A flexible linear gyro-fluid eigensolver with Onsager symmetry

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Gyro-fluid equations are velocity space moments of the gyrokinetic equation. Special gyro-Landau-fluid closures have been developed to include the damping due to kinetic resonances fit to the collisionless local response functions [1,2]. This damping allows for accurate linear eigenmodes to be computed, even in the collisionless limit, with a relatively low number of velocity space moments compared to gyrokinetic codes. An analysis of the gyro-Landau-fluid closure schemes finds that the Onsager symmetries [3] of the resulting quasilinear fluxes are not preserved. Onsager symmetry guarantees that the matrix of diffusivities is positive definite, an important property for a transport model. The constraints on the closure due to Onsager symmetry and other considerations are shown to be very restrictive. A new, simpler scheme for regularizing the gyro-fluid equations that preserves the Onsager symmetry and is scalable to higher velocity space moments without change of the damping model is presented. Linear eigenmodes from the new system of equations are compared with gyrokinetic results, with and without collisions, including parallel and perpendicular electromagnetic fluctuations at high beta. The new linear gyro-fluid equation eigensolver (GFS) will be used to extend the TGLF quasilinear transport model [4] so that it can compute the energy and momentum fluxes due to parallel magnetic fluctuations, completing the transport matrix. The GFS equations do not use a bounce average approximation to the magnetic mirror force. General flux surface magnetic geometry is included. Only pitch angle scattering for electron collisions are included and equilibrium rotation is restricted to be subsonic. The Onsager symmetries will enable faster transport solvers since the matrix of convection and diffusion coefficients will all be computed by a single call to the quasilinear transport model.

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