Development of an instrument to measure ion drift velocity and density in the ionosphere

*Takumi Abe[1], Shigeto Watanabe[2], Akinori Saito[3], Ryuto Hashiba[4]

1. Japan Aerospace Exploration Agency, Institute of Space and Astronautical Science Department of Solar System Sciences, 2. Hokkaido Information University, 3. Kyoto University, Graduate School of Science, 4. Hokkaido Universiity

The lower ionosphere is known as a unique region where charged particles and neutral particles co-exist. The charged particles tend to move in a direction different from neutral particles, because of a difference in those behaviors against the electromagnetic force. Characteristic phenomena such as dynamo current and polarization electric field existing in this region are attributed to such peculiarity in this region. The momentum transfer between the charged and neutral particles plays an important role in generating these phenomena. It is desirable to make a direct measurement of charged and neutral particles by using instrument on the sounding rocket to further understand such unresolved phenomena.

In 2018, we started developing an ion drift velocity analyzer which enables us to estimate the ion drift velocity and density in the lower ionosphere. It is well known that Ion Drift Meter (IDM) and Retarding Potential Analyzer (RPA) had been installed on low-altitude satellite, such as Dynamic Explorer-2 and Atmospheric Explorer series. Our instrument will be required to have the functions that these two have.

As the first step of the instrument development, a numerical simulation was carried out to design the internal structure, and thereby we determined a basic structure of the instrument which consists of RPA section in the front and multiple sector anodes of IDM section in the end. In the first half of 2019, the prototype model was developed after we obtained the design outlook that the instrument provides the ion density and velocity in a good accuracy. The IDM section has a total of 72 small sector electrodes so that an estimation of the drift velocity vector can be made with enough accuracy. The electrodes are arranged in the hemispheric inner surface which receives the incident ions passing through the RPA section.

Then, we put the prototype instrument in the vacuum chamber to evaluate its performance on the ionospheric plasma condition. The main results from our evaluation are summarized as follows:
1) Individual electrode in the IDM section can measure significant level of current due to thermal ions which pass through the RPA section.
2) The electrode can independently detect incident current even though the space between adjacent electrodes is small.
3) The ion current distribution represented by the 72 electrodes seems reasonable as expected from a velocity of the incident ions.
4) The current collected by the electrodes has a decreasing trend as expected as an RPA function, and it significantly changes depending on the DC bias applied to the RPA voltage.

In the next step, we are going to develop a low-energy ion source which can generate drifting ions whose energy is several eV. Through the experiment using the ion source, a function to estimate the bulk energy of the ions will be evaluated. The latest status of our instrument development will be explained in the presentation.

Keywords: Ionosphere, Ion drift, Instrument development

