# Plasma Physics via Vlasov simulations

F. Califano

The Vlasov equation is the fundamental model equation of collisionless laboratory and space plasmas. Only recently, because of the impressive increase in computing memory and CPU power, it has become possible to use kinetic Eulerian “Vlasov codes” to solve the Vlasov equation and follow the time evolution of the distribution function (d.f.) in phase space. These “Vlasov codes” were previously used (but still they are!) for low dimensionality problems only because of the many order of magnitude gaps between the various time and space scales entering the solution of a plasma physics problem (this is also true, even if to a lesser degree, in the case of fluid models).

The “Vlasov code” integrates the Vlasov equation for the d.f. in phase space using an Eulerian approach consisting in a fixed in time space-velocity grid. The Vlasov code is complementary to the well-known Particle in Cell code because of the Eulerian versus Lagrangian approach, but the physics they solve is the same being both based on the “mean field theory” model of plasma. The main advantage of the Eulerian approach is that it allows a direct, very accurate and almost noise-free (even in the non linear regime) investigation of the evolution of the d.f. On the other hand, a Vlasov code requires a very large computational memory and a corresponding computing CPU power presently at the limit of the largest parallel computers available allover the world. On the other hand, a Vlasov code is a formidable, unique tool for the understanding of plasma physics mechanisms underlying the dynamics of laboratory and space plasmas.

Here we will give a rapid summary on the mathematics of the algorithms and methods adopted in Vlasov codes shifting rapidly towards their application to solve plasma physics problems of relevance for scientific research in laboratory and space, stressing the strategies and motivations underlying the choice of a Vlasov code, from low dimensionality problems up to 2D-3V and finally 3D-3V very recent simulations.