EXTENDED MHD EFFECTS IN THE MODELING OF TOKAMAK PLASMAS

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Extended-MHD effects such as the decoupling of ion and electron flows and temperatures, the generalized Ohm's law and the contribution of the ion gyroviscosity, the pressure anisotropies (sometimes called parallel viscosities) and the heat fluxes to the momentum and energy equations, play a crucial role in many problems of current interest in magnetic fusion research. This talk will give an overview of recently obtained results in the fluid theory of low-collisionality magnetized plasmas, that provide an improved description of such extended-MHD effects [1-3]. These results are based on the perturbative solution for the fluid moments of the kinetic equation (assuming small gyromotion periods and Larmor radii compared to any other time and length scales) and contain very general first-significant-order evolution equations for the stress and stress-flux tensors. The analysis is valid for arbitrary magnetic geometry and plasma beta, and for fully electromagnetic non-linear dynamics with arbitrary fluctuation amplitudes. It is also valid for strong anisotropies and does not require the distribution functions to be close to Maxwellians. It can be applied under both the fast (sonic or Alfvenic motions) and slow (diamagnetic drift motions) orderings. The finite-Larmor-radius dynamic evolution equations for the parallel heat fluxes are particularly novel, as are the terms in the gyroviscous stress tensor and the perpendicular heat fluxes associated with strongly anisotropic distribution functions. The exact divergence of the gyroviscous stress tensor (gyroviscous force) is written in coordinate-free vector form, for the most general magnetic geometries, parallel gradients and mass and heat flows. With a subsidiary large-aspect-ratio and small-parallel-gradient ordering for plasmas in a strong guide magnetic field of weak curvature, a new system of reduced two-fluid equations is derived, which takes into account all the diamagnetic effects associated with arbitrary density and anisotropic temperature gradients.

[1] J.J. Ramos, Phys. Plasmas 10, 3601 (2003).

[2] J.J. Ramos, Phys. Plasmas 12, 052102 (2005).

[3] J.J. Ramos, Phys. Plasmas 12, 112301 (2005).