SIMULATION OF COSMIC RAY ACCELERATION DURING FORMATION OF THE LARGE SCALE STRUCTURE

Francesco Miniati (1) and T. W. Jones (2) and Dongsu Ryu (3) and Hyesung Kang (4)
(1) Max-Planck-Institut fuer astrophysik, (2) University of Minnesota,
(3) Chungnam National University, (4) Pusan National University

Recent growing observational evidence of non-thermal activity in the intra-cluster medium has raised several questions about the physical processes that dominate there. Several issues are still open: the mechanism responsible for the radio halos and relics, the properties of the magnetic fields, the origin of observed radiation excesses in the hard X-ray and, perhaps, EUV bands with respect to what expected from the thermal emission, the role of non-thermal pressure component including contributions from cosmic rays (CR) and magnetic fields. To explore these issues we have performed Eulerian TVD hydro + N-body fully cosmological simulations including, for the first time, explicit treatment of CR protons, primary and secondary electrons and magnetic field. The CR treatment includes the effects of injection, diffusive shock acceleration and mechanical and radiative and losses. All of these non-thermal components, i.e. cosmic rays and magnetic field are treated as passive quantities. We find that CR protons produced in large scale structure shocks could provide a substantial fraction of the total pressure inside clusters of galaxies. The corresponding gamma-ray flux should be easily observable by GLA ST for nearby, large clusters, allowing a direct estimate of the CR content there. Such CR protons generate a population of secondary electrons through p-p inelastic collisions, which could account for many observed properties of radio halos, provided a magnetic field ~ 1\mu G in a Coma-like cluster. Radiation power emitted from primary electrons directly injected at accretion shocks is comparable to that of the large radio relics, although not all of the spectral properties are reproduced.