PIC simulation on non-linear development of lower hybrid waves instabilities driven by energetic ions with a ring-like velocity distribution: the comparison of initial value problems and energetic-ion injection models.

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Instabilities driven by energetic ions are important issues both for space plasma and magnetically confined plasma aimed for fusion energy. In the auroral region of the Earth’ s magnetosphere, waves near the lower hybrid resonance frequency, ω_{LH}, driven by energetic ions can contribute ion energization. Here, ω_{LH} is estimated as $\omega_{LH} \sim \sqrt{\Omega_i \Omega_e}$ where Ω_i is the ion cyclotron frequency and Ω_e is the electron cyclotron frequency. These waves, namely lower hybrid waves (LHWs) driven by energetic ions are also observed in the Large Helical Device (LHD) for fusion plasma. In the LHD, energetic ions are generated by the perpendicular neutral beam injection (NBI) for plasma heating.

One-dimensional, electromagnetic, particle-in-cell (PIC) simulations are used to investigate the non-linear evolution of lower hybrid waves instabilities driven by energetic ions with a non-Maxwell velocity distribution. These instabilities can excite LHWs. Energetic ions have a ring-like velocity distribution perpendicular to the magnetic field. Here two models with and without the continuous injection of energetic ions into plasma are examined in detail. The speed of the energetic ions is smaller than the Alfvé n speed, and the density ratio of the energetic ions to the bulk ions is several percent. The following results are obtained in the injection model. LHWs keep the larger amplitudes after the saturation. The clear wavenumber shift is found due to the change of the velocity distribution function. Furthermore, the electric field resulting from the instabilities gives energy to the bulk ions. On the other hand, in the value problem, LHWs get damped immediately after the saturation and the clear wavenumber shift is not observed. Other simulations varying the width of the ring-like velocity distribution are also performed.

Keywords: lower hybrid wave, energetic ion, PIC simulation

