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Collisional operators: Comparison between kinetic and exact *N*-body simulations

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In a plasma, the charged particles interact via long-range forces and this interaction causes the plasma to exhibit collective effects.

If the graininess parameter g goes to zero (ideal collisionless plasma), the binary collisions can be neglected and collective effects are dominant. But as g increases, the effects governed by the two-body collisions can no longer be neglected. Therefore, the transition between a collisionless and a collisional regime can be studied by progressively increasing the value of the graininess parameter g.

Here, we study the evolution of Langmuir waves for different values of g. The *N*-body code solves *exactly*, in one spatial dimension, the dynamics of N parallel plane sheets for both ion and electron populations.

The total electric field has a step-like profile and the motion of a particle is uniformly accelerated as long as it does not cross one of its neighbors. As the electric field is constant between two planes, and using the Newton's law, the motion can be integrated exactly (except for computer round-off errors).

We compare the results of the exact *N*-body code with simulations performed using a semi-lagrangian Vlasov code [4] augmented by a Krook collision operator.

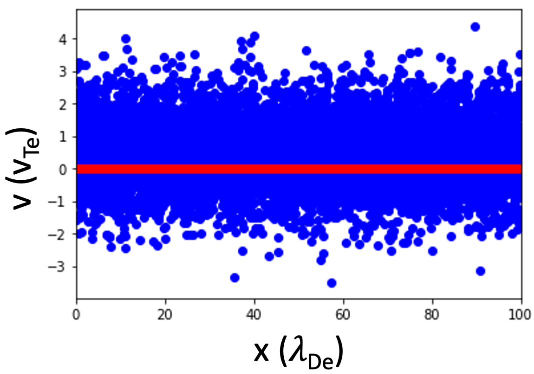

Figure 1: Phase space at t = 0 (electrons in blue, ions in red). A momentum kick (0.5 v_{Te}) is given to the electrons that throws the system out of thermal equilibrium.

Recent works [5-7], based on a weak-turbulence calculation starting from the Klimontovich equation and including all wavenumbers, suggest a modification of the collision operator for the Vlasov distribution function. Using this theory, it was estimated that the collisional damping of Langmuir waves is up to two orders of magnitude smaller than predicted by a Krook operator. In the long run, our exact *N*-body simulations aim at clarifying the predictions on the collisional relaxation rate put forward in Refs. [5, 6].

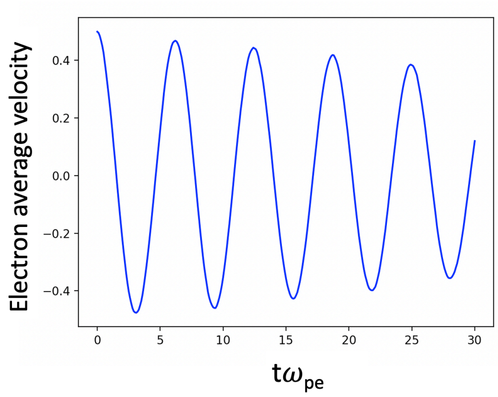

Figure 2: Plasma oscillations. At t = 0 a momentum kick is given to the electrons (Fig.1), the electron average velocity is plotted against time (from the exact *N*-body code, for 6 000 sheets). Plasmas oscillations at $\omega = \omega_{pe}$ are observed.

References

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