

# Narrowband Ion Cyclotron Waves at and near the Moon in the Earth's Magnetotail and the Association with the Plasma Environment

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**Abstract.** Ion cyclotron waves occur in the vicinities of many planetary objects, and they can often provide information about the plasma environment nearby. We observed narrowband ion cyclotron waves at and near the Moon in the Earth's magnetotail. These waves exhibit left-handed polarization, and most of their wave frequencies are close to the local proton gyrofrequency. We found in the partially restored Apollo Lunar Surface Magnetometer (LSM) data that  $H^+$  waves occurred frequently when the Moon was located in the Earth's magnetotail. These waves appear in multiple wave packets in the LSM data recorded on the lunar surface, and each series of wave packets can last for more than an hour. The Apollo 15 and 16 LSMs observed these waves simultaneously even though the two stations experienced very different local magnetic field conditions. The ARTEMIS spacecraft that are currently in the Earth-Moon libration orbit have also observed several cases of narrowband ion cyclotron waves in the magnetotail. Most of these waves are  $H^+$  waves, and they were found when the spacecraft passed by the dayside of the Moon and when plasma with characteristics of plasma sheet particles was present. The observed Poynting vectors suggest a source location above the dayside surface. The observation of the ion distribution during a wave event exhibited a clear loss cone in the direction away from the Moon, which is consistent with the loss cone driven mechanism and indicates that particles were absorbed at the Moon. In one wave event ARTEMIS observed  $He^+$  waves several lunar radii away from the nightside of the Moon, and we will discuss the possible sources of  $He^+$  associated with these waves.