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A New Parameterization of Nu-Ra Relation in Turbulent Rayleigh-Bénard Convection[1] J. CHEN, ZI-PING CHE, ZHEN-SU SHE, State Key Lab. for Turbulence & Complex Sys., Dept. Mech. & Engg. Sci., College of Engg., Peking Univ. — Nusselt-Rayleigh relation is a key subject in the study of turbulent Rayleigh-Bénard convection (RBC). She et al. introduced Structural Ensemble Dynamics(SED) theory to study wall-bounded turbulence, which yields a multi-layer model of velocity and temperature profiles for RBC system. Here, we report a result of this study, i.e. a new parameterization of Nusselt number(Nu) as a function of Rayleigh number(Ra): $Nu = \alpha Ra^{1/7} \exp\left(\gamma \mathrm{Ra}^{\beta}\right)$. The parameters ($\alpha$, β and γ) are supposed to be slowly varying with Ra and other physical parameters, in particular Prandtl number(Pr). Analysis of a set of experimental data with $Ra = 10^8 \sim 10^{12}$ and $Pr = 0.7 \sim 7.0$ shows that this parameterization is efficient, yielding an accurate description of Nu-Ra with errors bounded within 1%. This parameterization surprisingly reveals two distinct states as α varies, with transition at $\alpha = 1$. Then, an analytic model linking the variation of the three parameters is proposed, yielding a uniform description for the enormous empirical Nu-Ra data, significantly more accurate than the well-known Grossmann-Lohse (GL) model. In conclusion, the SED theory emphasizing the internal profiles provides a viable description of the RBC system.

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