

Ion Composition Measurement with a Rocket-Borne Mass Spectrometer at Syowa Station

Nobuyoshi FUGONO*, Takeshi SUITSU* and Iwao IWAMOTO*

ロケットによる正イオン組成の観測

畚野信義*・水津 武*・巖本 巖*

要旨: 高度 80~108 km における正イオン組成の観測により, NO^+ と O_2^+ のほか, 数種の金属イオンが E 層領域で, また D 層領域では hydrated イオンが観測された.

Abstract: A positive ion mass spectrometer was flown on the S-210JA-12 rocket at Syowa Station in the Antarctic Region ($69^\circ 00'S$, $39^\circ 35'E$), at 13:00 LT, on Feb. 11, 1972. Measurements were obtained from about 108 km, its apogee, to about 80 km on descent. A few metal ions in E -region and hydrated ions in D -region of the ionosphere were observed in addition to the main NO^+ and O_2^+ profiles.

1. Introduction

Several ion composition measurements with rocket-borne mass spectrometer in the polar ionosphere have been reported (*e. g.* JOHNSON *et al.*, 1958; ZIPF *et al.*, 1970; SWIDER *et al.*, 1973). Those results, however, have been somewhat vague about making a positive identification of the effects of the aurora because of difficulties of knowing the exact relative position of the rocket with respect to the aurora, problems in the instruments such as relatively slow scanning time to cover a wide mass range, and other problems including insufficient knowledge of the aurora.

This experiment was not designed to be made in an aurora but rather during a quiescent daytime period as a preliminary experiment.

2. Experiment

A circular concave type quadrupole mass spectrometer was used with a vacuum pump system which is composed of a titanium getter pump and a metallic molecular sieve pump in the hope of expanding measurable altitude in the D -region of the ionosphere. A schematic drawing of the part of the mass spectrometer sensor and the vacuum pumps are shown in Fig. 1. Results of laboratory experiment

* 郵政省電波研究所. Radio Research Laboratories, Nukuikita-machi, Koganei-shi, Tokyo.

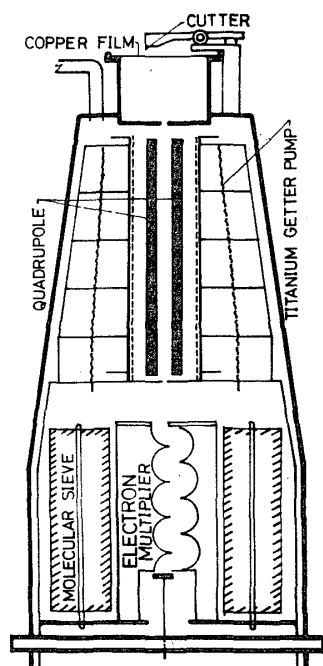


Fig. 1. Schematic drawing of the vacuum vessel containing the mass spectrometer sensor, pump system and vacuum gauge.

show that the pumping system keeps the pressure in the 10^{-5} torr range in the container of the mass spectrometer for a pressure outside the container of as much as 10^{-2} torr for longer than three minutes.

The orifice of the container was opened at about 70 km and ions were sampled through a 1 mm diameter aperture. The mass range of the mass spectrometer was from 1 to 50 a.m.u.. Only the data on descent were reducible from the raw data obtained in this flight.

3. Results and Discussion

The reduced profiles of NO^+ and O_2^+ from the measurements which are dominant ions in the altitude range are shown in Fig. 2. Fig. 3 shows the results of an electron density measurement on the descent of the same rocket. The density profiles of the ions and that of electrons are very much alike and suggest that the two species of ions are the only dominant ions in this altitude range. That is also clear in the raw data. The profiles, however, have intentionally been left unnormalized because large variations in these profiles are probably caused not by actual density variations but by irregular motion of this particular rocket that is suspected from other circumstantial evidence. A correction has been attempted but its reliability is questionable because no attitude sensor had been installed in the rocket.

Some other constituents in the upper atmosphere, such as NO, can be estimated from these results by using some additional information for minor ions or even by neglecting them. These calculations, however, are not given here because of the ambiguity of the attitude problem.

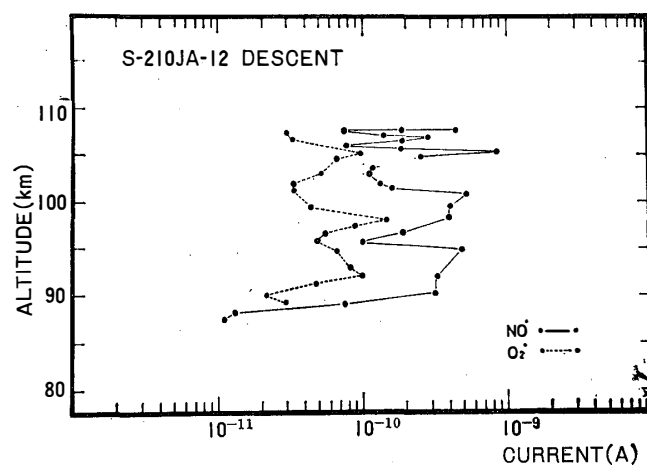


Fig. 2. Measured altitude profiles of nitric oxide ion (NO^+) and oxygen molecular ion (O_2^+) by S-210JA-12 on descent.

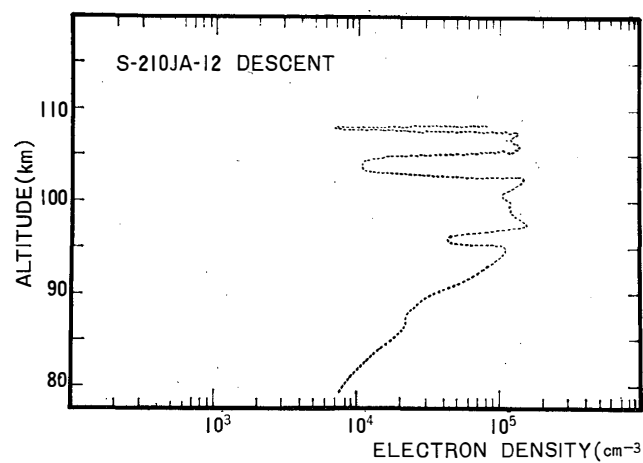


Fig. 3. Electron density profile measured on the same rocket by S. MIYAZAKI.

S-210JA-12 DESCENT

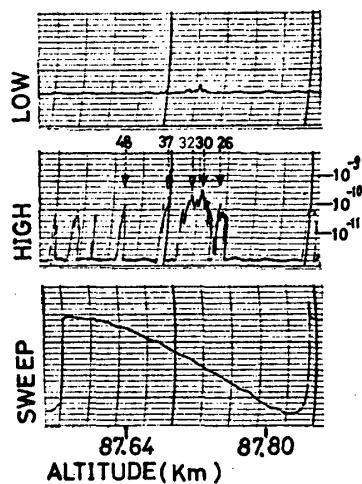


Fig. 4. A raw mass spectrum on which water-cluster ions appear at 37 and 48 a.m.u..

Some metal ions such as Mg^+ and Al^+ and water-clustered ions such as $\text{H}_3\text{O}^+\cdot\text{H}_2\text{O}$ and $\text{NO}^+\cdot\text{H}_2\text{O}$, appear on the mass spectra in very specific altitude ranges. A section of the raw spectra of lower altitude which shows water-cluster ion signatures is shown in Fig. 4 as an example. It is expected that more information about these cluster ions will be obtained by improving the pump system.

Acknowledgments

The authors are grateful to Mr. S. MIYAZAKI and the staff of the 13th Japanese Antarctic Research Expedition for their efforts in making a successful launch. They also thank the National Institute of Polar Research for being given the opportunity to conduct the experiment. This research was supported by the National Institute of Polar Research.

References

- JOHNSON, C. Y. and J. C. HOLMES (1958): Ion composition of the arctic ionosphere. *J. Geophys. Res.*, **63**, 443-444.
- SWIDER, W., C. SHARMAN and R. S. NARCISI (1973): Auroral ion composition—measurements and model. *EOS Trans., AGU*, **54**, 388.
- ZIPF, E. C., W. I. BORST and T. M. DONAHUE (1970): A mass spectrometer observation of NO in an auroral arc. *J. Geophys. Res.*, **75**, 6371-6376.