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Generation of Electron Cyclotron Harmonic waves around the Moon

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We study plasma wave generations around the moon based on the plasma wave data observed by the KAGUYA spacecraft which is the Japanese mission to the moon. The WaveForm Capture receiver revealed that various plasma waves are excited due to moon-space plasma interactions. In the present paper, we focus on the Electron Cyclotron Harmonics (ECH) among the plasma wave phenomena taking place around the moon. The ECH waves have been widely studied in the relation to the electron precipitation in the terrestrial magnetosphere due to the loss cone in-stability. However, that does not directly link to the observation of the ECH around the moon orbit. KAGUYA observes the ECH around its orbit very frequently. That is unlikely to occur without the moon at the distance of 60RE from the Earth.. ECH waves are observed around the moon with KAGUYA plasma wave data.

First, we analyze the observation points to know why ECH waves are observed under the environment around the moon. By examining observation points in the SSE coordinates, it is revealed that ECH waves are observed only when the moon stays inside the magnetosphere. Furthermore, we found ECH waves are mostly observed on the night side, where surface of the moon is not lit by the sunlight. We also found the existence of the good correlation between the observation of ECH and magnetic anomalies.

Next, we examine plasma particle data. Lunar Prospector found that once ambient magnetic fields connect to the magnetic anomaly, the resultant mirror force causes the reflection of electrons with their velocity distributions above the loss cone angle. In addition to the loss cone distribution, Lunar Prospector also found the existence of low energy electron beams that are accelerated by the negative potential of the moon surface on the night side. We found the good correlation of the ECH waves to the loss cone electron distribution with low energy electron beams. We assumed low energy beam is necessary to excite ECH waves as well loss cone distribution. However, loss cone distribution and low energy beam are observed not only in the magnetosphere but also in the wake region which is found when the moon is in the solar wind. However, we never observe of ECH waves in the lunar wake region. We assumed ECH waves are generated only under the parametric condition in the magnetosphere.

Next, in order to study the generation of the ECH waves, we calculated the linear growth rate by solving the kinetic plasma dispersion relation using the realistic plasma parameters of electromagnetic environment of lobe, plasma sheet and wake based on the KAGUYA observation. The result shows fundamental harmonic and second harmonic are unstable under the coexistence of the electron of the electron loss cone and the low energy electron beam.

In the present paper, we examine the parametric dependence of the destabilization of the ECH waves by the liner dispersion analysis and we establish the comprehensive generation model of the ECH waves around the moon.