Resonant scattering of radiation belt electrons at Saturn by ion cyclotron waves

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Excited by the ring distribution of water-group ions (e.g., O^+, OH^+, H_2O^+) picked up from the E-ring, ion cyclotron waves are primarily left-handed polarized with frequencies close to the gyro-frequency of water group ions. Ion cyclotron waves are frequently observed between the orbits of Enceladus and Dione that embedded in the Saturnian magnetosphere. Ion cyclotron waves are widely used in estimating the ion producing rate near the E-ring. In this study, the resonant interactions between ion cyclotron waves and radiation belt electrons at Saturn are investigated for the first time. By assuming that the water-group ions consist of pickup ions and ambient thermal ions, we solve the kinetic dispersion relation of ion cyclotron waves. Subsequently, we perform detailed calculations of electron bounce-averaged diffusion coefficients using the statistical averaged spectra of ion cyclotron waves obtained from Cassini observations. We find that ion cyclotron waves can efficiently pitch angle scatter electrons with energy from > 1 MeV to tens of MeV on timescales of < 1 min to a few days, while the mixed and momentum diffusion coefficients can be negligible. The most efficient scattering near the loss cone is found at 2-10 MeV. As L-shell increases, the pitch angle diffusion coefficients increase significantly due to the weaker ambient magnetic field intensity and stronger wave intensity at higher L-shells. In addition, electron pitch angle scattering efficiency is found to be strongly dependent on the abundance and temperature of pickup ions. Our results demonstrate that ion cyclotron waves play a significant role in the loss of relativistic electrons in Saturn's radiation belts.