence that very high velocity winds do exist above 200 km. Records of the 6300 Angstrom OI emission obtained from the Tomahawk flights showed quite clearly that the excited atoms were moving considerable distances between excitation and emission - the mean life of the 'D state is around 100 seconds, and a sizable fraction of the excited atoms have still not radiated at 200 seconds. If these are moving at 500 meters/sec they may emit 100 km from where they were excited. The rocket photometer data showed that this was happening and that the motion was not constant in either direction or speed at different altitudes. At present, data from barium releases, vapor trails, incoherent scatter radar and satellite mass spectrometers all combine to show that both neutral and ionized components of the atmosphere in the auroral regions are often moving with quite high velocity. As a result, all rate coefficient and equilibrium concentration calculations involving processes with time constants of several seconds and more are now on very shaky ground. Even the long accepted argument that recombination time in the F-region must be very long because ion density remains high long after photo-ionization has ceased, no longer carries much weight since the ions may be brought in from somewhere else. It is becoming increasingly evident that the morphology of the magnetosphere and ionosphere are closely related, and that understanding of one also requires knowledge of the other.

The dynamics of the ionosphere and coupling between ionosphere and magnetosphere are thus emerging as an area of major interest at the present time and data on both neutral and ionized atmospheric motions at the higher altitudes is needed. The incoherent scatter radar provides data in regard to ion motions, but there is only one high latitude installation and its altitude capability is severely limited. This installation also provides information in regard to neutral winds, but again only at comparatively low altitudes. Satellite observations extend to high altitudes, but each pass covers only a narrow altitude range. Barium releases of the thermite type can provide data on ion motions anywhere in the magnetosphere provided that a big enough rocket is used, and also produce neutral wind data at low altitudes, as do various vapor trail experiments. Vapor trails, however, are limited in altitude capability by the rapid dissipation of neutral gas. Barium lined shaped-charges, however, can be used to procure data on ion motions anywhere in the magnetosphere using only moderate-sized rockets. Present experiments concentrate on probing the magnetosphere out to 6-7 earth radii, or even further, which requires that the rocket reach 500 km or above. From observations made on releases below this altitude in the University of Alaska-Los Alamos Scientific Laboratories program, and the results of the Max Planck Institute firings, we conclude that a Nike-Tomahawk could carry a shaped-charge high enough to produce an observable streak to 1000-2000 km altitude. The streak would be continuous from the release point upward at first and later from about 200 km upward. If the charge presently carried by the Tomahawk is used, the portion of the streak between 2 and 5 hundred km is bright enough to be tracked against any sky background dark enough to obtain star images. (The streak can be seen almost to ground sunrise, but star images are needed for tracking.) It is therefore recommended that a program for such releases be considered, in addition to the deeper probing of the magnetosphere which needs larger rockets. It should also be noted that such streaks should be observable from spacecraft when the streak is on the dayside where ground observation is impossible. This should also be considered.

Neutral wind observations should be extended to higher altitudes. Rocket photometer observations in 4278, 6300 and 5577 offer a means of doing this. Records obtained while the photometers are looking essentially along an auroral arc show the excited 'D and 'S OI "blowing away" from the excitation region. The photometer line of sight extends to infinity, so that it passes through the entire atmosphere above the rocket. So far, this portion of the records has been examined only qualitatively because of the work necessary to calculate the path length, but it could and should be analyzed for neutral wind data. Additional rocket shots would also be desirable.