Call for applications for PhD position in the laboratory of excellence, Labex Plas@Par

Title of the postdoc project: Streaming instability in low-energy cosmic rays

Project description

Low-energy cosmic-rays (<100 MeV) are one of the main sources of ionization of dense prestellar cores, and have an important influence not only on the chemistry and thermal balance of the gas, but also on it's coupling to magnetic fields, and ultimately on the formation of stars themselves. The spatial distribution of low-energy cosmic rays is determined by the physics of an instability, which occurs when energetic ions stream along a magnetic field with a bulk velocity in excess of the Alfven speed [1]. This instability excites non-linear hydromagnetic waves and leads to the generation of micro-turbulence, filaments, and to the heating of the background gas. However, the non-linear phase of the instability and its saturation depend critically on the wave damping mechanisms and non-linear decay, which for low-energy cosmic rays is dominated by ion-ion and/or ion-neutral collisions. However, there are no numerical models confirming this pictures [2].

The project aims are twofold. The first is to develop a modelling platform to study the streamng instability within a hybrid regime including Coulomb collisions [3]. The second aim is to study, for the first time, the effects of collisions on the physics of the streaming instability. We want to understand how collisions modify (1) the spectra of micro-turbulence, (2) the formation of density and magnetic field filaments and structures, (3) the saturation of the instability, (4) and finally, to provide information on the heating (and ionization) of the background medium, and its implications for star formation.

The hybrid code is already developed and benchmarked. Most of the numerical work will be dedicated to the parallelization of the Coulomb collision operator, and should be done during the first year. The two subsequent years will be dedicated to run the code (with and without collisions), identify the regimes where quasi-linear theory is at play, and study the non-linear evolution of the instability. For that issue, the candidate should have a strong formation in plasma physics, good skills in computer science (C language and Python for the visualization) and be ready to work on the parallelization.

[1] Kulsrud R. and W. P. Pearce, The Effect of Wave-Particle Interactions on the Propagation of Cosmic Rays, Astrophys. J., 1969

[2] Padoan P. and J. Scalo, Confinement-driven Spatial Variations in the Cosmic-Ray Flux, Astrophys. J. Lett., 2005

[3] Takizuka T. and H. Abe, A binary collision model for plasma simulation with a particle code, J. Comp. Phys., 1977

Requirements for the candidate: Have a master diploma or equivalent.

Applications with CV, copies of degree diplomas and grades, two reference letters, and copies of any previous research-related work statement of motivation. Application deadline is May 31st 2014.

The application should be sent preferably by e-mail to: roch.smets@upmc.fr or andrea.ciardi@upmc.fr

Location and starting date: LERMA and LPP laboratories, University Pierre & Marie Curie, 4 Place Jussieu, 75006 Paris. Starting date: October 2014, 1st.