Rayleigh-Bénard Convection in Partially Molten Layers

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Résumé

Partially molten layers are common in geophysics, from solidifying magma oceans to icy satellite shells or the lowermost lunar mantle. Their thickness can reach hundreds of kilometers, making microscale simulations of solid–liquid interactions impractical. Building on mesoscopic volume-averaging approaches, we develop a unified non-linear fluid dynamics model describing percolation, compaction, convection, and phase change in two-phase flows. Phase transitions are treated by relating melt fraction to the phase diagram, enabling efficient calculations. We also examine how different formulations of the viscous stress tensor affect convective vigor, an open question in the literature. Finally, we introduce a smooth, self-consistent treatment of the transition between partially molten and fully solid regions, allowing robust modeling of evolving planetary interiors. Future work will explore whether the seismic anisotropy of the Earth's Inner Core could originate from compaction-driven convective flows.

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