Heat and momentum transport scalings in vertical convection

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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 $N_u$ and the Reynolds number $Re$. For laminar vertical convection we derive analytically the dependence of $Re$ and $N_u$ on the Rayleigh number $Ra$ and the Prandtl number $Pr$ from our boundary layer equations and find two different scaling regimes: $N_u \sim Pr^{1/4}Ra^{1/4}$, $Re \sim Pr^{-1/2}Ra^{1/2}$ for $Pr \ll 1$ and $N_u \sim Pr^{0}Ra^{1/4}$, $Re \sim Pr^{-1}Ra^{1/2}$ 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 agreement 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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