Interaction of Fanaroff-Riley class II radio jets with a randomly magnetised intra-cluster medium

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Introduction

The Faraday rotation effect is observed on the AGN polarised radio emission traveling through the ICM, revealing magnetic fields of ∼100 kpc scale threading this media. RM maps are consistent with the following facts about the cluster magnetic fields [1] (CMFs):

• $|\mathbf{B}| \sim \mu G$,
• $|\mathbf{B}(r)| \propto \rho_{CMF}(r)$,
• $|\mathbf{B}| \propto M_{cooling \ flow}$.

Turbulent structure.

Open questions: The origin, evolution and role of the CMFs in the ICM stability. Since AGN jets have strong effects on the ICM, it is not clear to what extent, and how, they affect both the CMFs and their RM characterisation. We investigate this in [2].

Effect of radio jets on the rotation measure

We calculate $RM = 812 \int_{D/kpc}^{0} (\frac{\rho}{\rho_0}) (\frac{\mathbf{B}}{\mathbf{B}_0}) dl$ rad m$^{-2}$ from the jets’ cavity contact discontinuity to the end of the domain, along different viewing angles. We do this at different times, with and without the jets to assess their effects on the CMFs. The fields in the region between the cocoon and the bow shock are compressed, stretched and amplified. e.g. below we show the case of jets’ velocity and density of 130 Mach and 0.004$\rho_0$, respectively, at a viewing angle of 45°.

![RM maps. Without the source (left) with the source (right).](image)

ICM magnetic energy and RM gradients

The energy decays due to numerical diffusion, but the jets with $\beta_{jet} = \{80, 130\}$ are able to impede this and to increase the energy in proportion to the jet velocity (image below).

![RM evolution as the model radio jets affect the magnetised ICM. Mean RM (left) and RM standard deviation (right).](image)

Model

Using Flash 3.1 [3] we solve the equations of MHD with a constrained transport scheme in a cubic Cartesian domain with 200$^3$ cells. The ICM is implemented as:

• Monoatomic ideal gas ($\gamma = 5/3$),
• King density profile
• Magnetohydrostatic equilibrium with central gravity,
• Magnetic fields with a Kolmogorov-like structure (following [5]),
• $\beta_{ICM} \geq 10$.

The plasma relaxes for one crossing time and then we inject mass and $z$-momentum to a central control cylinder. We experiment with the jets’ power using velocities of 40, 80 and 130 Mach, and densities of 0.02$\rho_0$ and 0.004$\rho_0$.

![Cut though the RM maps at y = -25 kpc (left), RM histograms (right).](image)

Conclusions

• The jets distort and amplify the CMFs, especially near the edges of the lobes and the jets heads,
• $RM$ and $\sigma_{RM}$ increase in proportion to the jets’ power. The effect may lead to overestimations of the CMFs’ strength by about 70%.
• A flattening of the RM structure functions is produced by the jets, at scales comparable to the source size.
• Jet-produced RM enhancements are more apparent in quasars than in radio galaxies.

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References

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