Electron beam instability in collisionless magnetic reconnection with a strong guide field

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Magnetic reconnection is a fundamental physics mechanism in magnetized plasma that causes a topological change of magnetic field lines and a conversion of magnetic energy to kinetic energy, leading to a self-organization of plasmas in laboratory and space. It is considered that the two-fluid effects or the kinetic effects facilitate the fast reconnection of magnetic field lines in colllisionless plasmas. Anomalous resistivity (AR) is one of the candidates that contributes to continuously drive the magnetic reconnection. A recent simulation study reports that AR induced by the Buneman instability accelerates the magnetic reconnection [1]. However, it is not clear how the instability causing the AR is spontaneously driven during the reconnection.
In our study so far, we have carried out numerical simulations of the collisionless magnetic reconnection by means of the gyrokinetic model of a slab plasma with a strong guide field [2][3]. During the reconnection, the parallel electric field is induced by the electron inertia at the X-point where electrons are acccelerated along the guide field. A liner analysis by use of the dispersion releation shows that the kinetic Alfvén waves (KAWs) are destabilized when the electron beam velocity exceeds the Alfvén speed, where, we assumed a plane wave in an uniform background profile. Furthermore, in this δf gyrokinetic model, the total distribution function F is approximately described as *F=FM+δf=(1+Uv)FM~1/2pi exp(-(v-U)*^{2}*/2),* where *FM* , *δf* and *U* are the Maxwellian, perturbed distribution function, and a beam velocity component, respectively. In order to analyze a stability of the KAWs in an inhomogeneous background profile during the collisionless magnetic reconnection, we must use the total distribution function rather than δf, since the KAWs are stable for *(1+Uv)FM,* according to the Nyquist criteria. Therefore, in this study, the magnetic reconnection process triggered by the electron inertia is simulated by use of a full-f gyrokinetic model of a slab plasma with the guide field. As a result, the shifted Maxwellian is formed at the X-point self-consistently by the parallel electric field. The attached figure shows distribution of the parallel electron beam on the reconnection plane in the nonlinear phase during the reconnection. It is possible to carry out the stability analysis in an inhomogeneous background by use of this simulation results. Results of the stability analysis will also be discussed at the meeting.

[1] H. Che, Phys. Plasmas (2017) 24, 082115
[2] A. Ishizawa, T.-H. Watanabe, Phys. Plasmas (2013) 20, 102116
[3] K. Shimomura, T.-H. Watanabe, et al, submitted to Phys. Plasmas (2019)

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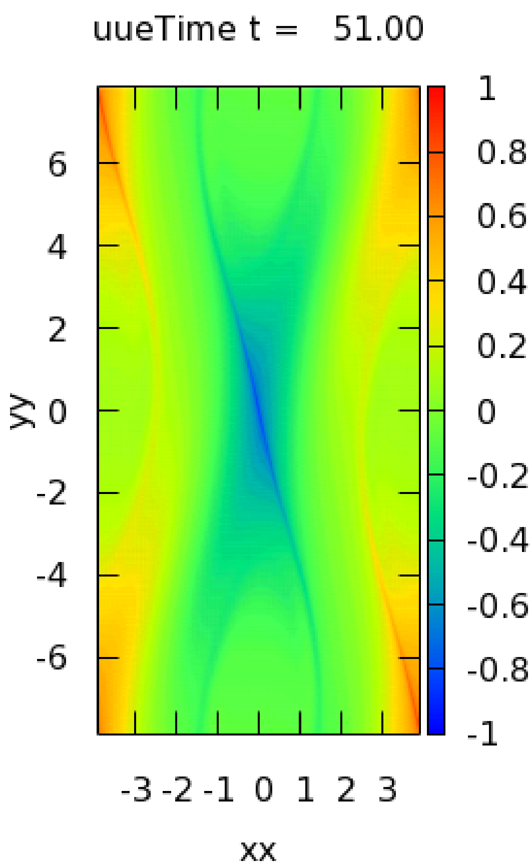
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