HEDLA 2022
13th International Conference on High Energy Density Laboratory Astrophysics
hedla@tecnico.ulisboa.pt

Electron Preacceleration at Weak Quasi-Perpendicular Shocks in Merging Galaxy Clusters

Ji-Hoon Ha[1,†], Dongsu Ryu[1], Hyesung Kang[2], Sunjung Kim[1]

[1] *Ulsan National Institute of Science and Technology (UNIST)*

[2] *Pusan National University*

[†] hjhspace223@gmail.com

Merger-driven shocks with low sonic Mach numbers, Ms $\sim$ a few, have been detected through X-ray and radio observations in the outskirts of merging galaxy clusters. While radio synchrotron emission from such shocks implies electron acceleration via diffusive shock acceleration (DSA; a.k.a. 1st-order Fermi acceleration), the detailed preacceleration mechanism for injection to DSA mediated by kinetic plasma processes has not been fully understood. To examine the electron injection problem, we performed two-dimensional Particle-in-Cell (PIC) simulations with relevant parameters (plasma beta, $\beta \sim 20$ - 100 and Ms = 2 - 3) for quasi-perpendicular shocks in the intracluster medium (ICM). According to the simulations, multi-scale plasma waves are induced by the dynamics of ions in the transition region of shock, and such waves play a crucial role in electron preacceleration. In particular, while the preacceleration is effective only at the ICM shocks with Ms $> \sim 2.3$, those with Ms $< \sim 2.3$ have been detected through observations, leaving DSA at such low Mach shocks as an outstanding problem. To resolve this issue, additional PIC simulations including preexisting nonthermal electrons were performed. However, preexisting nonthermal electrons alone would not resolve the issue, because the nonthermal electrons do not affect the dynamics of ions and the generation of ion-scale waves.