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Experimental investigation of superstructures in turbulent liquid metal convection

Summary: The appearance of thermal superstructures in turbulent convection within very low Prandtl number fluids will be investigated experimentally in a large aspect ratio domain. The experiments will be conducted using the liquid metal gallium-indium-tin (GaInSn) that has a Prandtl number of Pr ≈ 0.03. Combined temperature and velocity measurements will provide detailed information about turbulent, convective superstructures and their dynamics. A novel Ultrasound-Doppler-Array technique will be used to measure for the first time two dimensional velocity vector fields of the superstructures in a turbulent liquid metal convection. The velocity measurements are complemented by simultaneous temperature measurements at up to 100 measuring positions to enable spatio-temporal mapping of the temperature distribution in the thermal boundary layer. High-frequency sampling of the velocity and temperature field at local positions will be performed to obtain turbulent statistics while long time measurements over ten thousands of convective freefall time units will reveal the long-term dynamics of the flow pattern. Besides that, we will provide scalings for the heat and momentum transport. The proposed experiments will set a new milestone for a deeper understanding of turbulent superstructures at very low Prandtl numbers with regard to their major relevance both in geo- and astrophysical flows as well as in engineering systems.

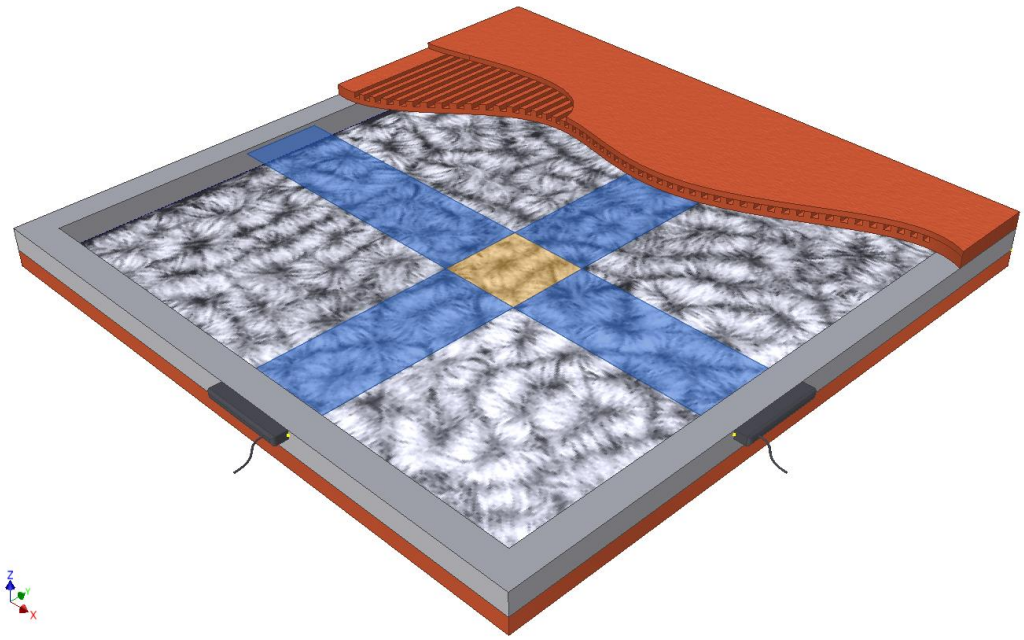

Figure 1: Schematic of the experimental set-up. Rectangular vessel with dimensions 100 x 100 x 4 cm³ ($\Gamma = 25$). Top and bottom heat exchangers are indicated orange. The UDV-arrays are marked black and their measuring area is indicated by blue/yellow colour. The flow field image was adopted from Pandey et-al. Nat. Comm. **9**, 2118 (2018).