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Fluid modeling for ion scale space plasmas

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Fluid models with first-order finite Larmor radius (FLR) corrections have been known since the early sixties. It however turns out that a correct dispersion relation for oblique Alfvén waves requires FLR corrections of at least second order in an asymptotics based on temporal and spatial scale separation. Supplementing Landau damping, that provides an essential ingredient for a realistic description of Alfvénic turbulence, is moreover delicate as, in these models, the combination of dispersive and dissipative effects can produce spurious instabilities in some parameter regimes. We thus propose a new kind of fluid model, closed at the level of the fourth-rank moments, that combines the advantages of fully-nonlinear large-scale FLR models, with a small-scale regularization where the nongyrotropic contributions of all the retained moments are evaluated consistently with the low-frequency linear kinetic physics, down to transverse scales comparable to or smaller than the ion gyroradius [see *Phys. Plasmas* **14**, 082502 (2007), *Phys. Plasmas* **19**, 082113 (2012)]. This model, which is based on a matching of the FLR expressions derived both from the fluid formalism and from the kinetic theory, is asymptotically valid at large scales. The small-scale "sub-grid" modeling leads to an accurate description of the linear properties of kinetic Alfvén waves and of the mirror instability, but also provides the correct (in the absence of cyclotron resonance) and sufficient dissipation for turbulent simulations, allowing for the development of power law spectra extending to the smallest resolved scale.