Excitation of selenogenic ion cyclotron waves: Implications from ARTEMIS observations and dispersion analysis

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A unique type of electromagnetic waves can occur when the Moon is inside the Earth's magnetotail. First detected by the Apollo Lunar Surface Magnetometers, these waves are narrowband ion cyclotron waves (ICW's), and their occurrence is due to the presence of the Moon. The exact generation mechanism of these narrowband ICW's at the Moon is still an open question. Here we investigate the excitation of ICW's at the Moon through ARTEMIS observations near the Moon and wave dispersion analysis. Two types of narrowband ICW's have been observed by ARTEMIS. The first type is found when ARTEMIS was close to and magnetically connected to the Moon. The ESA instrument aboard ARTEMIS detected keV ions that are typical of the Earth's plasma sheet. The velocity distribution of ions shows a half-sphere geometry, except for ions with higher energies that can come over from the other side of the Moon through gyration motion. The second type is detected when ARTEMIS was several lunar radii from the Moon and was not magnetically connected. The ESA instrument detected ions at energies of around 100 eV, and the ion velocity distribution was mostly symmetric with a net flow velocity. With the dispersion analysis by WHAMP, we find that the observed particle distributions for both types of wave events are ion cyclotron unstable. These wave and particle observations support the hypothesis that each of two different processes near the Moon could lead to ion cyclotron waves. First, the ICW events at locations near and magnetically connected to the Moon strongly hint a wave generation through the absorption of ions by the Moon. This process is similar to the loss-cone-induced ion cyclotron instability in the inner magnetosphere, and it implies that the presence of the Moon can modify the local plasma condition in the Earth's magnetotail. Second, the ICW's located at several lunar radii from the Moon are likely caused by PUI's that originate from the lunar exosphere. Because PUI's are one of the major loss mechanisms of the lunar exosphere, the observations of ICW's at the Moon can help understand the loss of volatiles from the Moon.

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