THE ROLE OF EXTRAGALACTIC JETS IN THE MAGNETIZATION OF THE INTERGALACTIC MEDIUM

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ABSTRACT. We consider a current carrying extragalactic jet and the corresponding return current closing the circuit. The Lorentz force for the return path is expansive. Assuming that the expansion occurs at the local Alfvén velocity, we calculate numerically the radial distance from the jet axis which the return circuit reaches due to this electrodynamic expansion. The calculations are made explicity for parameter values observed for the sources Cygnus A, NGC 6251, 3C465 and M84. The results obtained can explain several magnetic features observed in these sources. The possible importance of previous generations of extragalactic jets in the large scale magnetization of the intergalactic medium is also discussed.

1. INTRODUCTION

We study the magnetization of the intergalactic medium due to magnetic fields generated by extragalactic jets (EJ) from galactic nuclei. Although such a process has been mentioned in a generic form (e.g., Dreher et al. (1987); Rees (1987)),it has not been discussed in detail and its implications analyzed.

2. THE MODEL

We treat a current carrying EJ and the corresponding return current (J_{ret}) closing the circuit. The Lorentz force ($\vec{F}_L$) for the return path is expansive. We assume that the expansion occurs at the local Alfvén velocity [$V_A(r,h)$] and calculate numerically the radial distance (r_e) from the jet axis which the return circuit reaches due to this expansion (where the cylindrical radial coordinate is r, and h is the jet height). We have for the time interval (τ) taken by the circuit to expand (radially):

$$\tau = \int_{r_i}^{r_e} dr/V_A(r,h) \quad , \tag{1}$$

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where r_i is of the order of the jet radius. We use the external density profiles inferred from X-ray data to evaluate $V_A(r,h)$.

3. APPLICATIONS

We made calculations for parameter values of several sources (as mentioned in the abstract). Here, because of the lack of space, we discuss briefly just the case of Cygnus A. (A fuller discussion will be published elsewhere.)

It has been observed by Dreher et al. (1987) that intracluster magnetic fields are found around Cygnus A, which are ordered on scales $\sim$ 20 - 30 kpc, with intensities $\sim$ 2 - 10μG.

We assume regular previous active (i.e., jet-current generation) periods, $\tau_{act} \sim f\,\tau_{inact}$ ($\tau_{inact} \equiv$ inactive period), and that $\tau_{act} \sim \tau_j$, the present jet age (taken as $\sim 6\times10^6$ years). Jet current generation has recently been discussed by Jafelice et al. (1989). We studied $f = 1$; 10^{-1}; and 10^{-2}. The above mentioned observations are found to be best fitted with $f = 10^{-1}$. We have $r_e \sim 16$ kpc and a mean azimuthal field $B_\phi \sim 3\mu G$ is obtained at this distance from the jet axis.

The calculated r_e and B_ϕ are in good agreement with observations. The proposed process, moreover, can give rise to the unusual magnetic field geometries which seems to be needed to explain observed large - scale rotation measure gradients in the lobes of Cygnus A (Dreher et al. (1987)).

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