Fundamental aspects of plasma sheath associated with secondary electron emission

By nature, a plasma is composed of charged particles which, in response to electromagnetic fields they generate or which are applied to them, exhibit collective behaviors from which quasi-neutrality results on spatial scales larger than the Debye lengths. This property break-down when the plasma encounters a solid frontiers where non-neutral sheath forms at Debye length scales and, potentially, deeply impact on the bulk dynamics, *i.e.* far from the frontiers. Ions and electrons dynamics, due to their mass difference, evolve with different temporal scales. In particular, when approaching an external object , which can be device boundaries in experiments or bodies in astrophyscal contexts, multi-scale physics phenomena emerge especially where the sheath is formed. Surfaces immersed in a plasma could emit secondary electrons which change the physics of the sheath. Even more, some numerical theories predict an "inverse sheath" [1].

The physics of plasma sheath is of major interest in the fields of, both, laboratory, astrophysics and fusion by magnetic confinement (tokamaks,...). Many studies have been devoted to the understanding of plasma sheath [2]. However, comparisons of theoretical models to experiment can sometimes show disagreements, in particular in sheath where secondary electrons are emitted [1, 3, 4]. In that context, the long-term goal of this intership is to improve comparison between models and experiments of electrostatic plasma sheath. Models developed during this internship will be compared with experimental results on emissive sheath obtained by the experimental group of the PIIM laboratory

Scales involved in plasma sheaths and the breakdown of quasi-neutrality make adequate the kinetic description. However, kinetic simulations are computationally too demanding for comprehensive kinetic simulations in some regimes compare to fluid approaches. Moreover, building reduced models to extract physics mechanisms, often, hinge upon fluid modeling with adequate closures. A clue in the sheath physics context of this work will be to specify also hypothesis for the distribution functions. Moreover it has been shown recently that fluid model can describe collisional sheaths [5]. To explore non collisional sheath physics which are ubiquitous in nature and experiments, as first step, a kinetic model with an appropriate physical modeling of sources [6] will be developed and compared to devoted experiments. This model will be used to derive closures for a two fluids model. Cross comparisons between kinetic and fluid models will be done in order to improve the fluid closures, both analytically and numerically.

The student must have master's level knowledge in mathematics, numerical calculation and plasma physics to carry out theoretical calculations and participate in numerical code development. He will have available fluid [5] and kinetic codes developed at the PIIM.

The master's internship will be supervised at the PIIM laboratory by M. Muraglia and N. Dubuit. This subject is associated to a thesis subject funded by AMIDEX which will be directed by M. Muraglia and co-directed by G. Fubiani (Lalpace laboratory at Toulouse) and supervised by N. Claire(PIIM) and O. Agullo (PIIM).

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