Observation of Plasma Waves Around the Wake of an Ionospheric Sounding Rocket

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Abstract

When a body moves in plasma at supersonic velocity, a rarefied plasma region called 'plasma wake' is formed behind the body. Wake is formed behind a body which is immersed in a plasma flow such as artificial satellites and ionospheric sounding rockets as well as a solar system body immersed in solar-wind plasma. Although there are several studies which report plasma waves around the wakes of a satellite [1] and of the moon [2], little attention has been given to plasma waves in association with the rocket wake. However, observational results from two rocket experiments performed in 1998 [3] and 2012 have suggested the generation of plasma waves around the wake of a rocket. It is very important to reveal the generation process of plasma waves near the rocket wake for understanding the universal physics related to the interaction between streaming plasma and a non-magnetized body as well as for interpreting wave data obtained in rocket experiments more accurately.

In the S-520-26 rocket experiment in 2012, with the impedance probe and the wave receiver, we measured the electron number density and plasma waves at 260-msec interval, which corresponds to one-fourth or one-fifth of the spin period of the rocket. During the flight, three kinds of plasma waves were observed. Based on the presumption that the observed waves are caused just near the wake of the rocket, they must be short-wavelength electrostatic waves such as electron cyclotron harmonic (ESCH) waves, upper hybrid resonance (UHR) mode waves, and whistler mode waves. In order to discuss generation mechanisms of the waves, we calculate linear growth rates of electrostatic waves with assumptions of an anisotropic electron distribution function which has a beam component or temperature anisotropy. Consequently, we obtain positive growth rates in frequency ranges similar with some of the observed waves. We also reveal the spatial distribution of the wave activities around the rocket and its relationship with the wake structure by analyzing the spin-phase dependence of the waves and the electron number density we observed. The spin-phase dependence suggests that there are localized hot plasmas around the wake structure, which can stimulate different types of plasma instability.

In this presentation, we clarify the frequency range and spatial distribution of the plasma waves around the wake based on the analyses of S-520-26 rocket experiment data. We also discuss the velocity distribution of electrons which can drive instabilities generating the plasma waves as observed.

References

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