Abstract Submitted
for the DFD19 Meeting of
The American Physical Society

Heat transfer and flow regimes in quasi-static magnetoconvection with a vertical magnetic field MING YAN, MICHAEL CALKINS, STEFANO MAFFEI, KEITH JULIEN, University of Colorado, Boulder , STEVEN TOBIAS, University of Leeds , PHLIPPE MARTI, ETH Zurich — Numerical simulations of Rayleigh-Bénard convection with an imposed vertical magnetic field are carried out over a broad range of Rayleigh numbers and magnetic field strengths. Three magnetoconvection regimes are identified: two of the regimes are magnetically-constrained in the sense that a leading-order balance exists between the Lorentz and buoyancy forces, whereas the third regime is characterized by unbalanced dynamics that is similar to non-magnetic convection. Each regime is distinguished by flow morphology, momentum and heat equation balances, and heat transport behavior. One of the magnetically-constrained regimes appears to represent an 'ultimate' magnetoconvection regime in the dual limit of asymptotically-large buoyancy forcing and magnetic field strength; this regime is characterized by an interconnected network of anisotropic, spatially-localized fluid columns aligned with the direction of the imposed magnetic field that remain quasi-laminar despite having large flow speeds. Heat transport is controlled primarily by the thermal boundary layer. Empirically, the scaling of the heat transport and flow speeds appear to be independent of the thermal Prandtl number within the magnetically-constrained regimes.

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Date submitted: 01 Aug 2019 Electronic form version 1.4