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Geophysical flow simulation experiment 'GeoFlow II' - steps towards a mantle convection experiment in spherical shells

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Thermal convection is a central objective in geo- and astrophysical research. To model convection by an experiment in the GeoFlow project 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 liquid as working fluid in the spherical cavity. This technique, i.e. realize a self-gravitating force field experimentally, requires microgravity conditions in order to reduce unidirectional influence of gravity, that would dominate fluid flow in the laboratory. For GeoFlow this specific conditions are available in the European module COLUMBUS of the International Space Station ISS. During mission GeoFlow I, which was running on orbit from July 2008 until January 2009, shells were filled with a fluid having approximately constant viscosity, i.e. silicone oil. 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 mission GeoFlow II (on orbit 2010) we propose to use nonanol as working fluid, having a temperature dependent viscosity. Herewith experimental modelling of mantle convection is the central goal.

Governing equations in Boussinesq form for the incompressible Newtonian fluid of nonanol are dominated by inertia. In contrast to traditional computer simulation work for mantle dynamics the Prandtl number for our planned experiment is reasonable high ($Pr \leq 200$), and not infinite. Therefore in a first step this Prandtl number influence have 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. Next steps are to simulate variations of thermal forcing (variation of Rayleigh number) with the specific viscosity contrast of nonanol. Here experimental realization offers the possibility to vary the viscosity contrast by variation of the working regime, too.