Chapter 1
Introduction

Solar energetic particles are generated from solar flare and coronal mass ejections (CMEs). A solar flare is an explosion on the surface of the Sun, mainly converting magnetic energy into heat. A coronal mass ejection is a mass ejection from the corona, which is the outermost portion of the Sun. Such an event mainly converts magnetic energy into kinetic energy. Both flares and CMEs release high-energy ions and electrons from the Sun into the interplanetary medium. These particles are called "solar cosmic rays" or "solar energetic particles" (SEPs). Solar energetic particles and associated phenomena have important effects on the Earth, such as disrupting radio communications, causing electric power failures and causing radiation warnings on transoceanic airplane flights. These is much interest regarding the study of the mechanisms of particle acceleration.

We use an equation of focused transport to explain the motion of solar energetic particles in interplanetary space (Ruffolo, 1995) which includes various processes that affect the transport of particles released from the Sun. This is the equation we use for simulating the cosmic rays' propagation from the Sun. The particle data, excluding the effects of the Earth's magnetic field, are obtained from spacecraft or ground-based neutron monitors. Most of the data are used to analyze the intensity of particles from the Sun. We simulate the transport of particles in the interplanetary medium, and then use the simulation results to fit the data. The results from the data fitting will tell us information about the acceleration of particles near the Sun, as well as their transport from near the

Sun to spacecraft near the Earth.

In particular, we have developed a new technique for analyzing spacecraft data on energetic particles and we have also introduced an automated technique for fitting.

1.1 The Objectives

The objectives of this work are

1. To fit particle data from spacecraft and determine the injection of particles from the Sun as a function of time and energy.

2. To prepare a detailed model of the transport of energetic heavy ions from the Sun for specific events.

3. To explore whether the duration of emission varies with the mass number or the ion energy.

1.2 Procedure and Outline

We examine the characteristics of the energetic heavy ions from interesting solar events by comparing results from a simulation program with data from spacecraft or ground-based instruments. The simulations give the particle distribution for various mean free paths. We use the linear least squares technique to fit the data using the improved methodology, techniques, and procedures presented in this work. The best fit results tell us about the injection time for each selected event, element, and energy range, as well as information about the acceleration of the particles near the Sun and their transport to near the Earth.

The author uses the transport equation (which is in the form of a Fokker-Planck equation) to explain the motion of SEPs in interplanetary space, considering processes that affect the transport as described in Chapter 2. The procedures, techniques, and methodology of fitting are described in Chapter 3. In Chapter 4, the author will explain the preparation of spacecraft data for fitting and a new technique for finding the uncertainties of spacecraft data. The results of the data fitting will be shown in Chapter 5, and the discussion and conclusions will be given in Chapter 6.

1.3 Usefulness of This Work

The usefulness of this work is as follows:

1. We have obtained an improved capability to analyze data from spacecraft and compare them with accurate transport simulations.

2. We can determine appropriate parameters for use in the transport equation of Ruffolo (1995) to explain the motion of SEPs in interplanetary space.

3. The results from the data fitting tell us information about the acceleration of particles near the Sun.