Abstract Submitted
for the DFD19 Meeting of
The American Physical Society

Effect of slip boundary conditions on the heat flux and near-wall temperature equations in turbulent Rayleigh-Bénard convection[1]
XIAOZHOU HE, MAOJING HUANG, Harbin Institute of Technology(Shenzhen), YIN WANG, Hong Kong University of Science and Technology, YUN BAO, Sun Yat-Sen University — We present direct numerical simulations (DNS) of the heat transport and near-wall temperature profiles in turbulent Rayleigh-Bénard convection (RBC) with slip boundary conditions (BCs) on horizontal walls. The mean horizontal velocity on the wall is assumed as $u_w = (b/L)(\partial u/\partial n)|_w$. Here L is the height of RBC sample, b is the slip length with $b = 0$ for no-slip BC and $b \to \infty$ for free-slip BC. The simulations were for $0 \leq b/L \to \infty$ and the Prandtl numbers $Pr = 4.3$ in the Rayleigh-number range $10^8 Ra \times 10^{10}$. As b/L increases, we found that the ratio of dimensionless heat flux, as expressed by the Nusselt number follows $Nu/Nu_0 = 0.8 \times tanh(100 \times b/L) + 1$, where Nu_0 is the Nusselt number for $b = 0$. Considering the boundary layer fluctuations, we derived the equation $\Theta(\xi) = \int_0^\xi (1 + p^x \eta^x)^{-n} d\eta$ for the mean temperature profile $\Theta(\xi)$ near the horizontal surface, where $p = \Gamma(1 + 1/x)\Gamma(n - 1/x)/\Gamma(n)$ with $2 \leq x \leq 3$ depending on b/L and $n > 1$ for varying geometries of the convection sample.

[1]Supported by NSFC Grant No.11772111.

Xiaozhou He
Harbin Institute of Technology(Shenzhen)

Date submitted: 01 Aug 2019 Electronic form version 1.4