Evolution and Distribution of Magnetic Fields from AGNs in Galaxy Clusters II. The Effects of Cluster Size and Dynamical State

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(Submitted on 13 Jul 2011 (v1), last revised 15 Jul 2011 (this version, v2))

Theory and simulations suggest that magnetic fields from radio jets and lobes powered by their central super massive black holes can be an important source of magnetic fields in the galaxy clusters. This is paper II in a series of studies where we present self-consistent high-resolution adaptive mesh refinement cosmological magnetohydrodynamic (MHD) simulations that simultaneously follow the formation of a galaxy cluster and evolution of magnetic fields ejected by an active galactic nucleus (AGN). We studied 12 different galaxy clusters with virial masses ranging from 1 $\times$ 10^{14} to 2 $\times$ 10^{15} M$_{\odot}$. In this work we examine the effects of the mass and merger history on the final magnetic properties. We find that the evolution of magnetic fields is qualitatively similar to those of previous studies. In most clusters, the injected magnetic fields can be transported throughout the cluster and be further amplified by the intra-cluster medium (ICM) turbulence during the cluster formation process with hierarchical mergers, while the amplification history and the magnetic field distribution depend on the cluster formation and magnetism history. This can be very different for different clusters. The total magnetic energies in these clusters are between 4 $\times$ 10^{57} and 10^{61} erg, which is mainly decided by the cluster mass, scaling approximately with the square of the total mass. Dynamically older relaxed clusters usually have more magnetic fields in their ICM. The dynamically very young clusters may be magnetized weakly since there is not enough time for magnetic fields to be amplified.

Comments:	34 pages, 15 figures, accepted for publication in ApJ, reference list fixed
Subjects:	**Cosmology and Extragalactic Astrophysics (astro-ph.CO)**
Report number:	LA-UR 11-02483
Cite as:	**arXiv:1107.2599 [astro-ph.CO]**
	(or **arXiv:1107.2599v2 [astro-ph.CO]** for this version)

Submission history

From: Hao Xu [view email]
[v1] Wed, 13 Jul 2011 17:00:56 GMT (6037kb)
[v2] Fri, 15 Jul 2011 21:38:21 GMT (6037kb)

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