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Magnetic Fields, Relativistic Particles, and Shock Waves in Cluster Outskirts

M. Bruggen, A. Bykov, D. Ryu, H. Rottgering

(Submitted on 26 Jul 2011)

It is only now, with low-frequency radio telescopes, long exposures with high-resolution X-ray satellites and gamma-ray telescopes, that we are beginning to learn about the physics in the periphery of galaxy clusters. In the coming years, Sunyaev-Zeldovich telescopes are going to deliver further great insights into the plasma physics of these special regions in the Universe. The last years have already shown tremendous progress with detections of shocks, estimates of magnetic field strengths and constraints on the particle acceleration efficiency. X-ray observations have revealed shock fronts in cluster outskirts which have allowed inferences about the microphysical structure of shocks fronts in such extreme environments. The best indications for magnetic fields and relativistic particles in cluster outskirts come from observations of so-called radio relics, which are megaparsec-sized regions of radio emission from the edges of galaxy clusters. As these are difficult to detect due to their low surface brightness, only few of these objects are known. But they have provided unprecedented evidence for the acceleration of relativistic particles at shock fronts and the existence of muG strength fields as far out as the virial radius of clusters. In this review we summarise the observational and theoretical state of our knowledge of magnetic fields, relativistic particles and shocks in cluster outskirts.

Comments: 34 pages, to be published in Space Science Reviews
Subjects: **High Energy Astrophysical Phenomena (astro-ph.HE)**
Cite as: **arXiv:1107.5223v1 [astro-ph.HE]**

Submission history

From: Marcus Bruggen [view email]
[v1] Tue, 26 Jul 2011 14:30:59 GMT (2276kb)

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