DY 16: Convection

Time: Monday 15:30–16:45 Location: ZEU 147

DY 16.1 Mon 15:30 ZEU 147

Resolved energy budget of superstructures in Rayleigh-Bénard convection — •Gerrit Green[1,2], Dimitar G. Vlaykov[1,3], Juan Pedro Mellado[4], and Michael Wilczek[1] — [1]Max Planck Institute for Dynamics and Self-Organization, Göttingen, Germany — [2]Faculty of Physics, University of Göttingen, Göttingen, Germany — [3]Astrophysics Group, University of Exeter, Exeter, UK — [4]Department of Physics, Universitat Politècnica de Catalunya, Barcelona, Spain

Coherent large-scale flow patterns in the presence of turbulent small-scale fluctuations are a ubiquitous phenomenon in natural flows. Currently, the interaction of these so-called turbulent superstructures with small-scale fluctuations is not understood in detail. In order to clarify this interaction, we study superstructures by means of direct numerical simulations in Rayleigh-Bénard convection. This idealized model system shows a complex coexistence of turbulent fluctuations and superstructures. Here, we employ a filtering approach to separate the superstructures from the small-scale fluctuations. We study the resolved energy budget at the scale of the superstructures and characterize the different contributions to the budget, such as the energy input by buoyancy, the direct dissipation, and the energy transfer between scales. We find that the energy transfer primarily acts as an energy sink but exhibits a complex structure in the boundary layer. Our detailed analysis of the energy budget sheds light on the interaction between superstructures and small-scale fluctuations and may help to guide the development of reduced-order models.

DY 16.2 Mon 15:45 ZEU 147

Differences between 2D and 3D rotating, incompressible convection in direct numerical simulations — •Kevin Lüdemann and Andreas Tilgner — Institute of Geophysics, Göttingen, Germany

Direct numerical simulations of an incompressible fluid are used to investigate differences between exact 2D and 3D simulations. The fluid is rotated about a direction perpendicular to the direction of gravity. The Prandtl number is 0.7 and the convection is controlled by a Rayleigh number ranging from 10^4 to 10^9. Rotation is characterised by the Ekman number ranging from 10^{-1} down to 10^{-6}. The convective flow will be restrained to the plane perpendicular to the direction of rotation at strong enough rotation due to the Taylor-Proudman theorem. This behaviour will break up once convective driving is strong enough. Thermal transport and kinetic energy density depart noticeably from the 2D scaling. In the regime of 3D isotropic turbulence the scaling of the Nusselt number is different from the 2D scaling by a constant factor.

DY 16.3 Mon 16:00 ZEU 147

Moist Rayleigh-Bérnard Convection in conditionally unstable environments — •Florian Heyder, Jörg Schumacher und Martina Hentschel — Technische Universität Ilmenau, 98693 Ilmenau, Germany

The presence of water vapour and liquid water leads to cloud formation in the turbulent atmosphere. The boost of buoyancy due to latent heat release by condensation at cloud level implies different dynamics for dry unsaturated and moist saturated air parcels. We investigate their motion by direct numerical simulations in a moist Rayleigh-Bénard (RB) model in the Boussinesq approximation. Our setup takes moist and dry dynamics into account by linearising the equation of state on both sides of the phase boundary. This simplified model allows us to study differences to classical RB systems without phase changes, as well as the formation of clouds in extended horizontal domains. Special emphasis is given to conditionally unstable environments where dry air is stably and moist air unstably stratified.

DY 16.4 Mon 16:15 ZEU 147

Heat and momentum transport enhancement in liquid metal convection exposed to horizontal magnetic fields — •Tobias Vogt[1], Juancheng Yang[2], Felix Schindler[1], and Sven Eckert[1] — [1]Helmholtz Zentrum Dresden-Rossendorf, Dresden, Germany — [2]Xi'an Jiaotong University, Xi'an, China

We investigate the effect of a static, horizontal magnetic field on a liquid metal Rayleigh-Bénard convection by means of laboratory experiments. Although a static magnetic field acts as a stabilizing force on the fluid, we find that self-organized convective flow structures reach an optimal state where the heat transport significantly increases and convective velocities reach the theoretical free-fall limit. Our measurements show that the application of the magnetic field leads to an anisotropic, highly ordered flow structure and a decrease of the turbulent fluctuations. When the magnetic field strength is increased beyond the optimum, Hartmann braking becomes dominant and leads to a reduction of the heat and momentum transport. The results are relevant for magneto-hydrodynamic convective flows in stellar interiors and planetary cores.

DY 16.5 Mon 16:30 ZEU 147

Helical Rayleigh-Benard Convection — •Philipp Reiter[1], Rodion Stepanov[2], and Olga Shishkina[1] — [1]Max-Planck Institute for Dynamics and Self-Organization, Göttingen, Germany — [2]Institute of Continuos Media Mechanics, Perm, Russia

Helicity is known to play a key role in generation of large coherent flow structures in a large class of geophysical and astrophysical flows. Here we suggest a new way to inject helicity in convective systems through coupling of the temperature and vertical vorticity via the temperature boundary conditions under the requirement that the area-averaged temperatures of the heated and cooled plates are kept constant.

Using 3D direct numerical simulations, we verify the impact of these boundary conditions on the mean-flow helicity, analyze the global flow structures and the heat transport and investigate their dependencies on the particular parameters of the boundary conditions. For a certain set of parameters, when a significant amount of helicity is injected, we observe generation of the mean vertical angular momentum. In that case, after an initial transitional phase, the flow enters a state of a well-pronounced stable rotation.