SLOSHING OF THE MAGNETIZED COOL GAS IN THE CORES OF GALAXY CLUSTERS

J. A. ZuHone[1,2], M. Markevitch[1,2], D. Lee[3]

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ABSTRACT

X-ray observations of many clusters of galaxies reveal the presence of edges in surface brightness and temperature, known as "cold fronts". In relaxed clusters with cool cores, these edges have been interpreted as evidence for the "sloshing" of the core gas in the cluster's gravitational potential. The smoothness of these edges has been interpreted as evidence for the stabilizing effect of magnetic fields "draped" around the front surfaces. To check this hypothesis, we perform high-resolution magnetohydrodynamics simulations of magnetized gas sloshing in galaxy clusters initiated by encounters with subclusters. We go beyond previous works on the simulation of cold fronts in a magnetized intracluster medium by simulating their formation in realistic, idealized mergers with high resolution ($\Delta x \sim 2$ kpc). Our simulations sample a parameter space of plausible initial magnetic field strengths and field configurations. In the simulations, we observe strong velocity shears associated with the cold fronts amplifying the magnetic field along the cold front surfaces, increasing the magnetic field strength in these layers by up to an order of magnitude, and boosting the magnetic pressure up to near-equipartition with thermal pressure in some cases. In these layers, the magnetic field becomes strong enough to stabilize the cold fronts against Kelvin-Helmholtz instabilities, resulting in sharp, smooth fronts as those seen in observations of real clusters. These magnetic fields also result in strong suppression of mixing of high and low-entropy gas in the cluster, seen in our simulations of mergers in the absence of a magnetic field. As a result, the heating of the core due to sloshing is very modest and is unable to stave off a cooling catastrophe.

Subject headings: galaxies: clusters: general — X-rays: galaxies: clusters — methods: hydrodynamic simulations