§4. Particle Acceleration in Shock Wave Produced by Coronal Mass Ejection

Den, M. (National Inst. Information Comm. Technology), Ogawa, T. (Kitazato Univ.), Yamashita, K. (Yamanashi Univ.)

The energetic particle event occurred on 314 DOY in 2000 is a good sample to investigate particle acceleration mechanism because both the coronal mass ejection and the energetic particles are observed. We obtained the energetic particles by using the stochastic differential equations method[1] with the velocity of the shock wave and the assumptions of the energy spectrum of the input pre-accelerated particles and the diffusion coefficient. The behaviour of the shock wave is obtained by using the hydrodynamical simulation produced at a point on the solar surface. The simulation was carried out by the adaptive mesh refinement scheme (AMR) in three-dimensional space. Figure 1 is a color contour of solar wind velocity in radial direction on the horizontal plane in which the sun is central. The boundary between dark blue and green suggests the shock wave position. We tested the models of

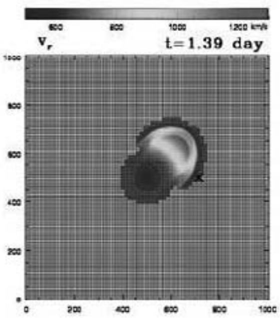

Fig. 1. A color contour is the intensity of the solar wind velocity in radial direction on the horizontal plane.

the diffusion coefficient and the input particles. Here we adopt the diffusion coefficient model as follows:

$$\kappa(p) = \frac{\kappa_o}{A(k)} \frac{B_o}{B} \frac{(p/p_o)^2}{\sqrt{(m_p c/p_o)^2 + (p/p_o)^2}} \qquad (1)$$

where κ, p, B, $A(k)$ are the spatial diffusion coefficient, a particle momentum, the interplanetary magnetic field intensity, and wave energy density, respectively [2]. For simplicity, we had several assumptions such as adoption of strong shock limit [3]. As for seed particle distribution, models are same as the previous works. Figure 2 presentes simulated diffusion coefficient. It shows our result is consistent with the model in eq. (1). Figures 3 display the spectra of the particles captured in every divided region for the model with eq. (1). In the region of 0.0-0.5AU the fluxes are shown to be small because the region is already in the downstream of the shock at the times after 0.77 days. However, there exist the particles with energies larger than 10MeV. This component is explained by the effect that the energetic particles are reflected back to this region due to the high diffusion coefficient. The similar effect is seen in

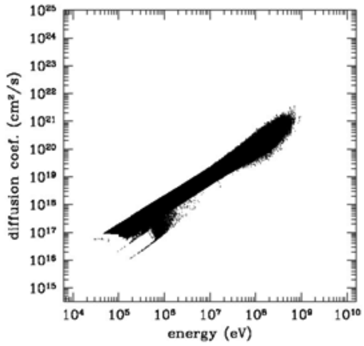

Fig. 2 The diffusion coefficient model.

the region of 1.3--2.5AU which is the upstream of the shock at the times before 1.54 days. At this region the fluxes are also totally small and only the accelerated particles are appeared by the high diffusion coefficient for the energetic particles. At the other regions of 0.5--1.3 AU the fluxes are commonly maximized at the time when the shock passes through the earth and the energetic particles escape from the shock to diffuse early.

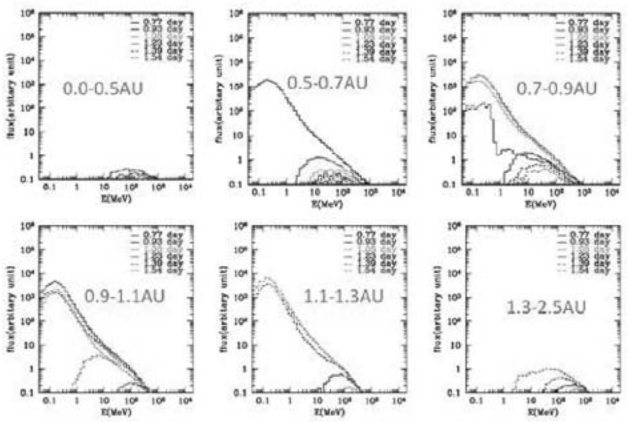

Fig. 3 The spectra of the particles captured in every divided region for the model with eq. (1)

We concluded that the non-constant model of the diffusion coefficient which depends on the energy of the particles and the interplanetary magnetic field might not reproduce the observation well and the input particles are required to be more energetic than the ambient ordinary particles.

1) Yoshida, T. and Yanagita, S. : Prog. of Theor. Phys. **92** (1994) 1217.
2) Bell, A.R., Mon. Not. Astron. Soc., **182** (1978) 147.
3) Zank, G.P., Rice, W.K.M, and Wu, C.C., J. of Geophys. Res., **105** (2000) 25,079..