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سامية محمد مصطفى

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التوثيق الالكتروني والميكروفيلم

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Preliminary Study of The MHD Waves In The Earth's Magnetosheath

Thesis

Submitted in partial fulfillment required for
the degree of M. Sc. In Space Physics
to Cairo University

By

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B.Sc. Astronomy and Physics, Cairo University
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Under the supervision
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Abstract

Key words: **Bow shock- Earth' Magnetosphere- Ionosphere- (MHD) waves- Magnetic reconnection- Magnetopause- Magnetosheath- Magnetotail- Polar cusps- Solar wind.**

It is important to study the interaction of the solar wind with the Earth's magnetosphere; the intended aim of this research was to understand this interaction and its effects on space weather phenomena. Particular attention is paid to the effect of the upstream 3-s waves on the Earth's magnetic field, and the waves propagate in the magnetosheath.

In Chapter (1) a brief historical overview on the topic, basic concepts and nomenclature are summarized. We reviewed in details the main components of the Earth's magnetosphere and end up the Chapter with summary and open problems.

In Chapter (2) we have constructed a computer code to calculate the strength, the direction, the rotation, and the main variance direction of the data on the components of the Earth's magnetic field using filtered 3-s waves data. The results showed that the eigen-values are all positive and real values. For the global interval and the highly oscillated wave packets (5 samples), these waves are circularly polarized waves with well defined vector (in minimum variance direction u3). They have also parallel propagation, although the angle between (u3 and B) is not zero.

In Chapter (3) we investigated the interaction of the magnetosheath with the magnetopause in terms of waves. The function of these waves is to reconfigure the solar wind flow and its frozen-in magnetic field from the solar wind state to the state specified by the magnetopause boundary condition.

For simplicity, we calculated the periodicity of one eigen-mode waves (Alfven waves). These calculations are carried out for two hypothetical cases

(spherical and non-spherical) depending on the shape of the Earth's magnetosphere. We found that: in the non-spherical case the periodicity is *~16.59 min*, while in the spherical case, there are two values of the periodicity corresponding to two different positions in the magnetosheath. One at the magnetopause, which is *~20.4 min*. The other is at the bow shock, which is ~ *42.36 min*.

We concluded that the Alfven waves could propagate near the inner magnetosheath (at the magnetopause) with shorter periodicity than that at the bow shock. We also conclude that the Alfven waves periodicity is equal or greater than the periodicity of the slow mode waves. These Alfven waves could be produced as a result of the oscillations of the magnetosphere as a spring.

In Chapter (4) we summarized the main outlines of the thesis.

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CONTENTS

Chapter One

Chapter (1)

Review of the Earth's magnetosphere

1.1 Introduction

One of the most interesting topics in space physics is the interaction of the solar energetic particles with electric and magnetic fields. Most of these charged particles are driven their energy from the Sun. In other word "the interaction of the solar wind with the magnetosphere". Magnetospheres can be found around all magnetized bodies surrounded by plasma flow, even around un-magnetized bodies (comets, planets without field), where they are shaped by the interaction between planetary magnetic field and the solar wind. Particular attention will be paid to the Earth's magnetosphere, where explosive growth in our knowledge about it arises since the recent missions of rockets and satellites have been launched.

It is important to study the interaction of the solar wind with the Earth's magnetosphere because this interaction controls space weather phenomena, affects on the satellite motion and/or its attitude control.

In this Chapter, a brief historical overview is given in Section (1.2), whereas simplified basic concepts and nomenclature are given in Section (1.3). The main components of the magnetosphere are summarized in Section (1.4). Finally summary and open problems are presented in Section (1.5).

1.2 A brief historical overview:

Chapmann (1918) postulated that "a singly-charged beam from the Sun cause magnetic disturbances", in what we refer to the interaction of the solar wind with the magnetosphere. In rarefied conditions of the outer space, where collisions between particles are infrequent, plasma is highly conducting. Chapmann and Ferraro (1931, 1932) postulated that" as the plasma from the sun approach the Earth, a mirror field compress the terrestrial field forming a ring of current around the Earth in the near equatorial region, now we refer it as "Geomagnetic storm". They were also, the first to discuss the existence of a boundary to the earth's magnetic field.

Biermann (1951), through the analysis of comet tails, showed that the solar wind is present all the times. Thus, some year before its discovery, the magnetopause was predicted to be a permanent feature (e.g.: Dungey, 1954). A series of rocket flights were launched into Arctic and Antarctic ionosphere at about 110 Km height. It enabled James Van Allen to detect "energetic electrons or bremsstrahlung radiation from electrons". As Explorer 1 (1958) was launched, a trapping region of high-energy charged particles surrounding the earth was detected by Van Allen, known as "The radiation belt ". The confirmation of the magnetotail was present in 1960's. Explorer 10 (1961) gave the first measurements across this boundary. Explorer 11 gave detailed evidence of it from Noon to Dawn meridian as for ring current. Later Dungey (1961) gave the idea for the reconnection and the importance of interplanetary magnetic field. Based on the laboratory experiments the cusp-shaped openings in the field pattern on the dayside and along the tail at night were developed. Axford (1962) and Kellogg (1962) proposed the bow shock. Mariner 2 (1963) explained the measurements of the solar wind. Dungey (1961 and 1963) first proposed the main mechanism by which the magnetized solar wind powers the magnetosphere. Carpenter