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A Turbulent Heating Mechanism via Magnetic Pumping in the Intracluster Medium of Galaxy Clusters (via Zoom)

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Turbulence driven by AGN activity constitutes an attractive energy source for heating the intracluster medium (ICM) in galaxy clusters. How this energy dissipates into the ICM plasma remains unclear, given its low collisionality and high magnetization, which precludes viscous heating in the ordinary gas dynamics sense. However, Kunz et al. 2011 proposed that gyroviscous heating, a form of heating based on the anisotropy of the plasma pressure with respect to the local magnetic field, could be a viable heating mechanism. In this work, we build upon this idea by studying how the anisotropy evolves under a range of forcing frequencies, what waves and instabilities are generated, and demonstrating that the particle distribution function acquires a high energy tail. We perform particle-in-cell (PIC) simulations of a plasma subject to periodic variations of the mean magnetic field $\mathbf{B}(t)$ to show that particles can be gyroviscously heated by large-scale turbulent fluctuations via magnetic pumping. When $\mathbf{B}(t)$ grows (dwindles), a pressure anisotropy $P_{\perp,j} > P_{\parallel,j}$ ($P_{\perp,j} < P_{\parallel,j}$) builds up ($P_{\perp,j}$ and $P_{\parallel,j}$ are, respectively, the pressures of species j perpendicular and parallel to $\mathbf{B}(t)$). These pressure anisotropies excite mirror and oblique firehose instabilities, which pitch-angle scatter the particles and limit the anisotropy level, thus providing a channel to heat the plasma. The efficiency of this heating mechanism depends on the frequency of the large-scale turbulent fluctuations and the efficiency of the scattering the instabilities provide in their nonlinear evolution. Our results show that this process can be relevant in dissipating and distributing turbulent energy at kinetic scales in weakly collisional plasmas such as the ICM.

Author: LEY, Francisco (University of Wisconsin Madison)

Co-authors: ZWEIBEL, Ellen (U Wisconsin-Madison); Prof. RIQUELME, Mario (Universidad de Chile); Prof. SIRONI, Lorenzo (Columbia University); Mr MILLER, Drake (University of Wisconsin Madison)

Presenter: LEY, Francisco (University of Wisconsin Madison)

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