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STRUCTURE PRESERVING PARTICLE IN CELL METHODS

- **TRACK NUMBER (100 - ADVANCED DISCRETIZATION TECHNIQUES)**

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ABSTRACT

Particle in Cell (PIC) methods have been used since the beginning of plasma simulations to approximate the Vlasov-Maxwell equations or related reduced models. Even though they are noisier than grid based discretizations, they are still more efficient for 6D simulations as they are not as much affected by the curse of dimensionality. As for other models, it has been recognized that the exact preservation of key invariants such as the divergence constraints in Maxwell's equations is essential for accurate long time simulations. These constraints actually come from the noncanonical Hamiltonian structure of the Vlasov-Maxwell equations. Field discretizations based on Discrete Exterior Calculus (e.g. Finite Element Exterior Calculus or Mimetic Finite Differences on dual grids) coupled to a particle method for the Vlasov equation yield in a natural way to a finite-dimensional noncanonical Hamiltonian system that can then be solved using strategies from geometric numerical integration of ODEs [1,2]. In particular splitting methods, either on the Hamiltonian or on the Poisson bracket are good choices.

On the other hand, adding collisions to the system in terms of the Landau or some approximate models, stills conserves energy, momentum and energy at the continuous level and adds the important property, namely the Boltzmann H-Theorem that stipulates that the entropy must grow. The full Vlasov-Maxwell-Landau system possesses a so-called metriplectic structure. There have been recent works devoted to the discretization of the collision operator that preserve this metriplectic structure including the H-Theorem at the semi-discrete level [3,4].

The mini-symposium will focus on the recent advances in the field as well in the development of original numerical methods as in the development of Open Source code infrastructures.

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