Temperature gradient effects on collisionless reconnection and magnetic stochastization

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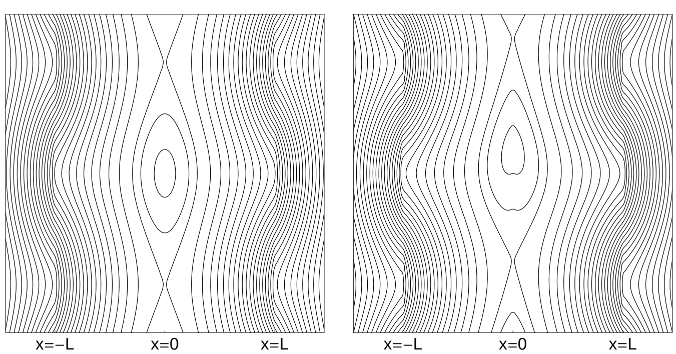
Magnetic reconnection is a key mechanism in transport processes in weakly collisional plasmas, both in space and in magnetic fusion experiments. When collisional dissipation is weak, resistive reconnection cannot always explain the observed reconnection rates. However, faster than resistive reconnection rates are possible due to electron inertia. Parallel electron compressibility can further accelerate this process, yielding fast reconnection rates comparable with those observed in tokamak plasma instabilities [1].
In order to study the effects of magnetic reconnection on energy confinement, it is important to describe the effects of temperature gradients on reconnection. The presence of a temperature gradient makes it necessary to describe the reconnection process of field lines that have different temperatures. In a collisionless plasma, this requires a kinetic description of the electrons. Using such a model it is found that a temperature gradient perturbs the vorticity and current distributions in the reconnection layer [2] and thus the entire magnetic island geometry [3].
Specifically, it is found that due to the temperature gradient, the magnetic perturbations of growing as well as saturated island chains have a poloidal phase-shift that varies with the radial coordinate (see figure). This has consequences for the stochastization of tokamak magnetic fields. During the growth of neighbouring island chains, the temperature gradient will modify the positions of secondary and higher-order island chains, thereby altering the onset of stochasticity and destruction of the last KAM-torus.



Magnetic islands due to collisionless tearing instability of a current layer of width $2L$. The inertial skin depth is $d_e = 0.5L$. The magnetic field and current have dominant components perpendicular to this plane. Left: case without temperature gradient. Right: a temperature gradient in the x-direction causes the island to be deformed and phase-shifted with respect to the perturbations at $|x| > L$.

References

[1] M. Ottaviani and F. Porcelli, Phys. Rev. Lett. **71** (1993) 3802.
[2] H.J. de Blank and G. Valori, Plasma Phys. Control. Fusion **45** (2003) A309.
[3] E.V. van der Plas and H.J. de Blank, 31st EPS Conference on Plasma Phys. London, 28 June – 2 July 2004 ECA Vol. **28G**, P-2.073 (2004)