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The importance of ion temperature profile in collisional sheath modelling

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Plasma discharges contains two distinct zones having different physical properties, namely the quasi-neutral bulk plasma and the sheath where the quasi-neutrality does not hold, separated by an intermediate transition zone called pre-sheath [1]. In particular, the sheath has a strong impact on the entire gas discharge since it is where the plasma interacts with the boundaries. The plasma-sheath transition is still a subject of active research today mainly due to its complex structure [2,3]. The modelling of an entire plasma discharge including the dynamics of sheaths is crucial to understand the behaviour of different plasmas such as nano-particle creation in sputtering magnetron discharge [4], also observed in the coldest region of tokamaks [5].

In this context a new and reliable numerical model for low-temperature plasma discharges including the sheaths is currently under development. Although kinetic models and Particle-In-Cell (PIC) methods [6, 7] are often preferred for their fidelity, they are limited by numerical constraints on the simulation time and memory requirements due to the high number of macro-particles necessary to accurately simulate high density plasmas and the sheaths.
Fluid approaches are limited by the model accuracy itself, but are less demanding in computational resources and is still capable of giving insights of the main physical phenomenon.
In this work, we focus on 1D plasma fluid model adapted for the simulation of medium to high pressure (10^{-1} - 10^{2}Pa) direct-current (DC) argon discharges.
In particular, a non quasi-neutral drift-diffusion model of two charged species –ions and electrons was developed aiming at correctly modelling the sheaths. The results are compared with PIC simulation outputs. Our results emphasize for the first time the importance of the ion temperature profile when their collisionality in the sheaths is not negligible.

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Keyword-2

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Keyword-3

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