IOP PUBLISHING JOURNAL OF PHYSICS D: APPLIED PHYSICS

J. Phys. D: Appl. Phys. **40** (2007) 6641–6645 doi:10.1088/0022-3727/40/21/024

A magnetized plasma sheath where the ion collision frequency depends on ion flow velocity

S Farhad Masoudi

Department of Physics, K N Toosi University of Technology, PO Box 15875-4416, Tehran, Iran

Received 6 June 2007, in final form 16 August 2007
Published 19 October 2007
Online at stacks.iop.org/JPhysD/40/6641

Abstract

Recently some correlative works have been done to investigate the effects of collisions between ion and neutral gas atoms on the characteristics of plasma sheath in an external magnetic field. In general, the momentum transferring cross section (and thus the ion collision frequency) has a power law dependence on the ion flow velocity in the depth direction. Usually in the literature, constant collision frequency and constant mean free path are treated. Here, by using a collisional fluid model, we investigate the characteristics of a magnetized plasma sheath where the ion cross section depends on the ion flow velocity. The numerical calculations show that the effects of collisions on ion characteristics are more powerful when the momentum transferring cross section is constant. However, some parameters such as the electron density distribution are independent of this dependence.

1. Introduction

The significant importance of the electrodynamic properties of the plasma sheath in plasma experiment equipment and other applications has generated interest in investigating the structure of the plasma sheath. Many researchers have recently tried to develop several works, both empirically and theoretically to study the plasma sheath [1–7]. In these works, the electrodynamic properties of the plasma sheath such as the electron and ion density distribution, ion flow velocity and electron potential have been investigated under various conditions such as in the presence of an external magnetic field or under the effect of collisions between the ion and the neutral gas atoms [7–9]. These effects are two important conditions which affect the structure of the plasma sheath. For example, Zou *et al* studied the structure of the non-collisional plasma sheath in an oblique magnetic field and showed that the magnetic field cannot be ignored compared with the electrostatic field [7]. A corresponding study for collisional magnetic plasma sheath has been done in [9], in which, by considering the ion collision frequency as a constant parameter, the effects of the magnitude of the ion collision frequency on the magnetic plasma sheath are investigated.

However, in the general case, the ion collision frequency depends on the ion velocity. As the ion flow velocity changes in the plasma sheath as a function of the depth direction, so does the ion collision frequency. Here we investigate the effect of this dependence on the characteristics of the magnetic plasma sheath.

2. Basic equations of the model

In our model, we consider a magnetic plasma sheath in contact with a planar wall. The density, velocity and mass of the ion (n_i, $\boldsymbol{v}$ and m_i, respectively), the external magnetic field ($\boldsymbol{B}$) and the effective ion collision frequency (ν_i) are related to each other by equations of continuity and momentum as follows:

Continuity:

$$\vec{\nabla} \cdot (n_i \vec{v}) = 0, \tag{1}$$

Momentum:

$$(\vec{v} \cdot \vec{\nabla})\vec{v} = \frac{e}{m_i}(-\vec{\nabla}\phi + \vec{v} \times \vec{B}) - \nu_i \vec{v}. \tag{2}$$

We assume that the electron energy is not very high. This assumption enables us to neglect the ionization [10, 11], as we consider this fact in the equation of continuity.

The ion collision frequency can be expressed as a function of neutral gas density (n_n), the momentum transferring cross

