A FLUID MODEL FOR THE ION-SCALE DYNAMICS OF A COLLISIONLESS PLASMA

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Although collisionless plasmas are not amenable to a standard MHD description, more general fluid approaches which include low-frequency kinetic effects can provide efficient frameworks for numerical simulations of three-dimensional turbulence, for example in the solar wind. We shall present a model that extends the anisotropic MHD to scales of the order of the ion gyroradius and below in the directions perpendicular to the ambient magnetic field, thus describing both the so-called fast and slow dynamics. This model is based on a closure of the fluid hierarchy derived from the Vlasov-Maxwell equations, performed at the level of the full ion and electron fourth-rank moment tensors in a way consistent with the low-frequency linear kinetic theory. It furthermore includes finite Larmor radius (FLR) contributions to the pressure and heat flux tensors which, as the result of a matching procedure, are asymptotically exact to the leading order of a large-scale asymptotic expansion, and consistent with the linear dynamics at all scales within the gyrokinetic ordering. The model in particular accurately reproduces the linear properties of kinetic Alfvén waves, and correctly describe the mirror instability (driven by the Landau resonance in anisotropic plasmas) together with its quenching at small scales by FLR effects. It is noticeable that retaining a linearly accurate description of the small transverse scales is needed to prevent spurious linear instabilities which, for some regimes of parameters, can otherwise occur beyond the spectral range of validity of the large-scale asymptotics, in the presence of Landau damping. The resulting model thus provides an efficient tool to describe Alfvenic turbulence in the absence of cyclotron resonance. Three-dimensional pseudo-spectral simulations of Alfvenic cascade as well as of mirror structures resulting from the saturation of the mirror instability will be presented.