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Turbulence-driven temperature anisotropy and constraining effects of the mirror instability in FLR-Landau fluid simulations

Pierre-Louis Sulem, Thierry Passot, Luca Marradi, and Dimitri Laveder
Université de Nice-Sophia Antipolis, CNRS, Observatoire de la Côte d'Azur, BP 4229, 06304 Nice Cedex 4, France (sulem@oca.eu, Fax:+33-(0)492003121)

Analyzes of the distribution of the ion perpendicular to parallel temperature ratio and of the ion parallel beta showed that temperature anisotropy in the solar wind is constrained by oblique pressure-anisotropy-driven microinstabilities (Hellinger et al., Geophys. Res. Lett. 33, L09101, 2006; Matteini et al., Geophys. Res. Lett. 34, L20105, 2007; Bale et al., Phys. Rev. Lett. 103, 21101, 2009). In particular, in the regimes where the perpendicular temperature dominates, the regulating factor is provided by the mirror instability. It turns out that this low-frequency instability (together with its quenching at small scales) can be accurately reproduced within a fluid approach that retains ion and electron Landau damping and ion finite Larmor radius corrections (Passot and Sulem, Phys. Plasmas 14, 082502, 2007).

We discuss, in this presentation, numerical simulations performed with this "FLR-Landau fluid" model, for a randomly driven ion-electron plasma in various regimes. A first observation is that, at least when the dynamics is limited to a prescribed quasi-transverse direction, simulations can be accurately performed without adding any artificial smoothing effect. Depending on the conditions and in particular on the initial beta, the development of one or the other type of ion temperature anisotropies is observed. When the perpendicular ion heating is dominant, the system stabilizes in a regime slightly above the theoretical threshold of the mirror instability for a warm bi-Maxwellian plasma, despite the persistent growth of the temperatures. As the effect of weak collisions is included in the model, this distance to threshold is reduced, while the system remains governed by the mirror dynamics. Detailed inspection of the structures in physical space reveals, in addition to quasi-static mirror structures, the presence of small-amplitude fast waves, secondary instabilities and resonance processes leading to the formation of quasi-singular profiles. The heating of the electrons is also analyzed, together with the tendency of

this species to evolve towards isotropic temperatures.