Structure of the distribution function and beam instability in collisionless magnetic reconnection with a strong guide field

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Magnetic reconnection is a physical mechanism that converts the magnetic energy into the kinetic energy in space and laboratory plasmas. It is considered that two-fluid or kinetic effects lead to reconnection of magnetic field lines in colllisionless plasmas while the detailed process is still an open issue. Anomalous resistivity (AR) is one of the possible mechanisms that sustain the reconnection electric field in collisionless plasma with a guide field. A recent study reports that AR induced by the Buneman instability accelerates the magnetic reconnection [1]. However, it is not well understood how the instability causing the AR is spontanously induced during the reconnection.

In this study, we have carried out numerical simulations of collisionless magnetic reconnection by means of the gyrokinetic model of a slab plasma with the guide field [2]. The initial condition is given by a sheared magnetic field with a parallel current. During the reconnection, parallel electric field is induced at the X-point and it accelerates electrons. As a result, as shown Fig.1, electron velocity distribution function at the X-point is given by the shifted Maxwellian with a parallel beam component has a parallel beam component.

Next, we derive a linear dispersion relation from the gyrokinetic equation including component at the X-point. The liner analysis shows that the kinetic Alfvén waves are destabilized when the electron beam velocity exceeds the Alfven speed. We have also estimated the maximum beam velocity for cases with different initial and magnetic flux have found that the instability condition could be sufficiently fulfilled in the simulation of collisionless reconnection.

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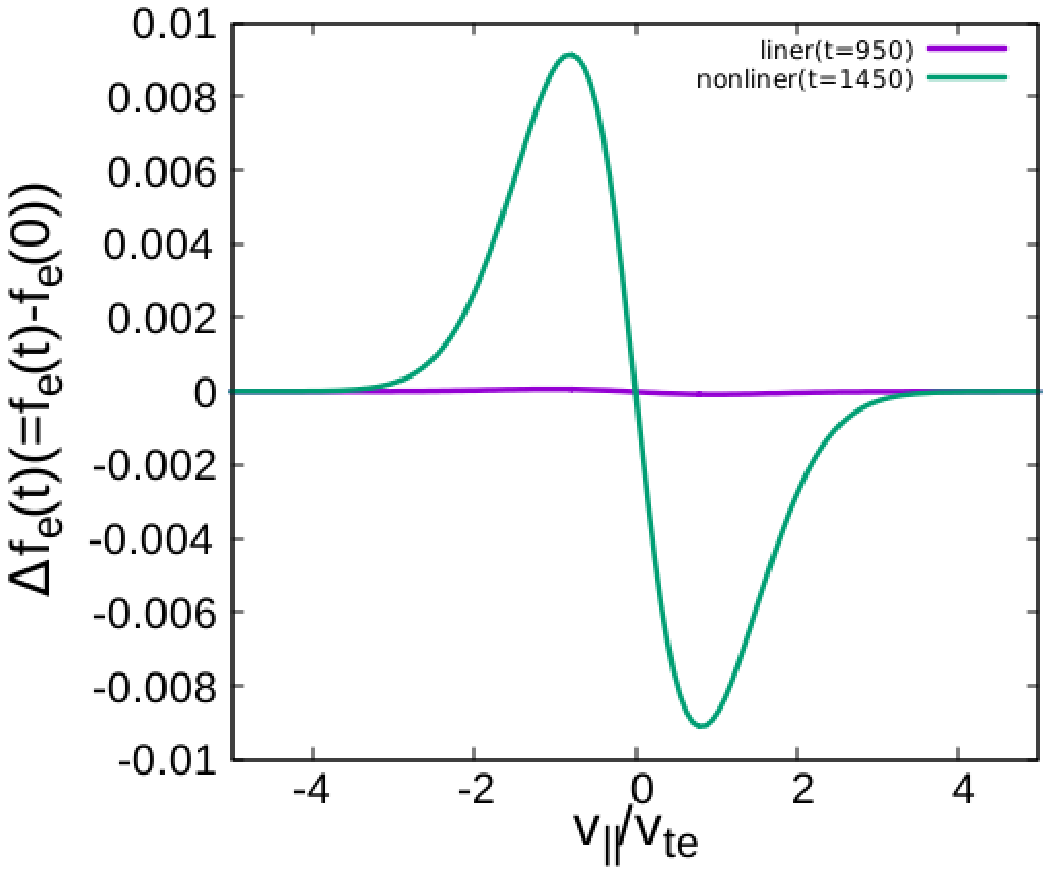
liner(t=950)
nonliner(t=1450)
$\Delta f_e(t)(=f_e(t)-f_e(0))$
0.01
0.008
0.006
0.004
0.002
0
-0.002
-0.004
-0.006
-0.008
-0.01
-4
-2
0
2
4
$v_{||}/v_{te}$