Initial Convection Experiments in Spherical Shells for Modelling Mantle Dynamics within the GeoFlow project

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Thermal convection is a central objective in geo- and astrophysical research. To model convection by an experiment we consider the fluid motion in a gap between two concentric spheres, with inner spherical shell heated and outer spherical shell cooled. Central symmetry buoyancy field is set-up by means of a high voltage potential and use of a dielectric insulating liquid as working fluid in the spherical cavity. This technique, i.e. realization of a selfgravitating force field experimentally, requires micrograviity conditions in order to reduce unidirectional influence of gravity, that would dominate fluid flow in the Earth laboratory.
For GeoFlow these specific conditions are available in the European COLUMBUS module part of the International Space Station ISS [1]. During GeoFlow I mission, which was running on orbit from July 2008 until January 2009, the shells were filled with a silicone oil with approximately constant viscosity. Motivated by convective motion of the Earth's outer core, patterns of convection and their spatial-temporal behaviour have been prospected. For the planned second GeoFlow II mission (on orbit 2010) we propose to use 1-Nonanol as the working fluid, having a temperature dependent viscosity. Therewith experimental modelling of mantle convection is the central goal [2].
Governing equations in Boussinesq form for the incompressible Newtonian fluid of 1-Nonanol are dominated by inertia. In contrast to traditional computer simulation work for Earth mantle dynamics the Prandtl number for our planned experiment is reasonable high ($Pr \leq 200$), but not infinite. Therefore in a first step this Prandtl number influence has been benchmarked with the spherical code GAIA assuming an isoviscous fluid and set-up with an infinite Prandtl number. As a conclusion from these numerical tests, the Prandtl number can be dropped. There steps are to simulate variations of thermal forcing (variation of Rayleigh number) with the specific viscosity contrast of 1-Nonanol.
With further tests for the overall behaviour of GeoFlow II's experimental fluid 1-Nonanol, it shall be possible to evaluate the theoretical predictions on thermal, dielectric and optical performance of the fluid. Two aspects in realization the experimental runs have to be considered: Increasing the viscosity contrast accompanied by decreasing Ra and vice versa. For this the working environment of the experiment has to be varied. Images of the tested runs as well as reached viscosity contrast demonstrate very clearly that the experimental fluid acts in combination of variation of working environment and variation of temperature difference.