Understanding And Computing Basic Plasma Physics Effects By *N*-body Dynamics

D.F. Escande[1], Yves Elskens[1], and F. Doveil[1]

[1] *Aix-Marseille Université, CNRS, PIIM, UMR 7345, 13013 Marseille, France*

A compact unified introduction to the basic plasma physics phenomena underlying wave-particle interaction is derived without appealing to fluid or kinetic models, but by using Newton's second law for a system of *N* electrons in a periodic box with a neutralizing ionic background [1,2]. This is done in a few steps with elementary calculations using standard tools of calculus, and no probabilistic setting. 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. Another calculation clarifies the nature of Debye shielding: any particle helps shielding all the other ones while being shielded by the latter as a consequence of the deflections ("collisions") of particles due to the Coulomb interaction. Using the Debye-shielded Coulomb potential, a third calculation derives for the first time collisional transport for all impact parameters *b*, with a convergent expression reducing to Rutherford scattering for small *b* [1,3]. No cutoff at the Debye length scale is needed, and the Coulomb logarithm is only slightly modified. Screening and collisions are thus intimately linked, and our global calculation of collisional transport rests on this link. All these works also shed light on the link between Vlasov equation and N-body dynamics [4].

[1] D.F. Escande, F. Doveil, and Y. Elskens, http://arxiv.org/pdf/1210.1546.pdf
[2] D.F. Escande, F. Doveil, and Y. Elskens, http://hal.archives-ouvertes.fr/hal-00827759
[3] D.F. Escande, Y. Elskens, and F. Doveil, to be published
[4] Y. Elskens, D.F. Escande, and F. Doveil, to be published,
http://arxiv.org/pdf/1403.0056v1.pdf