

## Direct detection of nonlinear generation process of electromagnetic ion cyclotron emissions observed by the Arase spacecraft

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Electromagnetic ion cyclotron (EMIC) emissions with various frequency changes are observed by the Arase spacecraft. The EMIC rising tone wave has been previously studied by employing the wave-particle interaction analysis (WPIA) method to the spacecraft data. By the method, we obtain the phase angle between the particle and wave field to analyze the nonlinear resonant currents controlling the energy transfer and the wave frequency drift. We use the WPIA method with the Arase electromagnetic field and ion particle data to analyze the nonlinear mechanism of the EMIC emissions with different frequency evolutions. The WPIA on an EMIC falling tone emission, observed on 15th Nov, 2017, indicates that nonlinear resonant currents control the frequency decrease and the significant wave growth. The existence of the proton hill predicted by the nonlinear growth theory is shown in the phase angle distribution of the proton flux. The motion of the proton hill in phase space which forms the nonlinear resonant currents is also discussed. Concurrent generation of the rising tone emission with the falling tone emission in different frequencies with the same proton energy is also suggested by the WPIA result.