Vacuum 83 (2009) 1031–1035

Contents lists available at ScienceDirect

Vacuum

journal homepage: www.elsevier.com/locate/vacuum

Effect of dust–neutral collisions on the dust characteristics in a magnetized plasma sheath

S. Farhad Masoudi [a,*], G. Reza Jafari [b], Hossein Akbarian Shorakaee [a]

[a] Department of Physics, K.N. Toosi University of Technology, 41, Shahid Kavian St., P.O. Box 15875, 4416 Tehran, Iran
[b] Department of Physics, Shahid Beheshti University, G. C. Evin, Tehran 19839, Iran

ARTICLE INFO

Article history:
Received 22 May 2008
Received in revised form
31 January 2009
Accepted 2 February 2009

Keywords:
Plasma sheath
Dust particles
Collision force
Magnetic field

ABSTRACT

The characteristics of dust in a plasma sheath are investigated in the presence of an external magnetic field and taking into account the dust–neutral collision force. The continuity and momentum equations of ions and dust particles are solved numerically with various magnitudes of collision force by using the fluid model. The numerical results have revealed that the collision force reduces the dust gyro radius, changes the positions of the extrema of the dust density and the velocity in the depth direction. It is shown that the collision force reduces the dust kinetic energy which has no fluctuation even in a strong external magnetic field.

1. Introduction

The problem of plasma flowing into a wall has previously been studied [1]. Investigation into the characteristics of the space charged region in front of the wall is one of the oldest problems in plasma physics. This region which shields the bulk plasma from the wall is named the "sheath". Studying the sheath region has continued to remain of the current interest because of its practical importance in plasma dynamics [2–6]. Recently, the study of the plasma sheath in the presence of dust has become an important research area due to its common observance in laboratory and space plasmas [7–11].

Compared with other charged grains, the dust has considerable charge and mass. The typical dust particles have ~micron sized, ~1000e negative charges and ~1000 kg/m^3 mass density. Moreover, as these characteristics are dynamic variables, the behavior of the dust particles modifies the plasma dynamics and their effects may have properties different from those caused by negative ions.

During the past decades, several studies have been developed to investigate the structure of dust plasma sheath [12–15]. They include for example, the fluid model [14,16], isolated particle model [17], electrostatic probe model [18] and a new one called the dust acoustic wave model [19]. These studies have considered the effect of parameters which modify the dust plasma characteristics, such as the action of electrostatic, gravitational force and the Lorentz force. Two important factors which affect the structure of the dust plasma sheath are the collision force and external magnetic field. Only a few of the studies have considered the external magnetic field [13–15,20,21]. It has been shown that the structure of the dust plasma sheath without magnetic field is considerably different from the dust plasma sheath in an external magnetic field.

In the present study, we simultaneously consider the effects of the electrostatic, gravitational, external magnetic field and the collision force on dust characteristics. Based on some earlier studies [14,15,22,23], the fluid model is used for a dust plasma sheath which has one-dimensional coordinate space and three-dimensional velocity space. Solving the basic equations of ion and dust movement, we investigate the effect of the magnitude of the collision force on some characteristics of dust grains like gyration movement, velocity, kinetic energy and the density of dust.

We assume that the collisions between ions (which are treated as a cold fluid) and neutrals can be neglected. The sheath is generally investigated in two limiting cases; collisionless ($\lambda_i >> \lambda_e$) and collisional ($\lambda_i << \lambda_e$) case, where λ_i is ion mean free path and λ_e is Debye length. For dust–neutral collisions we assume $\lambda_d \sim \lambda_e$ for the weak collision case where λ_d is the dust mean free path. The ratio of dust mean free path to the Debye length is taken into account by using a parameter α. This means we are in a regime where $\lambda_e/\lambda_i = \alpha_i << 1$ and $\lambda_e/\lambda_d = \alpha_d \sim 1$. This regime has been considered elsewhere [12,24]. The numerical simulations are investigated under various conditions of the external magnetic field and the results are compared.

* Corresponding author.
E-mail address: masoudi@kntu.ac.ir (S.F. Masoudi).

0042-207X/$ – see front matter © 2009 Elsevier Ltd. All rights reserved.
doi:10.1016/j.vacuum.2009.02.003