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hedla@tecnico.ulisboa.pt

Outstanding issues of intracluster plasma for laboratory astrophysics

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

[1] *UNIST, Korea*

[2] *Pusan National University, Korea*

[†] dongsu.ryu0@gmail.com

Clusters of galaxies are filled with superheated plasmas, called the intracluster medium (ICM). The ICM is accumulated and heated through successive mergers of subclumps during the hierarchical formation of clusters. The intracluster plasmas, hot and also rare, are very weakly collisional with plasma parameters much higher than those of laboratory plasmas. Yet the basic physics governing plasma processes is expected to be the same for both the plasmas. The phenomena observed in the ICM have been studied through theoretical investigations and simulations. They include turbulence, shocks, magnetic fields, and high energy particles, and involve gravitational and fluid dynamical processes, as well as plasma processes at microscopic scales. While some have been successfully described, others need to be further explained. In this talk, we introduce two outstanding issues involving plasma processes. The first issue is about shocks. Merger shocks, formed as a consequence of mergers, have been observed as radio relics. They are weak mostly with Mach number, Ms, a few, and some of them have Ms as low as 2 or even lower. On the other hand, studies using PIC simulations have suggested that thermal electrons could be preaccelerated and injected into diffusive shock acceleration (DSA) only in supercritical shocks with Ms > 2.3 in intracluster plasmas. The second issue concerns turbulence. The energy released by mergers is expected to be dissipated mostly through the turbulence that is also produced during the merging process. Simulations using hybrid and PIC codes seem to indicate that the turbulence energy preferentially goes to ions, resulting in a large thermal disequilibration of ions and electrons. On the other hand, there is no observational evidence of a large discrepancy in the ion and electron temperatures in the ICM. While further observations as well as simulations would be necessary, these are the issues that laboratory astrophysics could help resolve.