Cosmic Ray Propagation in Turbulent Magnetic Fields

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Abstract

How a high energy cosmic ray behaves in space is one of the major issues in astrophysics. Cosmic ray propagation in the astronomical environment can be explained as a diffusion phenomenon. My research used the Monte Carlo technique to calculate diffusion tensors and analysed the energy dependence of the diffusion tensor on the cosmic ray energy and magnetic field turbulence.

Turbulent magnetic fields exist in an astronomical environment. The power spectrum of the turbulence is proportional to $k^{-5/3}$, where k is the wavenumber. This turbulence is called the Kolmogorov-like magnetic field.

To understand cosmic ray propagation in the astronomical environment, it is useful to study cosmic ray diffusion in turbulent magnetic fields. Monte Carlo simulation is the most suitable technique for the study of the cosmic ray diffusion in turbulent magnetic fields. The aim of my research is to determine the diffusion tensors by using the Monte Carlo simulation and to study how the magnetic field turbulence scale affects the cosmic ray diffusion. My research is applied to simulation of an actual astronomical phenomena, known as shock acceleration.

Chapter 1 provides a brief introduction of high energy cosmic rays and Kolmogorov-like magnetic field. Chapter 2 introduces three different simulation methods for cosmic ray diffusion.

Chapter 3 describes the simulation technique by Honda [11]. He sampled vector potentials to produce Kolmogorov-like turbulent magnetic fields.

Chapter 4 describes the simulation technique by Giacalone and Jokipii [7] [8] [9]. They used a superposition of isotropic plane waves to produce Kolmogorov-like magnetic field.

Chapter 5 discusses the application of a cosmic ray diffusion simulation method to

cosmic ray shock acceleration. In this chapter, the simulation method by Giacalone and Jokipii was selected to investigate cosmic ray shock acceleration.

Chapter 6 presents a summary of whole work in my research and future work to extend this study.

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