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Plasma-Sheath Revisited

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The formulation of the plasma-wall problem goes back to Langmuir and Tonks, but up to this day has remained an intriguing and controversial problem. Its numerical solution shows a smooth transition from plasma to sheath and provides a limited understanding of the plasma-sheath interface. In many applications (such as plasma probe diagnostics, dc and rf discharges) the electrical properties of bounded plasma-sheath systems are controlled by the sheath. It is therefore common to study plasma and sheath separately using different mathematical models which provide an insight into each region. These models are quite simple, and often can be solved analytically, or by using simple numerical schemes. When plasma and sheath are studied separately, one has to decide how to join the solutions of the corresponding models. Two approaches are found in the literature to deal with this problem: one is the method of matched asymptotic expansions and the second one is patching. Application of asymptotic matching techniques to the plasma-wall problem has led to important theoretical results. However, the mathematical formalism and complexity associated with that method makes it difficult to use in applications. Moreover, the asymptotic plasma and the sheath solutions cannot be matched directly, and the modeling of an intermediate layer between the plasma and the sheath is required for a successful matching. Patching seems to be a more practical approach. Its idea is to join solutions of two different models by forcing their values and perhaps several derivatives to agree at some chosen point (the patching point). The main purpose of patching is to obtain continuity, but, in theory, smoothness is also possible. In contrast to asymptotic matching, it is possible to patch the plasma and the sheath solutions directly, eliminating the need for modeling an intermediate layer. The subject of this presentation is to discuss various fluid plasma and sheath models and their relationship to the corresponding plasma-wall problem. We will discuss the regions where the plasma and the sheath solutions are valid and develop discrete two-media plasma-sheath models which can be used to express the sheath characteristics through the plasma characteristics, or to find the integral characteristics of the sheath for given plasma parameters.