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Why there is no simultaneous detection of Gamma rays and x-rays from x-ray bright galaxy clusters? A hydrodynamical study on the manufacturing of cosmic rays in the evolving dynamical states of galaxy clusters

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Galaxy clusters are known to be reservoirs of Cosmic Rays (CRs), as inferred from theoretical calculations or detection of CR-derived observables. CR acceleration in clusters is mostly attributed to the dynamical activity that produces shocks. Shocks in clusters emerge out of merger or accretion, but which one is more effective in producing CRs? at which dynamical phase? and why? To this aim, we study the production or injection of CRs through shocks and its evolution in the galaxy clusters using cosmological simulations with the {\sc enzo} code. Particle acceleration model considered here is primarily the Diffusive Shock Acceleration (DSA) of thermal particles, but we also report a tentative study with pre-existing CRs. Defining appropriate dynamical states using the concept of virialization, we studied a sample of merging and non-merging clusters. We report that the merger shocks (with Mach number $\mathcal{M} \sim 2-5$) are the most effective CR producers, while high-Mach peripheral shocks (i.e. $\mathcal{M} > 5$) are mainly responsible for the brightest phase of CR injection in clusters. Clusters once merged, permanently deviate from CR and X-ray mass scaling of non-merging systems, enabling us to use it as a tool to determine the state of merger. Through a temporal and spatial evolution study, we found a strong correlation between cluster merger dynamics and CR injection. We observed that the brightest phase of X-ray and CR injection from clusters occur respectively at about 1.0 and 1.5 Gyr after every mergers. This is the reason for simultaneous non-detection of Gamma rays and x-rays from x-ray bright galaxy clusters.

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