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Influence of the Prandtl number on the heat transport enhancement in rotating turbulent Rayleigh-Bénard convection[1] STEPHAN WEISS, PING WEI, GUENTER AHLERS, University of California, Santa Barbara
— We present new Nusselt-number (Nu) measurements for slowly rotating turbulent thermal convection in cylinders with aspect ratio $\Gamma = 1$. By using compressed gasses and various liquids, we now have data in the Prandtl number (Pr) range $0.74 <\mathrm{Pr}< 35.5$ and for Rayleigh numbers (Ra) in the range $4 \times 10^8 <\mathrm{Ra}< 2 \times 10^{11}$. With these data we investigate in detail the effect of Pr and Ra on the heat-transport enhancement close to its onset. This enhancement takes place for rotation rates larger than a critical value, as expressed by the dimensionless inverse Rossby number $(1/Ro)$, since only then vortices form, in which due to Ekman pumping fluid is transported from the thermal boundary layers into the turbulent bulk. We found that the critical inverse Rossby number $(1/Ro_c)$ decreases with increasing Pr, following a power law with exponent $\alpha = -0.40 \pm 0.02$. For larger rotation rates, the relative heat transport enhancement (Nu_r) increases first linearly with a slope $S = \partial Nu_r/\partial(1/Ro)$. We show that also the slope S follows a power law $S \propto Pr^{\beta} Ra^{\gamma}$ with $\beta = -0.10 \pm 0.06$ and $\gamma = -0.14 \pm 0.04$. We found that the maximum heat transport enhancement (up to 40%) increases with increasing Pr and decreasing Ra.

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