Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

PEM26-P12 Room:Convention Hall Time:May 22 10:45-12:15

Stability of structure of cosmic ray modified shocks

SAITO, Tatsuhiko[1*], HOSHINO, Masahiro[2]

[1]EPS, the University of Tokyo, [2]Department of Earth and Planetary Science, The University of Tokyo

Galactic cosmic rays are believed to be produced around shocks at supernova remnants in our galaxy. A standard shock acceleration theory of cosmic ray is “Diffusive Shock Acceleration”, which is known as first-order Fermi acceleration. Recent observations of supernova remnants have revealed that in some cases, a temperature of downstream thermal plasma is lower than that predicted from Rankine-Hugoniot relations, and energy of cosmic rays is comparable to that of thermal plasma. This fact means that a certain ratio of the upstream kinetic energy is used for the acceleration of cosmic rays, and the proportion of energy used for heating the downstream thermal plasma decreases. In those situations, cosmic rays exert the “back-reaction” to background shocks and change the structure of shocks significantly. These shocks are called “Cosmic Ray Modified Shock (CRMS)”. In CRMS, the acceleration of cosmic rays proceeds to the nonlinear phase and cosmic rays are strongly coupled with background thermal plasma, namely with background shocks.

In our research, we base on “MHD two-fluid model”, where the background plasma and cosmic rays are described as fluid, to discuss about fluid-scale structures of CRMS. It is known that there are multiple solutions in a Rankine-Hugoniot relation of CRMS in the two-fluid model. This leads that there are three possible downstream states with one upstream state.

We conduct one-dimensional numerical simulations and study the time-evolution from these three possible shock structures. The results show that in the three, the structures that produce the most or the least downstream cosmic rays are stable. On the contrary, intermediate structures between the two are unstable and transit easily to the others. We also find there is no dependency of the stability of structures on upstream shock angles.

Next, we conduct simulations from initial conditions where there are not cosmic rays in the downstream or upstream regions. We confirm analytical steady states are realized in nonstationary time-evolution from those initial states.

Keywords: cosmic rays, shock, nonlinear evolution, stability of structure