High-order moment models for partially-ionized plasmas

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Partially-ionized plasmas play a fundamental role in a number of diverse scenarios, including the solar lower atmosphere [1], the divertor of tokamaks or the plasmas that are used to create the thrust in satellite electric propulsion [2,3]. In general, these plasmas are difficult to model because of the strong non-equilibrium conditions that result from the mass disparity between the particle species and the interplay of the charged species with the electromagnetic field. For this reason, standalone fluid-based models usually fail to fully represent the physics in weakly-collisional regimes. In this talk, we will derive a velocity-moment plasma model from the kinetic equation by means of Grad's method that accounts for a multi-component reacting mixture in chemical and thermal non-equilibrium with the effect of an electromagnetic field [4]. In addition to mass, momentum, energy, the model considers the evolution of high-order moments as the heat-flux vector and the contracted fourth moment balance. By doing this, the depletion of the electron energy distribution function at high energies, typical in partially-ionized temperature plasmas, is self-consistently captured by the model. We will explain the derivation of the collisional terms for both elastic and inelastic collisions by using the Boltzmann operator as opposed to a simplified BGK operator. The implementation of the set of equations and the numerical difficulties of the coupling with the electromagnetic field will be discussed [5, 6]. Comparison of the plasma moment model with kinetic simulations and experimental results of an inductively coupled plasma discharge for electric propulsion will be also discussed in this seminar.

References:
[1] A. Alvarez Laguna *et al* 2017 *ApJ* **842** 117
[2] T Charoy *et al* 2021 *Plasma Sources Sci. Technol.* **30** 065017
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[6] Alejandro Alvarez Laguna *et al* 2018 *J. Comput. Phys* **231** 31