Applications of hybrid computer models in plasma sheath physics

J. Hromadka, T. Ibehej, R. Hrach

Department of Surface and Plasma Science, Faculty of Mathematics and Physics, Charles University, Prague, Czech republic

An increase in performance of computers as well as advancements in high performance parallel algorithms over several past decades allowed computer modelling to be included among other plasma research tools as a valuable source of information. Problems that are addressed in plasma physics are often difficult to be treated analytically due to various reasons (nonlinear effects, nonequilibrium plasma states, complex 3D geometries, etc.) and thus, it becomes an area where computer models are able to provide deeper insight into the studied phenomena.

Plasma is known as an environment where phenomena over multiple length and time scales are coupled. However, particle computer models that are able to capture microscopic effects precisely enough demand huge computational resources. As a result, they are often limited to 2D configurations of limited size. On the other hand, macroscopic fluid models that are not so computationally demanding give results with only limited accuracy caused by the lack of microscopic information. Hybrid models (e.g. [1], [2]) that take advantage of both modelling techniques mentioned above seem to be a promising concept to overcome these difficulties. Our contribution presents possibilities how to extend the applicability of current hybrid models, particularly to low pressure regime.

Findings of plasma sheath physics are of great importance in applications where plasma interacts with surfaces of solids (e.g. Langmuir probe diagnostics, industrial plasma-based surface processing of materials, plasma facing components in fusion devices, etc.). The theory of plasma sheath has already been developed, e.g. [3]. However, a lot of questions are still open – e.g. effect of multiple ion species and their finite temperature on Bohm criterion, behavior of plasma sheath in complex 3D geometries, interaction of several plasma sheaths. Our contribution addresses these questions by developed 3D hybrid model for various pressure regimes.