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VISUALISATION OF THREE-DIMENSIONAL TIME-DEPENDENT FLOW MECHANISMS IN TURBULENT CONVECTION

G. Grötzbach, M. Wörner, E. Hesselschwerdt*
Kernforschungszentrum Karlsruhe
Institut für Reaktorsicherheit
*Institut für Neutronenphysik und Reaktortechnik
Postfach 3640, D-7500 Karlsruhe
Germany
Tel. 07247/824477

ABSTRACT

Direct numerical simulations of Rayleigh-Bénard convection provide data to improve and calibrate turbulence models for pure natural convection. The results of the simulations using up to some million mesh cells are analysed by statistical methods to determine coefficients in existing models[1]. To generalise these models by new assumptions the mechanisms in natural convection are investigated in detail[2]. For this purpose we firstly use static three-dimensional graphical presentations to find regular or systematic structures in the turbulent flow at an arbitrary time. Secondly, we use dynamic presentations of selected calculated results to learn about the dynamics of the dominant convection processes. For both kinds of investigations the AVS software is applied on a graphic workstation STARDENT GS 2000 with 128 MB memory. Fig 1 is an example for the static analysis of Rayleigh-Bénard convection in sodium at a Rayleigh number of 6,000. The isosurface indicates the locations at which the correlation $(T\text{-}0.5)*w = 0.006$, with T = local temperature between 0 and 1, w = vertical velocity. This correlation tends to zero (0.006) near midplane where $T = 0.5$; here one finds long band-like structures in the temperature field indicating the existence of regular rolls as in laminar convection. The correlation also tends to zero near the lower and upper walls where w tends to zero; there the bands show rough boundaries and highly irregular spoke patterns across the rolls indicating that the velocity field is highly turbulent and has very small scales. The latter result is also shown by different colours which represent the local values of w. Thus, this single picture represents both main features of this flow: The temperature field is largely controlled by molecular conduction, whereas the velocity field is highly turbulent. This means, the turbulence models for the velocity field have to account for the high turbulence level, whereas the models for the thermal energy field have mainly to account for molecular conduction and for convection at large scales. So, the graphical tools give a highly flexible interactive access to the results of three-dimensional time-dependent simulations. Especially in analysing large amounts of data such tools are absolutely necessary, but in such cases the performance of current software and hardware have to be improved to achieve more efficient applications.

1 M. Wörner, G. Grötzbach, "Contributions to turbulence modelling of natural convection in liquid metals by direct numerical simulation," This conference.

2 G. Grötzbach, M. Wörner, "Analysis of flow mechanisms in Rayleigh-Bénard convection at small Prandtl numbers," This conference.

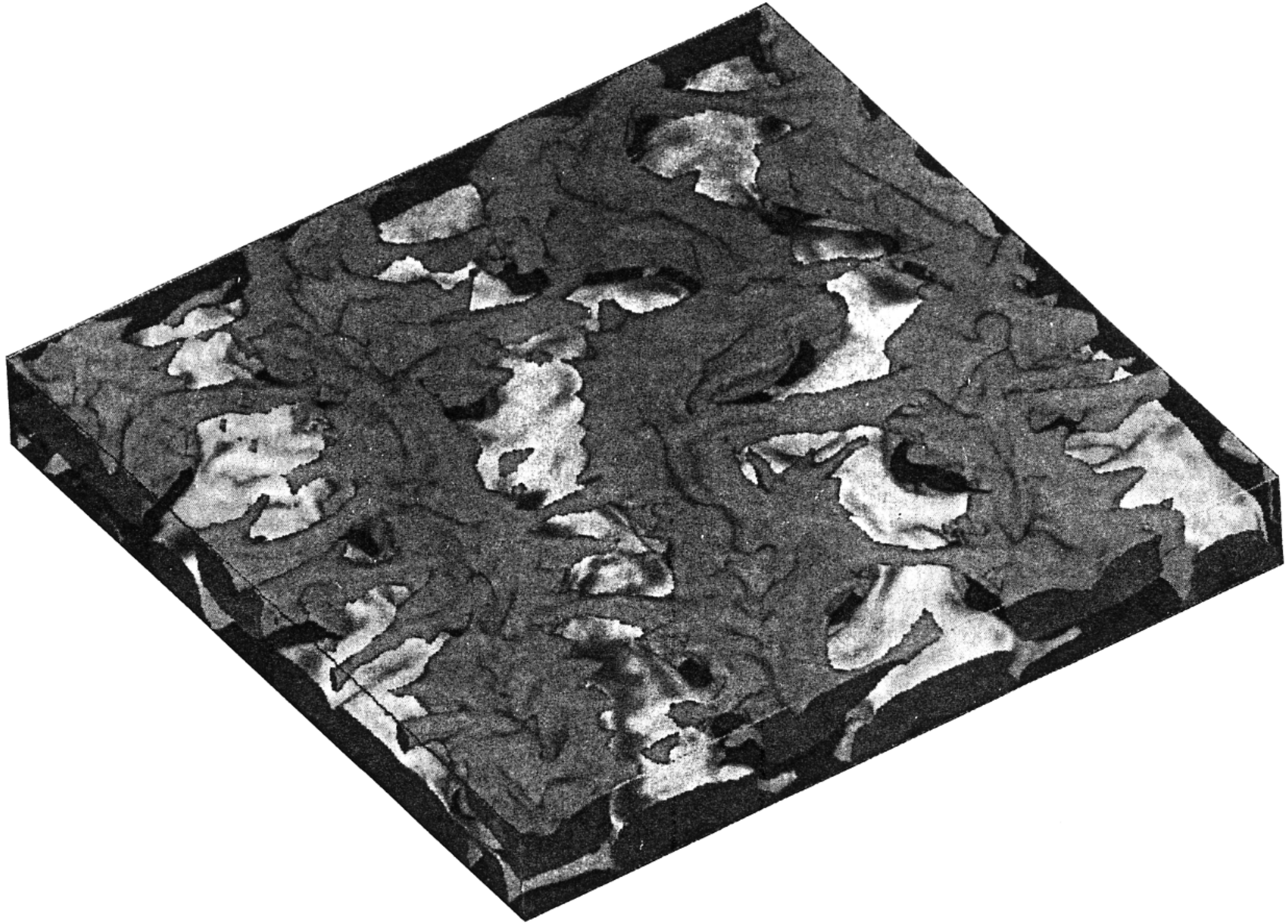

Fig. 1: Isosurface for $(T-0.5)*w = 0.006$ in Rayleigh-Bénard convection, colour code for vertical velocity, $Ra = 6{,}000$, $Pr = 0.006$, $120 \cdot 120 \cdot 19$ mesh cells.