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Laboratory Measurement of Non-Rotating Magnetoconvection in Liquid Gallium: Wall-mode Onset and Supercritical Precessional Mode[1]

YUFAN XU, University of California, Los Angeles, SUSANNE HORN, Coventry University, JONATHAN AURNOU, University of California, Los Angeles — Turbulent flows in the Earth's molten outer core, driven by convection, generate a planetary-scale, nearly axial, dipole-dominated magnetic field. The behaviors of strongly turbulent convection in the presence of strong Lorentz forces are mostly unknown. Thus, we present results of laboratory experiments on non-rotating Rayleigh-Bénard convection of liquid gallium in the presence of a vertical magnetic field. Our heat transfer survey in a diameter-to-height aspect ratio $\Gamma = 1$ tank, with $10^6 < Ra < 10^8$ and $0 < Ch < 3 \times 10^5$, shows that the convection onsets well below the predicted Ra for an infinite fluid layer. Magnetoconvection in our finite cylindrical tanks likely onsets via stationary wall-attached modes (Houchens et al., 2002; Busse, 2008). In a $\Gamma = 2$ tank and with $Ra \approx 2 \times 10^6$, we vary the applied magnetic field corresponding to interaction parameter numbers N from 0 to 10. Our thermal measurements show the existence of a novel precessional mode at $N \approx 0.5$ with electrically conducting boundaries (Cu), but not with electrically insulated boundaries (Teflon coated Al). This finding suggests the possibility of slowly traveling magneto-precessional modes attached to the electrically conductive boundaries of Earth's outer core.

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