Drag force on an absorbing body in highly collisional plasmas

S. A. Khrapak

Max-Planck-Institut fuer extraterrestrische Physik, D-85741 Garching, Germany

Of particular importance for complex plasmas is the ion drag force associated with the momentum transfer between the (drifting) ions and highly charged dust particles (grains). The formation of so-called ``voids'' in experiments with complex plasmas under microgravity conditions, which can be explained by the action of the ion drag force, provides a good example of the significance of this effect. Many studies were recently concentrated on this important issue, including theories, computer simulations, and experiments. The large interest in the problem of ion drag demonstrates not only the importance of this topic, but also its complexity. Such factors as ion-neutral collisions, the degree of ion-grain coupling, deviations of the electric potential around the grain from (the often assumed) Debye-Hückel (Yukawa) form etc. can greatly affect the physics of the momentum transfer and the magnitude of the ion drag force. In view of this complexity no comprehensive model describing all possible situations of interest has yet been constructed. Rather, there exist several approaches which can be used under certain conditions.

The focus of this talk is on the effect of ion-neutral collisions on the ion drag force. For sufficiently small grains in collisionless situations there is generally a satisfactory agreement between modern analytical theories on the one hand and results from numerical simulations and experiments on the other hand. There is also indirect confirmation of the reliability of these collisionless ion drag models: The experimentally determined potential inside the void in complex plasmas under microgravity conditions at low pressures is in reasonable agreement with the theoretical predictions. In the opposite collisional case available numerical simulations have demonstrated a *decrease* of the ion drag force even leading to *negative values* (i.e., ion drag force is directed oppositely to the ion flow) [Schweigert et al. (2004), Maiorov et al. (2005)]. On the contrary, an analytical model by Ivlev et al. (2004,2005) developed recently predicts an *increase* of the ion drag force with the ion collisionality. The effects associated with plasma collection on the grain were, however, neglected in these theoretical studies.

Motivated by these circumstances, a detailed analysis of the highly collisional limit, where the effects of plasma absorption can be easily accounted for, has been carried out using the linear response formalism. In particular, we demonstrate that plasma absorption and related effects play an important role and lead to a considerable reduction of the ion drag force. The magnitude of this reduction is proportional to the value of the ion flux absorbed by the grain, and if an asymptotic expression for the ion flux in the continuum limit is used, the force can indeed assume *negative* values. The reliability of this result is discussed and several issues which require further investigation are summarized.