Ultimate regime of rapidly rotating convection: experimental and numerical assessment of the 'geostrophic turbulence' scaling predictions

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Several regimes of rotating convection arise depending on the background rotation rate and the strength of the thermal forcing. Of particular interest is the 'geostrophic turbulence' scaling regime, an 'ultimate' or diffusivity-free scaling regime that is believed to govern the transport of heat and tracers in planetary and stellar interiors. This regime has remained undetected in laboratory experiments for a long while, despite an effort of the community to build ever-taller rotating Rayleigh-Bénard convection cells. We recently introduced an alternate rotating convection setup where the fluid is heated radiatively through the absorption of visible light. This approach led to the first experimental observation of the 'geostrophic turbulence' regime[1], based on measurements of the heat transport efficiency. Beyond this characterization of the Nusselt-versus-Rayleigh scaling behavior, the 'geostrophic turbulence' regime is associated with scaling predictions for the turbulent kinetic energy, the temperature fluctuations and the typical scales of the convective flow[2,3]. Based on recent experimental and numerical data of rapidly rotating radiatively driven convection, we assess the validity of these additional scaling predictions and discuss the range of validity of each prediction independently.

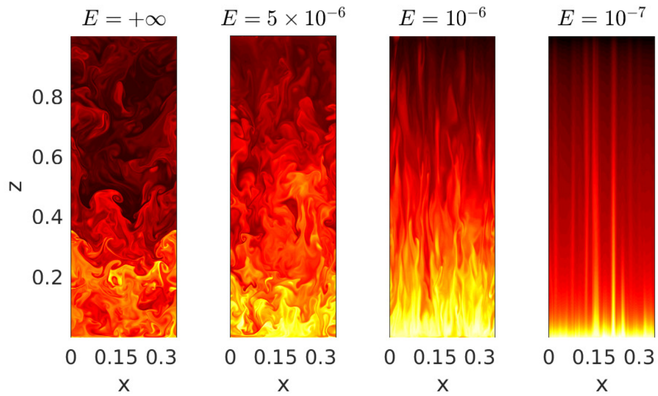

Figure 1: Vertical sections of the temperature field for increasing rotation rate (left to right). The flow evolves from fully 3D non-rotating convection to a rapidly rotating regime characterized by vertically elongated structures.

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