Experimental observation of the geostrophic turbulence regime of rapidly rotating convection

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The competition between turbulent convection and global rotation in planetary and stellar interiors governs the transport of heat and tracers, as well as magnetic field generation. These objects operate in dynamical regimes ranging from weakly rotating convection to the "geostrophic turbulence" regime of rapidly rotating convection. However, the latter regime has remained elusive in the laboratory, despite a worldwide effort to design ever-taller rotating convection cells over the last decade. Building on a recent experimental approach [1] where convection is driven radiatively, see Figure 1, I will report heat transport measurements in quantitative agreement with this scaling regime [2], the experimental scaling law being validated against direct numerical simulations (DNS) of the idealized setup. The scaling exponent from both experiments and DNS agrees well with the geostrophic turbulence prediction. The prefactor of the scaling law is greater than the one diagnosed in previous idealized numerical studies [3,4], pointing to an unexpected sensitivity of the heat transport efficiency to the precise distribution of heat sources and sinks, which greatly varies from planets to stars.

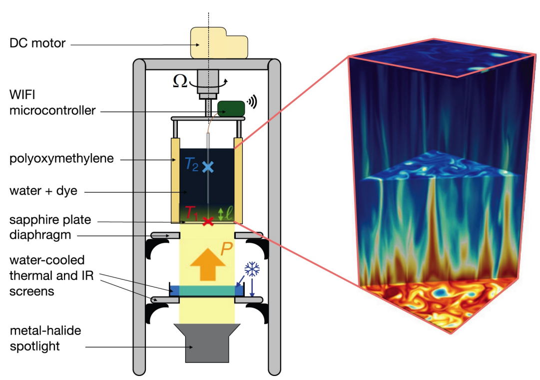

Figure 1. Radiatively driven rotating convection. A powerful spotlight shines from below at a mixture of water and dye. The resulting internal heat source decreases exponentially with height over the absorption length, delivering a total heat flux P. On the right-hand side is a DNS snapshot of the temperature field in horizontally periodic geometry devoid of centrifugal and sidewall effects, highlighting the vertically elongated structures of rotating convection (arbitrary color scale ranging from blue for cool fluid to red for warm fluid).

References

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