WPI Programme 2011

Workshop "Vlasov-Maxwell kinetics: theory, simulations and observations in space plasmas."
[Responsible organiser: Califano; co-organizer: F. Valentini]

March 28 - April 1

http://www.df.unipi.it/~califano/Vlasov_W./Vlasov_workshop.html

High temperature laboratory plasmas and, even more, rarefied space plasmas are characterized by a typical collisional time scale much longer than the plasma dynamics time scale. As a consequence, these plasmas can be considered in first approximation as collisionless and the dynamics as Hamiltonian. The best example is probably the solar wind system where the mean free path is of the order of the dimension of the system and where *non Maxwellian* distribution functions are often observed. Therefore, kinetic effects are play an important role in the plasma dynamics in particular concerning the transfer of "ordered" (large scale) energy on small scale fluctuations which, reacting on the particles, push then the system toward an "isotropisation". Coherent kinetic structures with corresponding *non Maxwellian* distribution functions are also generated. At such kinetic length scales, the collisionless *Vlasov mean field theory* is the basic physical model for the study of plasma dynamics.

In this context, the understanding of cross-scale, fluid to kinetic self-consistent evolution is an outstanding theoretical problem, today considered as one of the most important lines of research in plasma physics. Large scales are responsible for the generation of small scale kinetic fluctuations and structures that in turn have important feedback on the global system evolution by relaxing the physical constraints of the large-scale physical regime. The best example is probably the magnetic reconnection process where the local, small-scale violation of the MHD frozen-in condition (i.e. the connection between "fluid elements" and the magnetic field) occurring at non-MHD scale is responsible for global changes of the magnetic field topology accompanied by a energy release up to the formation of coherent kinetic Debye length structures.

The study of cross-scale, fluid to kinetic processes is nowadays the subject of fervent discussion in the scientific community of plasma physics, in particular concerning the study of solar wind turbulence for which a large amount of in-situ, high resolution measurements are available. A fundamental question here is: how the energy coming down from the large MHD scales along the turbulent cascade can be finally dissipated at short wavelengths in the absence of collisional viscosity ?

Modern space missions provide observation data of electric and magnetic fluctuations at high frequencies, thus allowing the systematic analysis of the tail of the turbulent cascade. Several empirical studies have recently addressed this problem exploring the evolution of the turbulent spectra in crossing the typical kinetic scales aiming at understanding the mechanisms responsible for short-wavelength dissipation. On the other hand, from the theoretical point of view, kinetic numerical simulations (Lagrangian PIC and Eulerian Vlasov simulations) using different mathematical models, but all based on the Vlasov equation, recently gave important insights for the interpretation of the system dynamics at short scales and qualitatively reproduced a complex phenomenology routinely observed by many in situ observations, like the generation of perpendicular temperature anisotropy and proton/electron-beam velocity distributions, as well as the presence of a significant level of electrostatic activity at high frequencies.

We propose a workshop where the focus will be on the solution of the Vlasov – Maxwell system of equations and related models able to capture the main physics at play in specific physical applications. The central core will be based on expert in the fields of theory and simulations of the Vlasov equations with applications to space plasmas, including scientists interested on the mathematical and computational aspects connected to this subject as well as experimentalist in the field of satellite observations to be considered as a possible reference for Vlasov model applications.

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