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Effects of Pr on Optimal Heat Transport in Rayleigh-Bénard Convection[1] DAVID SONDAK, MARKO BUDIŠIĆ, FABIAN WALEFFE, LESLIE SMITH, University of Wisconsin, Madison — Steady flows that optimize heat transport are obtained for two-dimensional Rayleigh-Bénard convection with no-slip horizontal walls for a variety of Prandtl numbers Pr and Rayleigh number up to $Ra \sim 10^9$. The presence of two local maxima of Nu with different horizontal wavenumbers at the same Ra leads to the emergence of two different flow structures as candidates for optimizing the heat transport where the Nusselt number Nu is a non-dimensional measure of the vertical heat transport. For $Pr \leq 7$, optimal transport is achieved at the smaller maximal wavenumber whereas for $Pr > 7$ at high-enough Ra the optimal structure occurs at the larger maximal wavenumber. Three regions are observed in the optimal mean temperature profiles, $\overline{T}(y)$: 1.) $d\overline{T}/dy < 0$ in the boundary layers, 2.) $d\overline{T}/dy > 0$ ($Pr \leq 7$) or $d\overline{T}/dy < 0$ ($Pr > 7$) in the central region, and 3.) $d\overline{T}/dy > 0$ between the boundary layers and central region. We also search for a signature of these optimal structures in a fully-developed turbulent flow by employing modal decompositions such as the proper orthogonal decomposition and the Koopman mode decomposition.

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