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Heat transport by turbulent Rayleigh-Bénard convection for $\Pra\ \simeq 0.8$ and $3\times 10^{12} \alt \Ra\ \alt 10^{15}$: Aspect ratio $Γ= 0.50$

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We report experimental results for heat-transport measurements, in the form of the Nusselt number \Nu, by turbulent Rayleigh-B\'enard convection in a cylindrical sample of aspect ratio $\Gamma \equiv D/L = 0.50$ ($D = 1.12$ m is the diameter and $L = 2.24$ m the height). The measurements were made using sulfur hexafluoride at pressures up to 19 bars as the fluid. They are for the Rayleigh-number range $3\times 10^{12} \alt \Ra \alt 10^{15}$ and for Prandtl numbers \Pra\ between 0.79 and 0.86. For $\Ra < \Ra^*_1 \simeq 1.4 \times 10^{13}$ we find $\Nu = N_0 \Ra^{\gamma_{eff}}$ with $\gamma_{eff} = 0.312 \pm 0.002$, consistent with classical turbulent Rayleigh-B\'enard convection in a system with laminar boundary layers below the top and above the bottom plate. For $\Ra^*_1 < \Ra < \Ra^*_2$ (with $\Ra^*_2 \simeq 5\times 10^{14}$) γ_{eff} gradually increases up to 0.37 ± 0.01. We argue that above $\Ra^*_2$ the system is in the ultimate state of convection where the boundary layers, both thermal and kinetic, are also turbulent. Several previous measurements for $\Gamma = 0.50$ are re-examined and compared with the present results.

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