

Contribution ID: 29

Type: **not specified**

Cosmic rays in galaxy clusters and their non-thermal emission

Thursday 14 August 2014 11:25 (25 minutes)

Observations of giant radio halos and radio relics in galaxy clusters demonstrate the presence of synchrotron emitting electrons with GeV energies in more than 50 clusters. The precise origin of these radio emitting electrons is, however, still unclear. In this talk I discuss two classes of cosmic ray models, hadronic and reacceleration, that can explain the origin of electrons in giant radio halos. In addition I use gamma-ray upper limits to constrain these models, and discuss the prospects for detecting the cosmic ray induced gamma-ray emission in the future. Finally, I show how structure formation shocks can leave behind an aged MeV electron population in the cluster outskirts. This population can be revived through diffusive shock acceleration in radio relics and dominate over fresh injection at low Mach numbers, allowing weak shocks which would be otherwise invisible to glow in radio emission.

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Session Classification: Thursday morning

Track Classification: Program