

Chapter 1

Introduction

1.1 Overview

The Sun consists of magnetic field and ionized gas called plasma. Some plasma on the Sun is trapped by Sun's magnetic field and some part continuous flows out into interplanetary space with the speed approximately to 400 km/s which we call this part as solar wind. The flow of solar wind is turbulent and at the same time it drags the Sun's magnetic field into the space. Due to the rotation of the Sun and turbulence of the solar wind, the characteristic of interplanetary of magnetic field is achedmedian spiral and turbulent as shown in Figure 1.1. The Sun also releases high energy particle called solar energetic particles into interplanetary space. Most of them are charged particles from keV to GeV. These particles effect to the Earth's atmosphere. Since the magnetic field is turbulent, the spectrum has the shape as Kolmogorov spectrum with has the slope $-5/3$ in inertial range. In this range the energy transfer from large to small scales. This is also the range that the plasma loses the energy called dissipation range. Taylor microscale is found as the scale that related to this range and observed from multi-spacecraft.

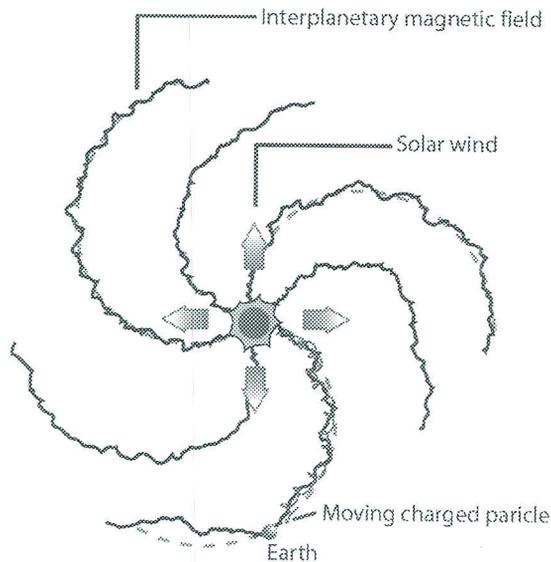


Figure 1.1 Structure of interplanetary magnetic field and solar wind with moving charged particle.

According to fundamental of electromagnetic field, when charged particles are in the magnetic field, they move as helical orbit around the magnetic field. The shape of spiral depends on the strength of magnetic field, particle's speed and the angle between the charged particle and the direction of magnetic field. Therefore, the energetic particles released from the Sun also orbit around the magnetic field. Since the magnetic field direction is the quantity that controls the transport of charged particles, the study of effect of the turbulent magnetic field to the charged particles in space is important to explain the mechanism and the phenomena that we can observe from the spacecraft data such as dropouts and solar modulation. Moreover, this research leads us to new knowledge about basic physics which might be able to apply to the motion of charged particles in turbulent magnetic field in laboratory.

From the previous study, the scientists are interested to explain the mechanism of the particle transport in the space. They can be divided into two big groups. The first one focuses the trajectories of the turbulent magnetic field line instead of the motion of charged particles. They assume that the guiding centers of particles are very close to the magnetic field line trajectories. They model several kind of magnetic turbulence and study the diffusion of field lines. This problem is less complicated than examining the motion of charged particle directly. However, we cannot understand all mechanisms if we only study the field lines. When we compare the real transport of the particles, they are still some different from field line theory. Another group of scientist studies the motion of charged particles in turbulent magnetic field directly and try to create the theory to explain the transport. Recently, there is no theory that can completely explain the mechanism and cover all general problems.

Therefore, this research examines the relationship between field line trajectories and the motion of the particle by using the numerical simulation and develops the theory to apply to particle transport in the interplanetary space. Furthermore, we also use method of generating field lines above to crate the signals which depend on time. Then we use the statistics properties that found in turbulent magnetic field to develop the technique to measure the Taylor microscale in real data from spacecraft.

1.2 Objectives

- To understand the relationship between the motion of particle and turbulent magnetic field.
- To find the drift and cross-field motion effects of charged particles due to the turbulence of magnetic field in both numerical and analytic calculation.
- To model the spectrum and generate the time-series signal to study the characteristic of length scale of turbulence of magnetic field.