

Computational Approach to Sub-Debye Physics

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Most of kinetic theories in space plasma physics are based on Vlasov equation. Usually the derivation of this equation is via the BBGKY theory, which starts with the Liouville equation and obtain one particle probability distribution function assuming two body correlation is negligible. The two body correlation is supposed to be negligible when (1) there are enough number of particles in a Debye sphere; (2) the spatial scale of the phenomena in interest is much larger than the Debye length.

There are, however, circumstances where the condition (2) above is not well satisfied. Plasma environment around a spacecraft in deep space is a good example. We do not know how to proceed to obtain tractable equations instead of Vlasov equation in such situations. Further, there are several problems on the foundation of Vlasov equations. The calculation of Debye shielding, for example, usually assumes thermal equilibrium, however, what is the thermal equilibrium of a collisionless plasma?

Extensive theoretical studies have been developed in the middle of the 20th century, however, there was no device to verify their assumptions and results in those days. Now, in the beginning of the 21th century, we have advantage of computational experiment; we can calculate rigorous N-body problem. Problems on the foundation of Vlasov equations will be reviewed along with possible approaches using computer experiments in the presentation.