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Microgravity Sciences onboard the International Space Station and Beyond (6)

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'GEOFLOW I AND II' - FLUID PHYSICS EXPERIMENTS ONBOARD ISS FOR MODELING CONVECTION PHENOMENA IN EARTH' OUTER CORE AND MANTLE

Abstract

Overall driving mechanism of flow in inner Earth is convection in its gravitational buoyancy field. A lot of effort has been involved in theoretical prediction and numerical simulation of both the geodynamo, which is maintained by convection, and mantle convection, which is the main cause for plate tectonics. Especially resolution of convective patterns and heat transfer mechanisms has been in focus to reach the real, highly turbulent conditions inside Earth. To study specific phenomena experimentally different approaches has been observed, against the background of magneto-hydrodynamic but also on the pure hydrodynamic physics of fluids. With the experiment 'GeoFlow' (Geophysical Flow Simulation) instability and transition of convection in spherical shells under the influence of central-symmetry buoyancy force field are traced for a wide range of rotation regimes within the limits between non-rotating and rapid rotating spheres. The special set-up of high voltage potential between inner and outer sphere and use of a dielectric fluid as working fluid induce an electro-hydrodynamic force, which is comparable to gravitational buoyancy force inside Earth. To reduce overall gravity in a laboratory this technique requires microgravity conditions.

The 'GeoFlow I' experiment was accomplished on International Space Station's module COLUMBUS inside Fluid Science Laboratory FSL und supported by EADS Astrium, Friedrichshafen, User Support und Operations Centre E-USOC in Madrid, Microgravity Advanced Research and Support Centre MARS in Naples, as well as COLUMBUS Control Center COL-CC Munich. Running from August 2008 until January 2009 it delivered 100.000 images from FSL's optical diagnostics module; here more precisely the Wollaston shearing interferometry was used. Here we present the experimental alignment with numerical prediction for the non-rotating and rapid rotation case.

The non-rotating case is characterized by a co-existence of several stationary supercritical modes, with

a strong influence of initial conditions leading to axisymmetric, octahedral/cubic or pentagonal solutions. Transition to chaos is in form of a sudden onset. Experimental data supports the numerically validated influence of initial conditions in showing the octahedral mode as most preferred stable state. Well-known issue of rapid rotation is the alignment of convective cells at the tangent cylinder due to the domination of centrifugal forces against the self-gravitating buoyancy field. The system shows very clearly the centrifugal effects by patterns in form of columnar cells.

For the planned second mission 'GeoFlow II' (2010) working fluid shall be an alcanole having a temperature dependent viscosity, i.e. nonanol. Herewith experimental modelling of mantle convection is going to spotlight.