DY 29: Focus Session: Rayleigh Benard System and Convective Turbulence

It is one of the outstanding problems to understand the interplay between the formation of structured pattern and turbulent disorder. For convective problems these emerging nonlinear structures are dominating the transport properties and they have manifold impact in nature. (Organizers Jörg Schumacher and Joachim Peinke)

Time: Thursday 15:00–17:00 Location: H44

Invited Talk DY 29.1 Thu 15:00 H44

Transitions in rotating Rayleigh-Benard convection at high Rayleigh numbers — •Andreas Tilgner — Institute of Geophysics, University of Göttingen

In geo- and astrophysics, convective flows are mostly studied in rotating frames of reference and are subject to the Coriolis force. Depending on the control parameters, the flow is either well approximated as non-rotating convection, familiar from numerous simulations and experiments, or it is in a rather less well understood regime in which the flow structures and the turbulence are organized by the global rotation of the frame of reference. The question immediately arises at which parameters the transition form rotating to non-rotating flows occurs. This talk will review characteristic features introduced by rotation. Much work has been done on pattern formation in rotating convection near onset. This talk will on the contrary focus on disordered and turbulent flows and explain the criteria separating rotating from non-rotating convection at high Rayleigh numbers.

Invited Talk DY 29.2 Thu 15:30 H44

Connecting Statistics and Dynamics of Turbulent Rayleigh–Bénard Convection — •Johannes Lülff[1], Michael Wilczek[1,2], Rudolf Friedrich[1], Richard Stevens[3,2], Detlef Lohse[3], Klaus Petschel[4], and Ulrich Hansen[4] — [1]Institute for Theoretical Physics, WWU Münster, Germany — [2]Turbulence Research Group, Johns Hopkins University, Baltimore, USA — [3]Physics of Fluids Group, University of Twente, Enschede, Netherlands — [4]Institute for Geophysics, WWU Münster, Germany

Turbulent Rayleigh–Bénard convection as an ubiquitous phenomenon remains in the central interest of scientists and engineers alike. Though major advances from experimental, numerical and theoretical side have been achieved in recent years, there is no full theory of turbulent convection; especially a comprehensive connection between coherent flow patterns, small-scale fluctuations and the statistics has not been established so far.

To tackle this problem, we apply statistical methods to turbulent Rayleigh–Bénard convection, which lead to insights into the dynamics of the system. We investigate from first principles the temperature statistics in the context of PDF equations, which gives rise to the average transport behavior and flow structures in phase space, and also examine the statistics of flow reversals with methods borrowed from the theory of stochastic processes. The methods are applied to data which is provided by different direct numerical simulations that are briefly summarized.

Invited Talk DY 29.3 Thu 16:00 H44

Temperature statistics near the ultimate state of turbulent Rayleigh-Bénard convection * — •Xiaozhou He[1], Dennis van Gils[1], Eberhard Bodenschatz[1], and Guenter Ahlers[1,2] — [1]MPI-DS, Goettingen, Germany — [2]UCSB, USA

We report on the study of temperature statistics in turbulent Rayleigh-Bénard convection (RBC) for Ra up to 10^{15} and for Pr $\simeq 0.8$. The experiment had been conducted in a pressure vessel known as the "Uboot" of Göttingen with compressed sulfur hexafluoride (SF_6) at a pressure up to 19 bars. We used two upright cylindrical RBC samples with the same diameter $D = 112$ cm but different heights $L = 112$ and 224 cm, corresponding to aspect-ratios $\Gamma \equiv D/L = 1.00$ and 0.50 respectively.

Using the elliptical approximation, we derived local velocities from temperature space-time cross-correlation functions $C_T(r,\tau)$ and found a Gaussian distribution for velocity fluctuations. We also determined an effective Reynolds number in both samples and observed a transition from the classical state to the ultimate state of turbulent RBC[1] near Ra $\simeq 10^{14}$, which agrees with the prediction by GL [2]. Finally, we observed the Kolmogorov $-5/3$ scaling in temperature energy spectra $E(k)$, $E(k) \sim k^{-5/3}$, above Ra $\simeq 10^{14}$ in both samples.

[1] X. He, D. Funfschilling, H. Nobach, E. Bodenschatz and G. Ahlers, Phys. Rev. Lett. **108**, 024502 (2012)

[2] S. Grossmann and D. Lohse, Phys. Rev. E **66**, 016305 (2002)

* Supported by the Max Planck Society, the Volkswagen Stiftung, the DFG SFB963, and NSF grant DMR11-58514.

Invited Talk DY 29.4 Thu 16:30 H44

Cloud formation studies in moist Rayleigh-Benard convection — •Jörg Schumacher — TU Ilmenau, Ilmenau, Germany

Conditionally unstable convection occurs when the stratification is stable for unsaturated air parcels but unstable for saturated air parcels. This leads to the development of isolated convective plumes or clouds which are separated by an extended unsaturated dry environment. Here the statistical behavior of conditionally unstable convection is studied in a model of moist turbulent convection with a simplified thermodynamics of cloudy air. It is closely related to the classical Rayleigh-Benard dry convection problem, but includes phase transitions between the gaseous and liquid phase and the effect of latent heat release on the buoyancy of air parcels. We demonstrate that this simplified model is not only capable to simulate cloud formation processes, but also indicates that the complex dynamics of moist convection results in the emergence of new convective regimes that do not exist in the absence of phase transition. The transition to self-aggregated convection is however highly sensitive to the diffusivity and viscosity used in the model, with the aspect ratio necessary for the transition increasing as the viscosity and diffusivity are decreased. In addition, it is also found that conditionally unstable moist convection is inefficient at transporting energy. We argue that this weak energy transport is tied to the presence of a diffusive layer near the lower boundary, which remains present even when the diffusivity is small. Furthermore, we investigate the impacts of radiative cooling on the self-sustained convective regimes.