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# Calculation of the ion current to a conducting cylinder in a supersonic flow of a collisionless plasma

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The diagnostics of low-temperature plasma flows using cylindrical probes is based on the classical Langmuir relation for the ion current to a thin, in comparison with the Debye length, cylinder. The aim of this work is to study the applicability of the Langmuir relation for a cylinder whose radius exceeds the Debye length.

The interaction of a conducting cylinder with a rarefied plasma flow was simulated numerically. The cylinder had a negative potential with respect to the plasma. Free molecular flow around the cylinder was simulated on the basis of a two-dimensional system of the Vlasov–Poisson equations. The electron-repulsing local equilibrium self-consistent electric field was calculated using the Poisson–Boltzmann model in the approximation of local equilibrium electrons and taking into account an electron sink on the cylinder surface in the central field approximation. The Vlasov equations for ions and the Poisson–Boltzmann equations for the self-consistent electric field were solved on nested grids by a finite-difference relaxation method with splitting by physical processes and using the method of characteristics. The reliability of the calculated results was confirmed by the solution of known model problems and a comparison with the results of other authors and the results of solving identical physical problems with the use of different mathematical models and methods.

The ion current to a cylinder placed transversely to a plasma flow was calculated as a function of the cylinder potential, the ion velocity ratio, and the ratio of the characteristic dimension of the cylinder to the Debye length. From the calculated results, numerical estimates were obtained for the range of applicability of the classical Langmuir relation for the ion current to a cylinder whose radius exceeds the Debye length. The results obtained may be used in the diagnostics of supersonic flows of a low-temperature rarefied plasma.

***Keywords***: rarefied nonisothermal plasma flow, transverse free molecular flow around a long circular cylinder, numerical simulation, system of Vlasov–Poisson equations, calculation of the ion current to a cylinder.

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