Abstract Submitted
for the GEC07 Meeting of
The American Physical Society

Sorting Category: 2.11 (C)

Numerical Solutions for Langmuir Probes[1] RICHARD FERNSLER, Plasma Physics Division, Naval Research Laboratory — A simple numerical technique is presented for computing the electrostatic potential around spherical and cylindrical Langmuir probes residing in plasmas consisting of hot electrons and cold, collisionless, positive ions. Rather than solving Poisson's equation directly, its derivative is solved instead using a "shooting" method. The new equation is one order higher, but it is linear in the field and can thus be solved implicitly. The scheme is therefore stable numerically, but it requires initial values for the potential, electric field, and derivative of the field at some starting location. Fortunately, these parameters are all easy to obtain in the bulk plasma. The numerical results show that the sheath around the probe can be surprisingly wide, and as a result the ion saturation current has a more complicated dependence on probe voltage than is commonly assumed. (That dependence is related to but separate from the variation seen with probes smaller than a Debye length.) The numerical technique presented can in principle be used with any nonlinear, ordinary differential equation (including with multipoint boundary conditions or unknown eigenvalues), provided a suitable set of initial values can be obtained.

[1]This work was supported by the Office of Naval Research

[X] Prefer Oral Session
[ ] Prefer Poster Session

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Date submitted: 15 Jun 2007 Electronic form version 1.4