Direct path from N-body classical mechanics to Debye shielding, Landau damping, and wave-particle interaction

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References [1, 2] provide a compact unified introduction to the basic plasma physics phenomena underlying wave-particle interaction without appealing to fluid or kinetic models. This is done in a few steps with elementary calculations using standard tools of calculus, and no probabilistic setting, by using Newton's second law for a system of N electrons in a periodic box with a neutralizing ionic background. Unexpectedly, Debye shielding is encountered on the way to Landau damping. The theory is extended to accommodate a correct description of trapping or chaos due to Langmuir waves. In the linear regime, the amplitude of such a wave is found to be ruled by Landau growth or damping and by spontaneous emission.

Recent calculations improved the derivation of section V of [2], and other ones shed more light on the validity of the Vlasov approximation in the limit where the number of particles in the Debye sphere tends to infinity [3].

References

[1] D.F. Escande, F. Doveil, and Y. Elskens, http://hal.archives-ouvertes.fr/hal-00827759

[2] D.F. Escande, F. Doveil, and Y. Elskens, http://arxiv.org/pdf/1210.1546.pdf

[3] D.F. Escande, F. Doveil, and Y. Elskens, to be published