Study on Plasma Waves and Electron Density Profile around the Moon Observed by KAGUYA in the Solar Wind

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Introduction

The moon has basically no intrinsic magnetic field and atmosphere, and plasma cavity called "Lunar Wake"' is created just behind the moon in the solar wind. Electrons which collided with moon surface are supposed to be carried toward downstream region of solar wind forming unique electron density distribution around the moon. In the present paper, we study electron density profile around the moon at nominal altitude of KAGUYA (~100km) in the solar wind controlled by the parameters such as IMF direction and solar wind velocity.

Observation

The waveform capture (WFC) onboard KAGUYA is one of subsystems of the Lunar Radar Sounder (LRS) to measure AC electric field below 1MHz. It consists of a fast sweep frequency analyzer covering from 1 kHz to 1 MHz and a waveform receiver covering from 100 Hz to 100 kHz. When KAGUYA was in the solar wind, intense electrostatic wave at local plasma frequency (f_p) was observed in the day-side of the moon. This wave was almost continuously observed in the frequency range of 10-20 kHz in the sunlit region, while the frequency suddenly decreased in the edge of the shade (occultation) region. Comparing these waves with ambient magnetic field data provided by the MAP/LMAG onboard KAGUYA, we found that the wave intensity became larger when the interplanetary magnetic field (IMF) was connected with lunar surface, but they sometimes superseded electrostatic solitary waves.

We derived electron density along the trajectory of KAGUYA when the spacecraft was at the nominal altitude (~100km). It was found that electron density in the dayside was ~1.5 times larger than the one measured by the WIND spacecraft on average when the solar wind velocity was relatively low (<400km/s), but the density enhancement was recognized only in the higher latitude region when the solar wind velocity was relatively high (>400km/s). We statistically analyzed electron density profile comparing the magnetic field data provided by the MAP/LMAG onboard KAGUYA, and found its asymmetric structure depending on the direction of the IMF, that is, electron density was enhanced when IMF was Bx>0 and Bz<0, or Bx<0 and Bz>0 in the northern hemisphere, while density enhancement in the southern hemisphere occurred under the opposite condition; Bx<0 and Bz<0, or Bx >0 and Bz>0. On the other hand, electron density drastically decreased down to a few percent of the ones in the solar wind when the spacecraft went ~100km into the lunar wake.

Conclusion

In the present paper, we studied a general electron density profile around the moon in the solar wind by comparing the data from WIND. Electron density at an altitude of ~100km was slightly larger than the one in the solar wind but was closely correlated with the IMF directions as well as solar wind velocity. As a future work, it is necessary to understand the dynamics of solar wind-moon interaction and propose a more parameterized electron density model around the moon.

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