Vlasov solver using rational Chebyshev function

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Vlasov simulation solves the Vlasov equation using a mesh in phase space. Compared to popular Particle-In-Cell method, it gives higher accuracy in general because of the noiseless property. However, it requires a lot more computational resource because of the use of additional mesh in velocity space. Velocity space essentially has an infinite interval, so the procedure of discretizing it is not obvious. A solver which is both accurate and efficient at the same time is needed.

In this study, a new Vlasov-Poisson solver using spectral method has been developed. The Vlasov equation is splitted into advection in x and v directions, both are calculated by a semi-Lagrangian method. Interpolation is done by approximating the distribution function by Fourier series expansion in x direction and rational Chebyshev series, which is Chebyshev polynomial transformed to cover infinite interval, expansion in v direction. One has to choose a "map parameter" which determines how far the grid points are spread out. This expansion should have the accuracy advantage of spectral method as well as being able to treat the distribution function as a truly unbounded function in v direction. Expansion of both x and v directions can be done using FFT.

Comparison against other methods for application to standard test problems in 1D such as linear and nonlinear Landau dampings and two stream instability will be presented. The optimum choice of “map parameter” L will also be discussed.

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