Topic number: 7

Screening of Absorbing Particles in Plasma with a Flow

Yuriy Tyshetskiy*, Sergey Vladimirov
School of Physics, University of Sydney, NSW 2006, Australia
* *y.tyshetskiy@physics.usyd.edu.au*

The problem of screening of a test (non-absorbing) charged particle (grain) in unmagnetized anisotropic plasmas is known since the late 1960s, starting with the works of Montgomery *et al.* [1] and Cooper [2]. The solutions of the screening problem, obtained for weakly [2] and strongly [3] anisotropic collisionless plasmas (i.e., plasmas with subthermal and superthermal flows, respectively), imply that two like-charged test particles aligned perpendicularly to the anisotropy axis will attract each other electrostatically, if they are at large enough distance from each other. This attraction can play a vital role in formation of dust crystals and clusters in complex plasmas [4]. However, absorption of ions by the grain affects the screening, changing the far asymptote of the screening potential, at least in isotropic plasma, and may change, or even eliminate completely, the attractive part of the screening potential in anisotropic plasmas.

In this work, we investigate how absorption of plasma ions by a dust particle (probe) affects the screening and, in particular, how it affects the possibility of attraction between like-charged absorbing particles in anisotropic plasmas. We base on the linear kinetic model of electrostatic screening of a small absorbing particle in anisotropic collisionless plasma. The model takes into account the ion absorption on the particle by using the point-sink approximation. Two limits are considered in which analytical solution can be obtained: subthermal flow $u \ll v_{Ti}$, and superthermal flow $u \gg v_{Ti}$ (here u is the flow velocity, and v_{Ti} is the ion thermal velocity). The linear electrostatic potential of the particle is obtained in both cases, which consists of two parts: the electrostatic potential ϕ_Q of a test (non-absorbing) particle, and the part ϕ_{abs} arising due to absorption. Using the obtained solutions, we analyse how the absorption affects the screening potential of the particle. In particular, we show that for both subthermal and superthermal flows, absorption leads to a qualitative change in the far asymptote of the grain potential from quadrupole-like (for non-absorbing grain) to dipole-like (for absorbing grain). In case of subthermal flows, this change can significantly modify or even eliminate the attraction between like-charged grains, therefore the absorption should be taken into account when considering interaction of grains in dust crystals or dust clusters in plasmas with weak (subthermal) flows. In case of superthermal flows, however, the qualitative change of the grain potential caused by absorption occurs only at distances that are typically very large compared to the characteristic screening scale, hence the effect of absorption on grain screening potential can be safely ignored in most practical cases relevant to experiments where dust grains are immersed in plasmas with superthermal flows.

References

[1] D. Montgomery, G. Joyce, and R. Sugihara, 1968 *Plasma Phys*. **10**, 681
[2] G. Cooper, 1969 *Phys. Fluids* **12**, 2707
[3] R. Kompaneets, S.V. Vladimirov, A.V. Ivlev, and G. Morfill, 2008 *New J. of Physics* **10,** 063018
[4] V.N. Tsytovich, G.E. Morfill, S.V. Vladimirov, and H. Thomas, 2008 *Elementary Physics of Complex Plasmas*, Lect. Notes Phys. 731 (Springer, Berlin Heidelberg)