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Gyrokinetic simulation of nonlinear tearing instability

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Current-sheet configurations in magnetized plasmas can be subject to the well-known tearing instability, whereupon magnetic field lines of opposite direction spontaneously break and reconnect in a different topological configuration. Tearing modes are important in fusion devices, since they drive the formation of magnetic islands which can significantly enhance the outward radial transport of heat and particles. Solar, stellar and accretion-disk flares, as well as substorms in the Earth's magnetosphere, are some of the many other contexts where the tearing instability is believed to play a crucial role.

In this presentation, we show numerical results of tearing instability simulations in a strong guide magnetic field limit using the AstroGK astrophysical gyrokinetics code.

Key questions for the magnetic reconnection study are: what mechanisms allow topological change of magnetic field lines, and what determines the reconnection rate. If plasmas are weekly collisional or collisionless, the electron inertia and off-diagonal pressure components thought to break the flux-freezing constraint instead of the collisional resistivity, and ion kinetic effects, such as the Hall effect or a finite Larmor radius (FLR) effect may enhance the reconnection rate.

Under a strong guide magnetic field, gyrokinetics provides a reduced kinetic model given in five-dimensional phase space which describes low-frequency fluctuations and contains the above mentioned kinetic effects important for magnetic reconnection.

We mainly focus on the electron kinetic effects and investigate the generalized Ohm's law derived from the electron momentum equation. Gyrokinetic simulation results will be compared with other simulation results based on PIC or fluid models. Specifically, we discuss the effect of off-diagonal elements of the electron pressure tensor.

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Keywords: magnetic reconnection, tearing instability, gyrokinetics