Vlasov simulations of beams with a moving grid

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Thanks to the rapid increase of computing power in recent years, simulations of plasmas and particle beams based on direct solution of the Vlasov equation on a multi-dimensional phase-space grid are becoming attractive as an alternative to Particle-In-Cell (PIC) simulations. Their strength lies essentially in the fact that they are noiseless and that all parts of phase space, including the tail of the distribution, are equally well resolved. Their major drawback is that, for inhomogeneous systems, many of the grid points (where no particles are present) are wasted. This is especially the case for beam simulations where the beam moves rapidly through the phase space (due to varying alternating-gradient focusing forces, for example). This inefficiency has made such Vlasov simulations unsuitable for those cases.

This presentation introduces the concept of a moving grid which is mapped at each time step from a logical uniform grid to the beam, so that it contains the whole beam without needing too many points with vanishing values of the distribution function. In order to implement this new method, we introduce a new time stepping algorithm which does not rely on the time splitting procedure traditionnaly used in Vlasov solvers. In this presentation we describe the moving grid algorithm as well as the new time stepping algorithm, and present some applications to the simulation of beams in transverse phase-space.