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The Effect of Velocity Dependent Wave-Particle Interactions on The Polar Wind Plasma

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Abstract

The escape of the polar wind plasma is an important element in the ionosphere-magnetosphere coupling. The effect of velocity dependent wave-particle interactions on the H^+ and O^+ outflow characteristics of polar wind plasma was investigated. The Monte Carlo model included gravitational field **g**, polarization electric field E_p , and the divergence of the geomagnetic field. In the simulation region (1.7 to 14 earth radii, R_e), the ions were assumed to be collisionless and the electrons to obey a Boltzmann relation. The effect of velocity dependent WPI was introduced in Monte Carlo technique and an iterative approach was used in order to converge to self-consistent results.

Due to perpendicular heating the ions are heated and move to higher altitudes, using the velocity dependent WPI, the heating becomes self limited, and the H^+ and O^+ ions distributions display toroidal features. This result is consistent with the observations of both H^+ and O^+ toroidal distributions at the high latitudes. This thesis reports the first mechanism to explain the toroidal observations in the high latitude region.

ملخص

يعد هروب بلازما الرياح القطبية عنصرا مهما في الربط ما بين طبقتي الايونسفير (ionosphere) و المغنتوسفير (magnetosphere) . تم اختبار تاثير تفاعل الامواج الكهرومغناطيسية المعتمدة على سرعة الايونات على خصائص تدفق البلازما في الرياح القطبية. لقد احتوى النموذج الحاسوبي على تاثير تسارع الجاذبية الارضية، المجال الكهربائي المستقطب، وانحدار المجال المغناطيسي الارضي بالاضافة الى تأثير تفاعل الموجة والجسيم ، ضمن منطقة المحاكاة (1.7-14 نصف قطر الارض)، تم اعتبار الايونات عديمة التصادمات والالكترونات تحقق علاقة بولتزمان.

تم دراسة اثر تفاعل الامواج الكهرومغناطيسية المعتمدة على السرعه باستخدام تقنية المونتي كارلو(Monte Carlo Technique) واستخدام تقريب مناسب للحصول على النتائج وكان الاستنتاج الرئيسي لهذه الدراسة ما يلي:

كنتيجة للتسخين العمودي بالنسبة للمجال المغناطيسي الارضي فان الايونات تسخن و تتحرك الى ارتفاعات عالية و باستخدام اثر تفاعل الموجات الكهرومغناطيسية المعتمدة على سرعة الايونات فان قوى التسخين تصبح محدودة ذاتيا، ويتخذ توزيع الايونات شكلا حلقيا، لقد اظهرت النتائج توافقا مع مشاهدات ا لتوزيع الحلقي لايونات الهيدروجين و الاوكسجين في دوائر العرض العليا.

Table of Contents

Chapter 1

Introduction

1.1 The polar wind

When the solar wind encounters the dipolar magnetic field of the Earth, that is the solar wind simply can not penetrate through the magnetic field lines and it is slowed down to a large extent and is deflected around the magnetic field lines. Since the solar wind hits the Earth magnetic field at supersonic speeds, a shock wave is formed, which is known as the bow shock.

At this bow shock the solar wind plasma is slowed down and substantial fraction of the kinetic energy of the particles is converted into thermal energy. The region of thermalized subsonic plasma behind the bow shock is called the magnetosheath. The magnetosheath plasma is more denser and hotter than the solar wind plasma and the magnetic field values are higher in this region compared to that in the solar wind. The shocked solar wind plasma in the magnetosheath cannot easily penetrate the Earth's magnetic field, it deflects around it. The boundary separating the two different regions is called the magnetopause and the cavity generated by the solar wind interaction with the Earth's magnetic field is known as the magnetosphere. All of these regions can be seen in figure 1-1, which also shows how the magnetic field of the Earth is compressed on the sunward side and stretched out on the anti-sunward or nightside of the Earth.

The interaction of solar wind with the Earth's dipole magnetic field significantly modifies the magnetic field configuration in a vast region close to the earth (Axford and

4.3 Summary and conclusion

Monte Carlo simulation was developed in order to study the effect of wave particle interaction-velocity dependent (WPI-V) on the H^+ and O^+ outflow in the polar wind. The simulation considered other mechanisms included in the "classical" polar wind studies such as gravity, polarization electrostatic field, and divergence of geomagnetic field. 10^5 ions were used in the simulation to compute the ion distribution function, and the profiles of its velocity moments (density, drift velocity, parallel temperature, and perpendicular temperature) for both H^+ and O^+ ions.

The boundary conditions selected are similar to those of Barghouthi et al., (1998) with body forces and altitude dependent wave particle interaction (WPI). As a result of perpendicular heating and velocity dependent, it was concluded that:

1- Above a certain point called saturation point the effect of velocity dependent WPI dominated and the ion heating becomes self-limiting.

2- Above the saturation point, the ion distribution function displayed a toroidal feature, because the ions tend to diffuse out of the heating zone in the velocity space.

3- The saturation point of O^+ occurred at lower altitudes ($\geq 4.3R_e$) than those for H^+ ($\geq 12R_e$).