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Double-Hump Distribution in the Polar Wind

By

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Double-Hump Distribution in the Polar Wind

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Declaration

I certify that this thesis submitted for the degree of Master of physics is the result of my own research, except where otherwise acknowledged, and that this thesis (or any part of the same) has not been submitted for a higher degree to any other university or institution.

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Dedication

To my father, Abu Samer, my mother, Um Samer.

To my wife, Ebtihaj, and my daughters, Lara and Sara.

To my brothers, and my sisters.

With Admiration

Abstract

In this study, the Monte Carlo model was used to investigate the characteristics of the H^+ polar wind under the effects of gravity, divergence of magnetic field , polarized electric field, Coulomb collision of H^+-O^+, and wave-particle interaction (WPI). The Fokker-Planck representation for Coulomb collision was used, and the wave-particle interaction was considered as a diffusion in velocity space. The simulation region was extended from 230 Km to 5350 Km.

It was found that WPI plays an important role in the characteristics of the H^+ polar wind. It enhances and increases the drift velocity, parallel temperature and perpendicular temperature of the H^+ ions; while it decreases the density. The WPI results in changing the shape of the velocity distribution function rapidly for high WPI values.

The H^+ double-hump distribution was observed at intermediate altitudes or around (~1570 km). Besides, this study has shown that the formation of H^+ double hump distributions can be observed at lower altitudes, (namely; ~1030 km for $\widetilde{D}_\perp = 0.01$ and at ~890 km for $\widetilde{D}_\perp = 0.1$) when WPI is included.

ملخص

في هذه الدراسه تم استخدام تقنية المونتي كارلو لدراسة خصائص الرياح القطبيه لايونات الهيدروجين تحت تاثير الجاذبيه الارضيه، انحراف خطوط المجال المغناطيسي الارضي، المجال الكهرباني المستقطب، اثر كولومب على تصادمات ايونات الهيدروجين وايونات الاكسجين وتفاعلات الموجه-الماده، تمتد منطقة الدراسه من ارتفاع 230 كم الى ارتفاع 5350 كم، وقد تم استخدام نموذج فوكر-بلانك لدراسة تاثير كولومب على تصادمات الانويه وتم اعتبار تفاعل الموجه-الماده كانتشار في فضاء السرعة.

من خلال الدراسة وجد أن تفاعل الموجه-الماده تلعب دورا هاما في خصائص الرياح القطبيه لتوزيع ايونات الهيدروجين، حيث تعمل على زيادة السرعة الاندفاعيه،وعلى زيادة عزم درجة الحرارة الموازية، و عزم درجة الحرارة العمودية لايونات الهيدروجين، بينما تقل الكثافة. اما شكل اقتران توزيع السرع فوجد انه يتغير باضطراد بسبب تفاعل الموجه-الماده، و خاصة عندما تكون قيمة معامل الانتشار كبيرة.

في هذه الدراسه تم الحصول على توزيعات ثنائية القمه لايونات الهيدروجين على ارتفاعات متوسطه (~ 1570كم). علاوة على ذلك، فقد تميزت هذه الدراسه بالحصول على توزيعات ثنائية ألقمه لايونات الهيدروجين وبالتحديد وجود هذه التوزيعات على ارتفاعات منخفضة (~1030كم عندما تكون قيمة $\widetilde{D}_{\perp} = 0.01$ ، و~890 كم عندما تكون قيمة $\widetilde{D}_{\perp} = 0.1$)كنتيجة طبيعيه لادخال اثر تفاعل الموجه-الماده.

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List of Abbreviations

WPI	Wave-particle interaction
PIC	Particle in cell
PWI	Plasma wave instrument
DE-1	Dynamic explorer-1
VDF	Velocity distribution function

Chapter One

INTRODUCTION

Chapter One

Introduction

1.1 The Polar Wind

The geomagnetic field configuration in a vast region closed to the earth is modified by the interaction of the solar wind with the earth dipole magnetic field (*Axford* and *Hines*, 1961). A typical shape of the geomagnetic field lines is shown in Figure 1. When the solar wind plasma flows a cross magnetic field lines, it compresses the magnetic field lines in the sunward side and a long tail-like structure in the antisunward side of the earth is formed(*Ganguli*, 1996). Since the pressure in the ionosphere is much greater than along the magnetosphere tail, a continual escape of thermal plasma should occur along these tails. This type of outflow was termed as "*polar wind*" in analogy to the solar wind (*Axford*, 1968). *Axford* has defined the polar wind as an outflow of thermal plasma in the polar cap region from high-latitude terrestrial ionosphere to the magnetosphere.

Sources of the polar wind are ionospheric plasma and the solar wind. In general the polar wind consists mainly of H^+, He^+, and O^+ ions and free electrons.

As the polar wind flows, four major transitions have been occurred: Firstly, chemical to diffusion dominance, secondly, heavy to light ion composition, thirdly, collision dominated to collisionless regimes and fourthly subsonic to supersonic flow (*Barghouthi et al.*, 1993). Collisions are important up to 2500 km after that a temperature anisotropy have been exhibited by the ions and electrons. Outflow of polar wind was found to vary with seasons, solar cycles and geomagnetic activities. For instance O^+ flux exhibits maximum values during summer season, while H^+ flux