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Electron density disturbances and plasma waves observed with S-310-40 and S-520-26 rockets

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From the end of 2011 to the beginning of 2012, two rocket campaigns were carried out at Uchinoura Space Center in Japan.

The first is the S-310-40 rocket experiment, whose rocket was launched at 23:48 on December 19, 2011. The purpose of the experiment was to understand the cause of the anomalous propagation of radio waves observed at Uchinoura sometimes in winter. We installed an impedance probe as one of instruments used in this experiment to measure the electron number density along the rocket's trajectory. The impedance probe detected UHR frequencies of the ionospheric plasma from 93 km to the apex 180km with a 125-msec time resolution. In addition, we successfully measured the phase of the impedance probe for the first time. Although we expected the existence of a high electron density layer in D-region or E-region of the ionosphere, the maximum electron density is about 5500/cc at most at altitudes between 100km to 105km. We also find that the electron density measurement was significantly affected by the rocket wake in the descending phase.

The second rocket experiment is 'WIND-II' (Wind measurement for Ionized and Neutral atmospheric Dynamics study -II) for the investigation of the momentum transfer between thermospheric neutral gas and ionospheric plasma. S-520-26 rocket was launched at 5:51 on January 12, 2012, just before the sunrise. In this experiment, lithium gas was released from the sounding rocket in the descending phase, and the resonantly scattered light was observed from three ground sites to measure some physical properties like the neutral wind velocity. We measured the electron number density and plasma waves along the rocket trajectory by an impedance probe and a plasma wave receiver in an altitude range of 90-298 km with a 250-msec time resolution to derive a vertical profile of background electron density in the ionosphere and to investigate the effects of the released lithium gas on the ionospheric plasma. The data from the impedance probe during both ascending and descending phase shows several electron density enhancements around altitudes of 90, 160 and 260 km, while the peak altitudes in the ascending phase were a few kilometers different from the descending phase. We also observed upper hybrid waves by the plasma wave receiver approximately above the altitudes of 240 km. Lithium gas had been supposed to release three times. However, the effects such as increases of electron density or decreases of the power of plasma waves were observed only about 10 sec and 30 sec after the expected time of the third release. On the event 10 sec after the third release, we couldn't detect the UHR frequencies probably due to the limit of the frequency range of the impedance probe. We also find effects of the rocket wake both on the electron density and the plasma wave measurements in the ascending phase as well as in the descending phase.

Moreover, it is striking that the impedance probe resonated at not only the UHR frequency but at other characteristic frequencies. For instance, in many cases of the measurements at an altitude of low electron number density, the impedance of the probe showed a local minimum value at the plasma frequency of the ambient plasma. Meanwhile, the local minimum values of the impedance appeared at twice the electron cyclotron frequency during the measurement in the relatively high electron density regions.

In this presentation, we show typical spectra obtained from the impedance probes as well as the results of the measurements by using the plasma wave receiver. We also discuss the electron density disturbances, the effects of the rocket wake or the lithium releases observed during the two rocket experiments.

Keywords: mid-latitude ionosphere, impedance probe, rocket experiment, electron density, plasma wave, chemical release