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TOWARDS LINKING FLUID AND KINETIC PARAMETERS NEAR THE PLASMA BOUNDARY

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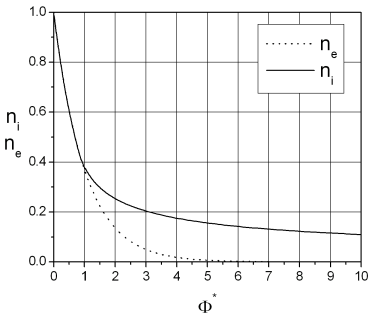
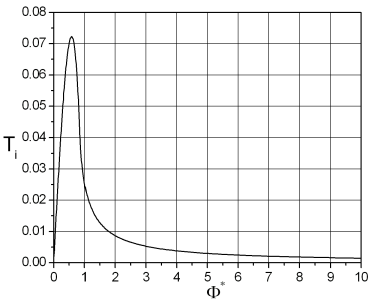
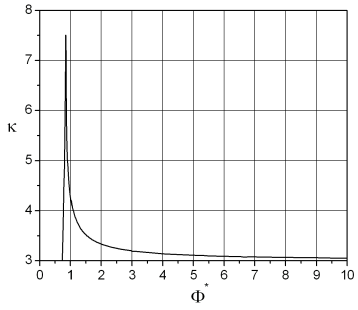
In this paper we consider the problem of linking fluid and kinetic plasma parameters at the plasma boundary, i.e., at the plasma-sheath edge. For this purpose, we propose a general method of explicitly calculating the ion polytropic coefficient in terms of any given ion velocity distribution, thus closing the set of related fluid equations. In the past, this problem has been elaborated in detail for the special case of a water-bag distribution (see e.g., [1]), where it has been shown that the closed moment description is entirely equivalent to the collisionless kinetic single water-bag model. Our method is first demonstrated for this simple case and then applied to the more complex Tonks-Langmuir model with the ion energy distribution







$$f_i(\mathcal{E}) = \frac{n_o}{\pi}\sqrt{\frac{2m_i}{kT_e}}\left[\sqrt{-\frac{kT_e}{\mathcal{E}}} - 2F\left(\sqrt{-\frac{\mathcal{E}}{kT_e}}\right)\right] \tag{1}$$

where e is the elementary charge, m_i is the ion mass, f_i is the ion velocity distribution, n_o is the plasma density far from the boundary, T_e is the electron temperature, k is the Boltzmann constant, $\mathcal{E} = m_i v^2/2 + e\Phi$ is the total particle energy, and

$$F(y) = \exp(-y^2)\int_o^y \exp(y'^2)dy' \tag{2}$$

is the Dawson function. We derive the adiabatic parameter for the distribution (1), thus arriving at a closure of the related hydrodynamic equations. Further development of our method is proposed in this paper for other theoretical and experimental ion velocity distributions that are of interest for laboratory and fusion plasmas.

References

[1] Ronald C. Davidson, *Methods in Nonlinear Plasma Theory*, Academic Press, New York and London (1972)