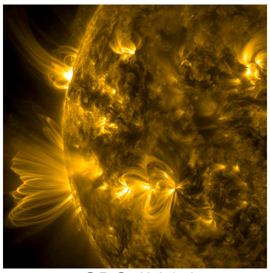
Mathematical modeling and simulation of non-equilibrium plasmas
Application to magnetic reconnection in the Sun atmosphere



SDO (2014)

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The PhD defense will take place on Friday November 15th at 2:15 PM at Amphitheater Sophie Germain at INRIA Saclay (1 Rue Honoré d'Estienne d'Orves, 91120 Palaiseau).

Summary of the thesis

The ability to model, simulate and predict magnetic reconnection(MR) is a stumbling block in order to predict space weather and geomagnetic storms, which can lead to harmful perturbation of satellites. Some fundamental aspects of MR are not yet well understood. The scientific issue at stake is the proper description of the unsteady energy transfer from magnetic energy to kinetic and thermal energy, which is still out of reach for the standard Magneto-hydrodynamics (MHD) models. The first objective of the present thesis is to develop a coherent fluid model for magnetized plasmas out of thermal and chemical equilibrium with a detailed description of the dissipative effects based on kinetic theory of gases, which thus inherits a proper mathematical structure. The second objective of the thesis is to focus on the closure of the fluid model and derive its transport properties computed at the kinetic level. The third goal is the development of a new numerical strategy, with high accuracy and robustness, based on a massively parallel code with adaptive mesh refinement able to cope with the full spectrum of scales of the model and related stiffness. The whole set of transport coefficients, thermodynamics relations and chemical rates in this magnetized two-temperature setting will be studied and compared to the one in the literature used in the field. Then, we will show that the model and related numerical strategy, obtained from this transdisciplinary work involving engineering, plasma physics, solar physics, mathematics, scientific computing and High-Performance Computing (HPC), is able to tackle the problem of MR. The validation of the approach through a series of test-cases relevant for the application to the dynamics of solar atmosphere in collaboration with VKI and NASA will provide a tool, the CanoP code, open to the community, capable of resolving several critical scientific and technological issues.

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