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Excitation of kinetic Alfvén wave driven by collisionless magnetic reconnection with strong guide field

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Magnetic reconnection is a fundamental physical mechanism that leads conversion of magnetic energy to kinetic energy, topological change of magnetic field lines, and self-organization in space and laboratory plasmas. In collisionless plasmas, it is considered that two fluid or kinetic effects play essential roles to produce the reconnection electric field in the diffusion region. It also suggests that the electric inertia effect and the anomalous resistivity become more important since particle orbit effects, such as finite Larmor radious effect become weak in case with a strong guide field.

The anomalous resistivity is one of possible mechanisms that can drive the fast magnetic reconnection in collisionless plasmas. A recent study reports that anomalous resistivity induced by the Buneman instability accelerates the magnetic reconnection in case with a guide field [1]. However, it has not been fully understood how the Buneman or the secondary instabilities is spontaneously realized during the magnetic reconnection.

In this study, in order to reveal the process spontaneously driving the secondary instability, the collisionless magnetic reconnection with the guide field is investigated by means of gyrokinetic simulations [2]. We have analyzed the velocity distribution function for electron at the X-point and have found the electron beam is formed through the acceleration by the reconnection electric field as shown Fig.1. We have also carried out numerical analysis of the dispersion relation of the kinetic Alfvén waves in a limit of plane waves, and have found that the kinetic Alfvén waves can be excited by the beam electrons accelerated at the X-point when the beam velocity exceeds the Alfvén speed as seen in Fig.2. Furthermore we also analyzed the beam instability of the kinetic Alfvén wave in the X-point configuration formed during the magnetic reconnection.

References
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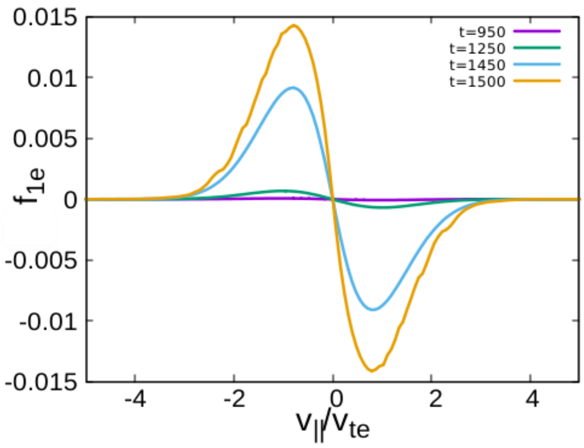

Figure 1 Gyrocenter velocity distribution functioni at the X-point for t=950,1250 (linear phase) and t=1450,1500 (nonlinear phase). The shifted Maxwellian ($v_{\parallel}F_M$) distribution is formed during the magnetic reconnection. The amplitude of f_e rapidly grows in the nonlinear phase making the beam component.

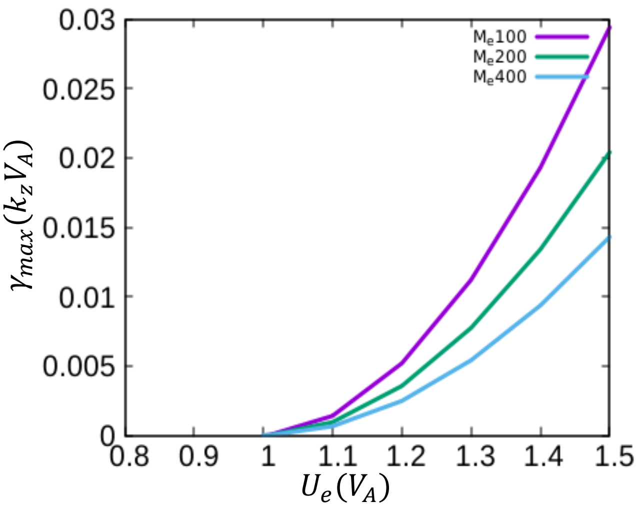

Figure 2 The maximum growth rate γ_{max} plotted for the beam velocity U_e normalized by the Alfvén speed, for the mass ratio of $M_e = m_e/m_i$=100,200,400. The kinetic Alfvén waves are unstable when the beam velocity exceeds the Alfvén speed.