Hyunbae Park[2] and Sungwook Hong[2]
[1]Korea Institute for Advanced Study
[2]Korea Astronomy and Space Science Institute

Redshift space distortion (RSD) is known as a powerful cosmological probe. The large-scale RSD has been detected by various redshift surveys and continues to be a major target of ongoing surveys. On the other hand, the small-scale RSD, called finger-of-god (FoG) effect, also has cosmological information, because different cosmological parameters cause different halo mass functions and viriarized velocities. We define the "length" of FoG and examine its dependence on cosmological parameters using the Multiverse simulation. We also use the SDSS DR7 data to see how strong constraints current data sets could provide. It is found that the volume-limited subsample D5, consisting of ~100,000 galaxies at z~0.08, yields $\Delta \Omega_m ~ 0.02$.

고에너지/이론천문

[구 HT-01] Proton Acceleration in Weak Quasi-parallel Intracluster Shocks: Injection and Early Acceleration

Hyesung Kang[1], Dongsu Ryu[2], Ji-Hoon Ha[2]
[1]Pusan National University, [2]Ulsan Institute of Science and Technology

Collisionless shocks with low sonic Mach numbers, $M<4$, are expected to accelerate cosmic ray (CR) protons via diffusive shock acceleration (DSA) in the intracluster medium (ICM). However, observational evidence for CR protons in the ICM has yet to be established. Performing particle-in-cell simulations, we study the injection of protons into DSA and the early development of a nonthermal particle population in weak shocks in high β plasmas. Reflection of incident protons, self-excitation of plasma waves via CR-driven instabilities, and multiple cycles of shock drift acceleration are essential to the early acceleration of CR protons in supercritical quasi-parallel shocks. We find that only in ICM shocks with $M \geq 2.3$, a sufficient fraction of incoming protons are reflected by the overshoot in the shock electric potential and magnetic mirror at locally perpendicular magnetic fields, leading to efficient excitation of magnetic waves via CR streaming instabilities and the injection into the DSA process. Since a significant fraction of ICM shocks have $M<2.3$ CR proton acceleration in the ICM might be less efficient than previously expected. This may explain why the diffuse gamma-ray emission from galaxy clusters due to proton-proton collisions has not been detected so far.

[구 HT-02] Evolution of particle acceleration and instabilities in galaxy cluster shocks

Allard Jan van Marle[1], Dongsu Ryu[1], Hyesung Kang[2], Ji-Hoon Ha[1]
[1]Department of Physics, School of natural Sciences, UNIST (Ulsan National Institute of Science and Technology)
[2]Department of Earth Sciences, Pusan National University

When galaxy clusters interact, the intergalactic gas collides, forming shocks that are characterized by a low sonic Mach number (~3) but a comparatively high Alfvenic Mach number (~30). Such shocks behave differently from the more common astrophysical shocks, which tend to have higher sonic Mach numbers.

We wish to determine whether these shocks, despite their low sonic Mach number, are capable of accelerating particles and thereby contributing to the cosmic ray spectrum.

Using the PIC-MHD method, which separates the gas into a thermal and a non-thermal component to increase computational efficiency, and relying on existing PIC simulations to determine the rate at which non-thermal particles are injected in the shock, we investigate the evolution of galaxy cluster shocks and their ability to accelerate particles.

Depending on the chosen injection fraction of non-thermal particles into the shock, we find that even low-Mach shocks are capable of accelerating particles. However, the interaction between supra-thermal particles and the local magnetic field triggers instabilities and turbulence in the magnetic field. This causes the shock to weaken, which in turn reduces the effectiveness of the supra-thermal particle injection. We investigate how this influences the shock evolution by reducing the particle injection rate and energy and find that a reduction of the particle injection fraction at this stage causes an immediate reduction of both upstream and downstream instabilities. This inhibits particle acceleration. Over time, as the instabilities fade, the shock surface straightens, allowing the shock to recover. Eventually, we would expect this to increase the