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INFLUENCE OF COLLISIONS ON WAKE DUE TO GRAIN IN NON-MAXWELLIAN PLASMAS

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Abstract: We discuss the formation of wake fields due to streaming around a charged dust particle, using three-dimensional particle-in-cell (PIC) simulations with charge-neutral collisions. Ion distribution becomes non-Maxwellian in the presence of external driving electric field and collision. In-depth investigation of role of collision in influencing the wake peak amplitude and position of the wake potential is analyzed for a wide range of ion streaming velocities. For very small flow velocities, collision-induced amplification is observed for both Maxwellian as well as non-Maxwellian distributions. However, the drift-driven non-Maxwellian distribution shows an increase of the wake peak amplitude higher collision frequencies at high streaming velocities.

1. INTRODUCTION

Wake formation behind a grain in the presence of streaming ions has been explored extensively in experiments[1], theory[2], and simulations[3]. A stationary dust grain immersed in stationary plasma acquires negative charge due to impact of highly mobile electrons. However, in the presence of streaming ions, the dynamics changes significantly. In previous reported works[4], shifted Maxwellian distribution has been used to model streaming ions past grain. These ions focus behind grain eventually leading to the formation of wake behind grain.

It should be noted that the presence of external driving electric field and charge-exchange collisions (which are the dominant ones) makes the ion distribution non-Maxwellian and to model streaming ions past grain would be inappropriate for many experimental situations eg for discharge experiments above 10Pa. In this work, we delineate the differences in the wake feature due to non-Maxwellian ion distribution from that due to Shifted Maxwellian and present a systematic study of the wake dependence on ion flow speed, collisions etc.

2. INTRODUCTION TO METHODOLOGY AND A COMPARISON WITH PREVIOUS MODELS

We study the wake attributes of grain in the presence of non-Maxwellian ions with COPTIC[5] particle-in-cell code and present its non-monotonic dependence on charge-exchange collisions.

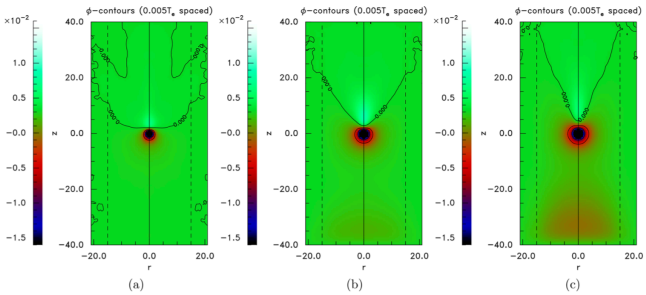
2.1 System Description

We have considered an isolated grain in streaming ions in three-dimensional cartesian system in the presence of external driving field as well as collisions. Ion dynamics in six-dimensional phase space in the presence of self-consistent or external driving electric field can be delineated by

$$m_i \frac{d\vec{V}}{dt} = -e\nabla\phi + \vec{D}$$

Here, $\vec{D}$ is the optional external field. Electrons are governed by Boltzmann description and can suitably be described with

$$n_e = n_{e0} \exp(e\phi/T)$$



Contour plots of the grain potential for various collision frequencies: (a) 0.02 (b) 0.2, and (c) 0.4 with streaming velocity (Mach Number =0.8) for the non-Maxwellian streaming ions.

3. RESULTS

4. DISCUSSION AND CONCLUSION

The wake behavior for the non-Maxwellian ions exhibit significant deviations from those observed within the purview of a shifted Maxwellian distribution. For the non-Maxwellian ions, only one potential maximum has been observed even for the weak damping case and wake amplitude increases with collisionality.

REFERENCES

[1] S. Sundar, Hanno Kaehlert, Jan-Philip Joost, Patrick Ludwig, and Michael Bonitz, “Impact of collisions on the dust wake potential with Maxwellian and non-Maxwellian ions”, *Phys. Plasmas*, **24**, 102130 (2017).