A mechanism of ion heating/acceleration and molecular ion upflow

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Suprathermal ion mass spectrometer (SMS) on Akebono satellite has observed ion heating and ion upflow at polar ionosphere over a decade. A great number of data sets obtained by SMS show that H+, He+ and O+ ions always upflow from polar ionosphere with the velocity of several km/sec and polar ionosphere has an important role in magnetospheric plasma source.

It is known that ion heating/acceleration occurs above about 1000 km altitudes which is the region between radar and satellite observations. However, the mechanism of ion heating/acceleration is not understood in detail because of restricted observation around 1000 km altitudes.

We are interested in molecular ion as a tracer of ion upflow occurring at 1000 km altitudes. Sometimes SMS observes molecular ion upflowing above 5000 km altitudes. We do not understand the mechanism of molecular ion outflow but it is certain that the source of molecular ion exists at several hundred km altitudes. If the ion upflow phenomena is continuously observed from ground, we can directly discuss the plasma transport process between ionosphere and magnetosphere.

The purpose of this study is to obtain basic data and parameters needed for ground observation. Then we have compared between ionosphere model with several ion species and molecular ion upflow observations by SMS. The results are following:

[Results of multi-species ionosphere simulation]
N2+ density profile in the polar ionosphere has not been measured in detail. We calculated ionospheric density profile containing molecular ions. The calculation consists of one dimensional equation of continuity, motion, and energy for each species. Comparison with the observed flux ratio of N2+, NO+, and O2+, shows that the source altitude of molecular ion upflow is between 500 km and 1000 km altitudes.

[Results of SMS data analysis]
- Magnetic local time/latitude distribution of molecular ion upflow occurrence
Yau et al.[1993] suggested that molecular ion upflow occurred in the cusp region and near midnight auroral region using SMS data during the period from 1989 to 1990. SMS data from 1991 to 1999 used in this study shows molecular ions as well as light ions sometimes upflow in all magnetic local time.

- Altitude of molecular ion heating
Source altitudes can be estimated by pitch angles of observed ions (H+, He+, O+, N2+). Source altitudes estimated from SMS data were usually higher than 1000 km where ion heating/acceleration occurred perpendicularly to the magnetic field.

The above results indicates that N2+ transports from higher altitude than that considered until now. On the other hand, there is difference between source altitude estimated from density ratio and heating altitude estimated from pitch angles. This difference may be explained by effects of finite heating time or N2+ generation by charge exchange reaction between upflowing He+ and local N2. We will improve the ionospheric simulation and analyze other events, in order to discuss the mechanism of ion heating/acceleration and molecular ion upflow.

[Reference]
-Yau, A. W et al., EXOS-D (Akebono) observations of molecular NO+ and N2+ upflowing ions in the high-altitude auroral ionosphere, J. Geophys. Res., 98, 11,205-11,224, 1993.