Lagrange' measurements in highly turbulent Rayleigh-Bénard convection

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Abstract:

Turbulent convection is a very frequently occurring state of flow in nature and technology. It is characterized by a very high degree of fluctuations at a relatively small mean of the velocity. For a systematic study of this type of flow the Rayleigh-Bénard (RB) system - a closed box with a heated bottom plate and a cooled top plate as well as adiabatic sidewalls - represents a well-defined model, which has been investigated in great detail in the past [1]. Compared with other highly turbulent model flows like pipe and channel flows or flows between counter-rotating propellers in which turbulence is driven by moving elements inside the fluid the flow in highly turbulent RB convection is free of any artificiality. The application of Lagrange' measurements to this type of flow will help us to better understand the heat transport between the boundary layers as well as the nature of turbulence in general.

We present a large-scale experimental facility which is called the 'Barrel of Ilmenau' and which is sketched in figure 1. The convection apparatus is a cylindrical box with an inner diameter of D = 7.15 m. It is filled with air (Pr = 0.7). An electrical heating plate at the bottom and a free hanging cooling plate at the top trigger the convective flow. Heating and cooling plate are flown through by water to maintain a very homogeneous temperature distribution $\Delta\vartheta<1$K. The distance H between both plates can be adjusted between 0.05 m < H < 6.30 m. In order to guarantee the adiabatic boundary condition at the sidewall the experiment is shielded by an electrical compensation heating system. In this unique facility turbulent convection can be explored in a very broad parameter domain ranging from $Ra=10^6$ (Γ=D/H=143, $\Delta\vartheta$=4K) to $Ra=10^{12}$ (Γ =1.13, $\Delta\vartheta$=60K) and with an unprecedented spatial and temporal resolution.

During the meeting we will not yet be able to present results from Lagrange' measurements. However, we want to discuss the application of this technique to large volumes of the order of 100 m³ and the opportunities which it will open in turbulence research in the future [2].

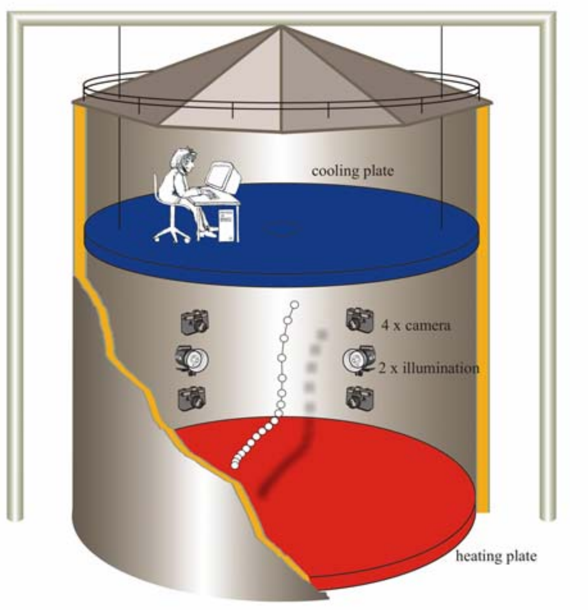

Figure 1: Sketch of the large-scale Rayleigh-Bénard experiment 'Barrel of Ilmenau' and the principle of the Lagrange' measurement technique

References

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