Simulation of the Interaction Between Two Rarefied Ionized Jets Using a Hybrid Method

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Accurate prediction of the shape and evolution of the velocity distribution function (vdf) $f(\vec{v},\vec{r},t)$ is of paramount importance for the optimization of industrial processes involving low temperature plasmas (LTP) [1]. This can be readily understood by considering that the rate k of kinetic processes (such as chemical reactions) can be written as:

$$k(\vec{r},t) = \int f(\vec{v},\vec{r},t)|\vec{v}|\sigma(\vec{v})d^3\vec{v}, \quad (1)$$

where $\sigma(\vec{v})$ is the particle cross section. This in turn implies that the rate of any such process can be maximized or minimized by optimally shaping the vdf.

The aim of the present study is to present some preliminary simulation results obtained for a canonical flow of argon gas that was specifically crafted to study the interaction between two different species within the context of a cold ionized rarefied flow. This flow is constituted of two counterflowing jets, as shown in Fig. 1: one composed of ionized Ar gas (Ar^+, e^-) and the other of neutral Ar. This canonical flow will be the subject, in upcoming years at the University of Michigan, of very detailed analyses, both experimental and numerical. Our main goal will be to validate numerical models for the prediction of the vdf for the various species in the flow.

The flow is simulated using a hybrid fluid-particle method. Collisions between heavier particles (Ar^+ and Ar) are handled via a direct simulation Monte Carlo (DSMC) method [2]. A particle in cell (PIC) method [3] is used to model the effect of the electrical field on the ions. The electrical field is obtained by modeling the electrons as a fluid and making use of the Boltzmann relation [1].

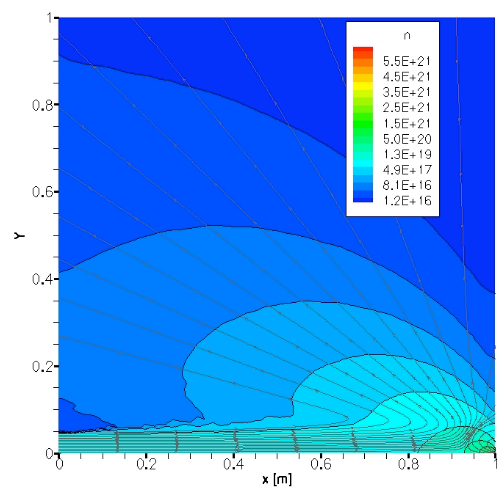

Fig.1: Streamlines and number density n [m^{-3}] of the flow.

An exploratory parametric study is conducted to determine the influence of the various parameters of the flow on the shape of the vdf for the heavy particles. The aim is to gain some understanding of the basic physical phenomena at play in such a flow as well as to identify any shortcomings of the simplified model that will need to be addressed in future work.

REFFERENCES

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