Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

PEM026-P01 Room:Convention Hall Time:May 25 10:30-13:00

Stability problem of cosmic ray modified shock

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Cosmic rays whose energy is less than $10^{15.5}$ eV are thought to be generated from galactic supernova explosion. Blast waves blown from explosion are main accelerator of high-energy cosmic rays. Standard acceleration theory of cosmic rays at supernova shock was proposed by Bell (1978), Blandford and Ostriker (1978), and so on, and was called Diffusive Shock Acceleration (DSA) theory.

However, the possible maximum energy expected from DSA theory was 10^{14} eV, which is less than knee-energy ($10^{15.5}$ eV) by an order of magnitude. And this energy gap problem has not been solved clearly yet.

One remarkable idea to this difficult problem is cosmic ray modified shock, which was proposed by Drury and Volk (1981). In cosmic ray modified shock, cosmic rays have back reaction to shock structure and make shock more compressive, and then compressed shock can generate cosmic rays more effectively. Recent observations of supernova remnants reveals that temperature of thermal plasma is lower than expected temperature from Rankine-Hugoniot relations, and this fact is supporting to this idea (Hughes 2000, Helder 2009). So, we should consider about cosmic ray modified shock in supernova remnants.

Our research is based on "two fluid model" , which is proposed Drury and Volk (1981). In this model, there are partially multiple shock solutions, each of them satisfies Rankine-Hugoniot relations. By numerical calculation, we find that two of them are stable and the other is unstable, and that transition of shock structure occurs when solution is unstable. Consequently, cosmic ray pressure becomes maximum or minimum.

Moreover, Mond and Drury (1998) suggested that corrugation instability occurs when shock solution is unstable. We investigate this suggestion by two-dimensional simulation.

Keywords: cosmic rays, shock acceleration, stability