Derivation of hydrodynamic models for massless electrons

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The dynamics of charged particles in a plasma or a semiconductor device can be described at the kinetic level by the Vlasov-Poisson-Fokker-Planck (VPFP) equations. In these models, electromagnetic and collisional effects occur on different time, space and velocity scales depending on physical parameters. It leads to a genuinely multiscale dynamics. A parameter of special importance is the small mass ratio $\varepsilon \ll 1$ between electrons and heavy particles, creating fast motion of the former and resulting, in particular, in a strong effect of the magnetic field.
In this talk, we discuss the rigorous derivation of several asymptotic models in the limit of massless electrons ($\varepsilon \to 0$) for the scaled VPFP equation. Depending on the magnitude of collisions, one recovers nonlinear hydrodynamic models of parabolic [1] or hyperbolic [2] type. Several aspects of the guiding center motion and Maxwell-Boltzmann-Gibbs equilibria are contained in these asymptotic models. Our analytical techniques are based on free energy renormalized solutions, relative entropy arguments, hypocoercive and hypoelliptic properties of the VPFP equation and moment methods to take limits. Derivation and well-posedness of asymptotic models are discussed as well as rates of convergence.

Références

[1] M. Herda, *On massless electron limit for a multispecies kinetic system with external magnetic field*, J. Differential Equations, 2016.

[2] M. Herda and L. M. Rodrigues, *Anisotropic Boltzmann-Gibbs dynamics of strongly magnetized Vlasov-Fokker-Planck equations*, submitted.

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