FAST MAGNETIC RECONNECTION IN FLUID MODELS OF PAIR PLASMA

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BACKGROUND

Although kinetic models of plasma allow for greater physical correctness, fluid models are preferred in order to decrease computational expense.

The phenomenon for which fluid models have been most apt to fail is collisionless fast magnetic reconnection. It is precisely this phenomenon which has been most critical to understanding the volatile dynamics of astrophysical plasmas. This has prompted extensive particle-based kinetic simulation of collisionless fast magnetic reconnection and comparison with fluid simulations in order to determine the essential phenomena that fluid models must incorporate to agree with kinetic simulations.

The GEM magnetic reconnection challenge problem (1) identified Hall effects as critical to fast magnetic reconnection in electron-ion plasmas. Since Hall effects are absent for electron-positron (pair) plasmas, this prompted (2-3) to demonstrate via kinetic simulations that fast magnetic reconnection occurs in collisionless pair plasma, which they attributed to pressure anisotropy.

The next challenge was to demonstrate fast reconnection in a fluid model of pair plasma. Assuming the case of a ubiquitous strong magnetic field allowed (4) to develop an analytical fluid theory for fast reconnection in pair plasma. For the case where there is a magnetic null point, (5) has demonstrated fast reconnection in an Euler-Maxwell model of isotropic pair plasma.

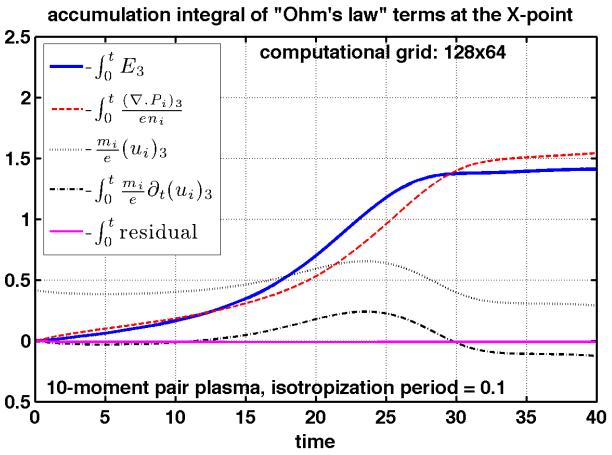
WORK

Since the mechanism for fast reconnection in an isotropic pair plasma can only be the inertial term, we have simulated fast reconnection in an adiabatic anisotropic fluid model of collisionless pair plasma. We have demonstrated that with the exception of very fast rates of isotropization it is indeed pressure anisotropy rather than the inertial term that provides for fast reconnection in the anisotropic fluid model (see figure).

We also have found that a small amount of isotropization plays a critical role in accelerating reconnection. We are in the process of studying non-adiabatic anisotropic fluid closures and hope to present results on this as well.

SIGNIFICANCE

The ability to model fast reconnection in a fluid model for the singular case of collisionless pair plasma is a critical step toward developing a robust, parsimonious, computationally efficient model of plasma that accurately resolves fast magnetic reconnection. Possible applications for such a model are space weather forecasting and confinement fusion.



[figure: contribution of pressure (red) versus inertia (black) to reconnected flux (blue).]

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