Lagrangian framework for Gyrokinetic codes: from continuous to discrete model.

N. Tronko, T. Görler, A. Bottino, and E. Sonnendrücker
Max Planck Institut für Plasmaphysik, Garching 85748, Germany

In fusion plasmas strong magnetic field allows the fast gyro motion to be systematically removed from the description of the dynamics, resulting in a considerable model simplification and gain of computational time. To perform the Gyrokinetic dynamical reduction systematically, advanced geometrical tools, such as Lie-transform perturbation techniques and Lagrangian formulation of dynamics are required.

The Particle-In-Cell (PIC) algorithm is broadly used for discretization and numerical simulation of gyrokinetically reduced Vlasov-Maxwell equations. The scope of that algorithm consists in self-consistent coupling between the dynamics of electromagnetic fields computed from the grid-based method and the Vlasov equation resolved from the particle's characteristics.

One of the essential points of the Monte-Carlo discretisation consists in possibility to get the self-consistently reduced coupled Vlasov-Maxwell system from the discrete Lagrangian. Then the code diagnostics, such as energy conservation is obtained from the Noether method for a semi-discretised system. This discretisation approach is following the essential idea of the Modern Gyrokinetic theory, which allows to get the self-consistently reduced set of gyrokinetic Vlasov-Maxwell equations from the first principle of dynamics.

The aim of this talk is to show the tight link between the abstract analytical theory and the Monte-Carlo PIC code implementation for the GK Vlasov-Maxwell equations derived from the continuous and discrete second order Lagrangians.

In particular, we are considering an example of the multi-species electromagnetic code ORB5. The continuous Lagrangian framework for that code has been recently derived and placed into the global hierarchy of the second order GK models in [1]. The corresponding set of discretized GK equations issued from the variational formulation is given in [2].

[1] N.Tronko, A.Bottino, E.Sonnendruecker, *Second order gyrokinetic theory for Particle-In-Cell codes*, ArXiv 1604.03538, under revision in Phys. of Plasmas.

[2] N.Tronko, A.Bottino, E.Sonnendruecker, *Monte-Carlo Particle-in-Cell finite-element simulations of the second order electromagnetic Gyrokinetic equations.*, in preparation