Abstract Submitted
for the DFD17 Meeting of
The American Physical Society

Kinetic thermal structure in turbulent Rayleigh-Bénard convection[1] JUN CHEN, ZE-XIA YIN, ZHEN-SU SHE, State Key Lab for Turb. & Complex Sys., College Engg., Peking Univ., Beijing 100871, China, YUN BAO, Dept. Appl. Mech. & Engg., Sun Yat-sen Univ., Guangzhou 510275, China — Plumes are believed to be the most important heat carrier in turbulent Rayleigh–Bénard convection (RBC). However, a physically sound and clear definition of plume is still absent. We report here the investigation of a definition of plume called kinetic thermal structure (KTS), based on the analysis of vertical velocity gradient ($\Lambda = \partial w / \partial z$), using direct numerical simulation (DNS) data of the three-dimensional RBC in a rectangular cell for $Pr = 0.7$ and $Ra = 1 \times 10^8 \sim 5 \times 10^9$. It is shown that the conditional average of temperature on Λ exhibits such a behavior that when Λ is larger than a threshold, the volume carries a constant temperature of fluid, hence defines an unambiguous thermal structure, KTS. The DNS show that the KTS behaves in a sheet-like shape near the conducting plate, and becomes slender and smaller with increasing Ra. The heat flux carried by KTS displays a scaling law, with an exponent larger than the global-Nu–Ra scaling, indicating stronger heat transport than the turbulent background. An advantage of the KTS is its connection to the balance equation allowing, for the first time, a prediction of the Ra-dependence of its vertical velocity and the characteristic Λ threshold, validated by DNS.

[1]Supported by NSFC (11172006, 11221062, 11452002), and by MOST (China) 973 project (2009CB724100).

Jun Chen
State Key Lab for Turb. & Complex Sys., College Engg., Peking Univ.

Date submitted: 31 Jul 2017 Electronic form version 1.4