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Heat and momentum transport scalings in vertical convection[1]

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For vertical convection, where a fluid is confined between two differently heated isothermal vertical walls, we investigate the heat and momentum transport, which are measured, respectively, by the Nusselt number Nu and the Reynolds number Re. For laminar vertical convection we derive analytically the dependence of Re and Nu on the Rayleigh number Ra and the Prandtl number Pr from our boundary layer equations and find two different scaling regimes: $Nu \sim Pr^{1/4}Ra^{1/4}$, $Re \sim Pr^{-1/2}Ra^{1/2}$ for $Pr \ll 1$ and $Nu \sim Pr^{0}Ra^{1/4}$, $Re \sim Pr^{-1}Ra^{1/2}$ for $Pr \gg 1$. Direct numerical simulations for Ra from 10^5 to 10^{10} and Pr from 0.01 to 30 are in excellent ageement with our theoretical findings and show that the transition between the regimes takes place for Pr around 0.1. We summarize the results from Shishkina, Phys. Rev. E 93 (2016) 051102R and present new theoretical and numerical results for transitional and turbulent vertical convection.

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