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Sheet-like and plume-like thermal flow in a spherical convection experiment with high viscosity contrast.

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We introduce our spherical experiments on electro-hydrodynamical driven Rayleigh-Bénard convection that have been performed either with temperature-independent properties of the fluid, called 'GeoFlow I', or with temperature-dependent properties, called 'GeoFlow II'. To set up a self-gravitating force field with radial directed buoyancy, we use a high voltage potential between the inner and outer boundaries and a dielectric insulating liquid and perform the experiment in the microgravity conditions of the ISS [1, 2]. We further run numerical simulations in a 3D spherical geometry to reproduce the results obtained in the GeoFlow experiments.

In the experiment the used optical method for flow visualization as delivered by the Optical Diagnostics Module ODM of the Fluid Science Laboratory, is the so called Wollaston-Prism shearing interferometry WSI, which produces fringe pattern images. For the numerical simulations we compute from the temperature field a fringe pattern of convection to compare it then to the experiment data. In this work, we present the flow imaging techniques and their numerical analogues, which were used to compare experimental results with numerical solutions.

An important finding is the difference in the flow pattern between our two experiments. We see a sheet-like thermal flow, if the physical properties of the fluid are not varying with temperature - a result from 'GeoFlow I'. In this case the convection patterns have been successfully reproduced by 3D numerical simulations using both the RESPECT [3] and GAIA [4] codes. If we use a liquid with varying (electro-hydrodynamic) volume expansion and temperature-dependent viscosity (GeoFlow II), for which the viscosity contrast measured in the experiment is 2, the structures change significantly and are plume-like. This result is not expected, since the viscosity contrast seems to be too small for this type of solution according to numerical simulations. However, using a viscosity contrast of two orders of magnitude or higher, we can reproduce the patterns obtained in the GeoFlow II experiment, implying that non-linear effects shift the effective viscosity ratio. Hence, the GeoFlow II experiment gives the possibility to study flows under high viscosity contrasts and is a promising candidate as reference experiment.

REFERENCES [1] B. Futterer, C. Egbers, N. Dahley, S. Koch, L. Jehring (2010). Acta Astronautica 66. [2] B. Futterer, N. Dahley, S. Koch, N. Scurtu, C. Egbers (2012). Acta Astronautica 71. [3] R. Hollerbach, R., (2000). International Journal for Numerical Methods in Fluids 32. [4] C. Huettig, K. Stemmer, (2008). PEPI.