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Contributions to research in turbulence

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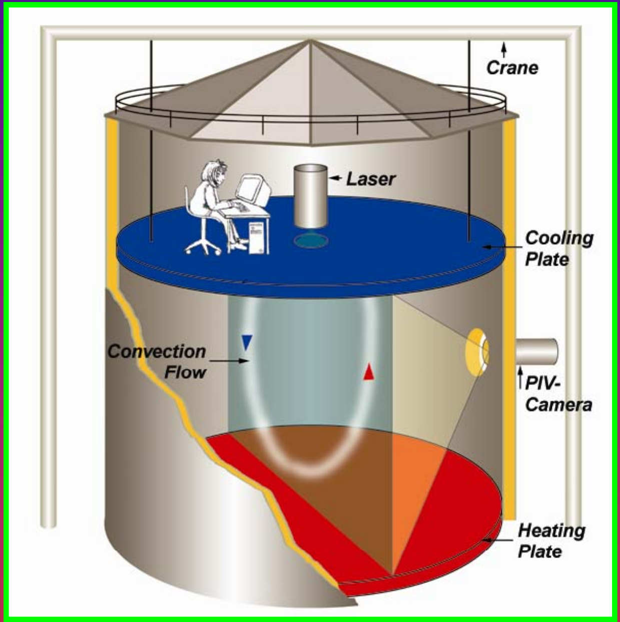
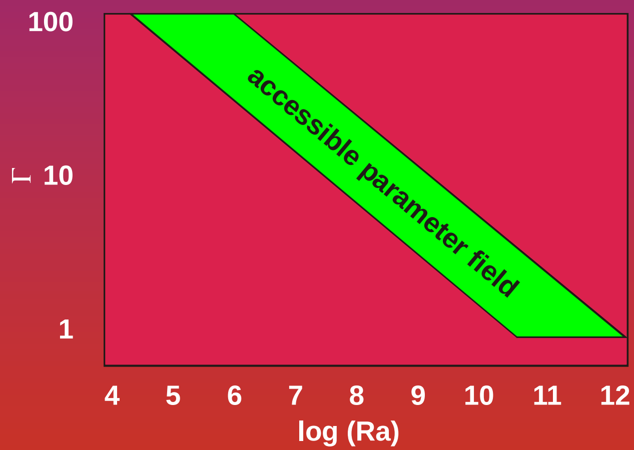
Technique and physical data



Physical parameter:

- d=7.15m, 0.05m<h<6,29m, 2K<ΔT<60K
- $10^5 < Ra < 10^{12}$, $1 < \Gamma < 150$, Pr=0.7
- Nu<650 (*P=10kW*), $Re_G < 3 \times 10^5$ (*v=0.6m/s*), $Re_\tau < 320$ (*δ=10mm*)



Technique:

- electrically heated bottom plate with a water-flown overlay for homogeneous temperature distribution ΔT=1K,
- Free hanging and water-cooled top plate
- Adiabatic sidewall with active compensation heating

Helium vers. large-scale experiments

High Rayleigh number experiments?

$$Ra = \frac{\beta g h^3 \Delta T}{\nu \kappa}$$

Helium experiments

„+“ highest Ra number up to Ra=10^{17},

„+“ small-scale experiments,

„+“ short time scales,

„+“ very small turbulent structures,

„+“ difficult measurement access,

„+“ less resolved (spatial and temporal) measurements.

Large-scale experiments

„-“ moderate Ra number up to Ra=10^{13},

„-“ large-scale experiments,

„-“ long time scales,

„+“ relatively large turbulent structures,

„+“ simple measurement access,

„+“ highly resolved (spatial and temporal) measurements.

Previous experimental research

Experimental series

constant Γ

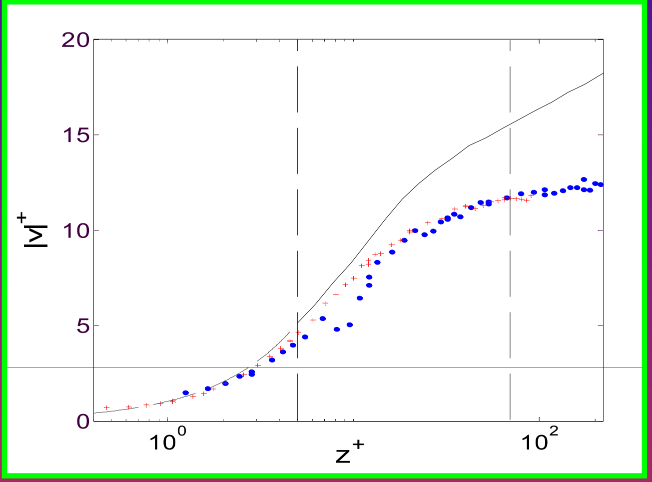
- 4K<ΔT<60K
- 10^{11}<Ra<10^{12}

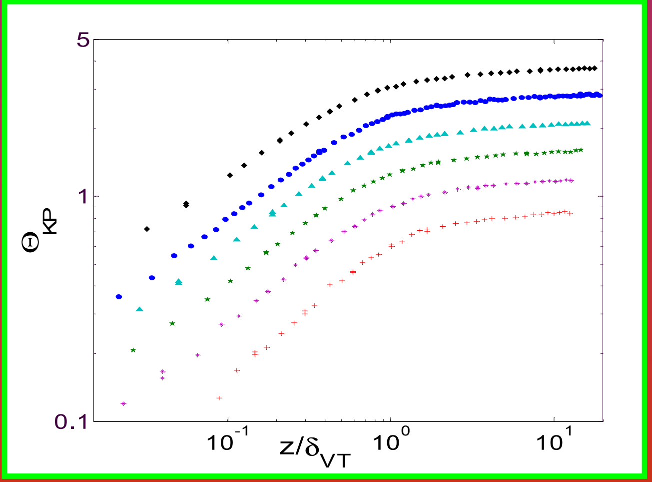
constant ΔT

- 11<Γ<1.1
- 10^{9}<Ra<10^{12}

Results

- global heat flux, Nu~$Ra^{1/3}$ for both series with increasing exponent for Ra→10^{12}
  J. Fluid Mech. 572(2007),
- global flow pattern and aspect ratio dependency, coherent oscillations, transition points: G=1.7 and G=3.7
  Phys. Fluids 18(2006), Phys. Rev. E 75(2007),
- boundary layer structure, v(z) ≠Cz, T(z)~$z^{1/2}$, non-Blasius boundary layer
  J. Fluid Mech. 572(2007), Phys. Rev. E (to be published).





Present (and future) activities

- temperature profiles at the heating plate with improved sensor geometry: evidence of cooling plate profiles, non-Boussinesq effects, radiation, spatial evolution of boundary layer, local heat flux,
- 3-d particle tracking system:
  systematic study of the global flow pattern and ist aspect ratio dependency,
- transitional effects at $Ra \approx 10^{12}$ (collaboration with institute Neel, Grenoble),
- mixed convection and room ventilation in high pressure SF_6, construction of a $1 m^3$ vessel (collaboration with various german universities),
- boundary (shear) layer research: analogies between various model experiments like pipe, taylor-couette, rayleigh-bénard (in discussion).

Our contribution to turbulence research

- highly resolved (in space and time) measurements of velocity (3-d) and temperature at each cell position,
- high aspect ratio and high Ra number experiments, velocity and temperature field without the influence of sidewalls (and a mean flow), reference data for numerical simulations,
- coherent oscillations in highly turbulent convection,
- global flow pattern and aspect ratio dependency, direct measurements of the global flow field using a novel 3-d particle tracking velocimeter.