MAGNETIC FIELD AMPLIFICATION AND INTERGALACTIC PLASMA HEATING THROUGH MAGNETIC TWIST INJECTION FROM ROTATING GALAXIES

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We propose a mechanism of amplification of magnetic fields and plasma heating in clusters of galaxies. Recent observations indicate the existence of $\sim \mu$G magnetic fields in clusters of galaxies (e.g., Kronberg 1994). There should be some mechanism which locally amplify magnetic fields. In clusters of galaxies, individual motions of galaxies may create locally strong field region by stretching and tangling the magnetic fields threading the galaxies. Magnetic reconnection taking place in the tangled magnetic fields may convert the kinetic energy of the galaxy motion into the inter-galactic plasma heating (Makishima 1996).

Here we present the results of three-dimensional magnetohydrodynamic simulations of large-scale magnetic fields threading the rotating galaxies. The initial state consists of two, constant angular momentum tori with polytropic index $n = 3$ rotating in a static isothermal halo. The gravita-

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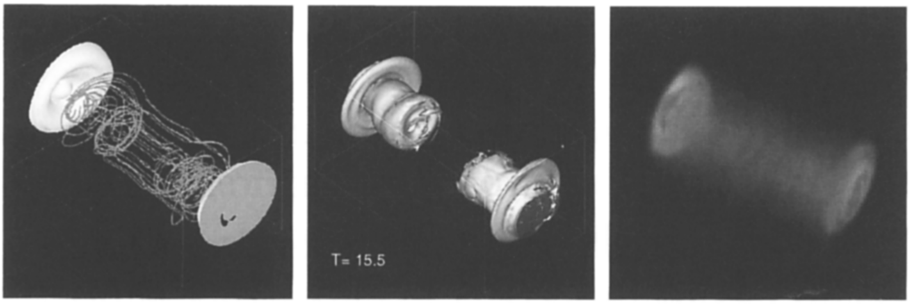

Figure 1. **Numerical results for a typical model with $\beta = 100$ at $t = 15.5r_0/V_{K0}$. The left panel shows the density isosurface and magnetic field lines. The middle panel shows the isosurface of magnetic field strength $B/B_0 = 10$. The right panel is the pseudo X-ray image rendered by using $\rho^2 T^{1/2}$.**

tional field is assumed to be given by two point masses at $(r,z) = (0,0)$ and $(0, z_{max})$ in a cylindrical coordinate. The initial magnetic field is assumed to be uniform and axial ($\mathbf{B} = B_0\hat{z}$). Symmetric boundary conditions are imposed at $z = 0$ and $z = z_{max}$. We solved the magnetohydrodynamic (MHD) equations by using the modified Lax-Wendroff method with artificial viscosity. Typical number of grid points is $(N_r, N_\varphi, N_z) = (122, 32, 240)$. Figure 1 shows the snap shot of magnetic field lines (left), magnetic field strength (middle), and pseudo X-ray image (right) at $t = 15.5r_0/V_{K0}$ where r_0 is the reference radius and V_{K0} is the Keplerian rotation speed at $r = r_0$. The initial plasma β ($= P_{gas}/P_{mag}$) at $(r,z) = (0, r_0)$ is $\beta = 100$.

Since torsional Alfvén waves generated by the rotation of galaxies extract angular momentum, the rotating disk infall toward the galactic center. The infalling gas further twists the magnetic fields and bunch them into a twisted filament along the rotational axis. Numerical results show that the magnetic pressure of this filament is comparable to the thermal pressure of the intergalactic medium. When the magnetic twist accumulates, the flux tube deforms itself into a helical structure due to the kink instability. Magnetic reconnection taking place in such kink-unstable flux tube may further heat the intergalactic plasma.

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