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Beyond analytic inference techniques with multivariate regression

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For nearly a century, Langmuir probes have been used to infer plasma densities and temperatures from current characteristics. In practically all cases, these inferences are based on analytic expressions obtained theoretically. Despite their limitations, analytic expressions continue to be used because of their relative simplicity, and the fact that they can be used to construct fast inference techniques requiring only modest computing resources. With recent advances in computer technology, and the development of sophisticated plasma simulation models, it is now possible to reproduce in silico, the response of sensors to different plasma environments, while accounting for more physical processes, a more detailed geometries, that possible analytically. However, even the fastest computers and the most advanced numerical models are unable to directly provide sufficiently fast inference algorithms for near-real time data processing. One approach that we have been pursuing consists of using 3D kinetic simulations to calculate sensor responses for a range of plasma parameters of interest, constructing solution libraries; that is sets of computed responses, along with corresponding plasma parameters. These sets can then be used to construct and test multivariate regression techniques whereby selected plasma parameters can be inferred. In this talk I will present the general steps involved in the construction of solution libraries, the use of inference models based on regressions, and the assessment of these methods. I will also present an application of the method to actual space plasma measurements.

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