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SUPERCRITICAL THERMAL CONVECTIVE MOTIONS IN SPHERICAL SHELLS UNDER CENTRAL FORCE FIELD (GEOFLOW)

C. Egbers, V. Travnikov, B. Futterer, M. Gellert and P. Beltrame
Department of Aerodynamics and Fluid Mechanics, Brandenburg University of Technology, BTU Cottbus, Germany, (egbers@las.tu-cottbus.de)

The ĎGEOFLOW" is an european experiment planned for the Fluid Science Laboratory on ISS under the scientific coordination (PI) of the Department of Aerodynamics and Fluidmechanics (LAS) at the Brandenburg Technical University (BTU) of Cottbus, Germany. The objective of the experiment is to study thermal convection in the gap between two concentric rotating (full) spheres. A central symmetric force field similar to the gravity field acting on planets can be produced by applying a high voltage between inner and outer sphere using the dielectrophoretic effect (rotating capacitor). To counter the unidirectional gravity under terrestrial conditions, this experiment requires a microgravity environment. The parameters of the experiment are chosen in analogy to the thermal convective motions in the outer core of the Earth. In analogy to geophysical motions in the Earth's liquid core the experiment can rotate as solid body as well as differential (inner to outer). Thermal convection is produced by heating the inner sphere and cooling the outer ones. Furtheron, the variation of radius ratio between inner and outer sphere is foreseen as a parameter variation. The flows to be investigated will strongly depend on the gap width and on the Prandtl number. Results of preparatory experiments and numerical simulation of the space experiment will be presented.

Thermal convection in a spherical shell under a central force field represents an important model in fluid dynamics, astro- and geophysics. The large scale motions of atmospheres of planets and in the convection zones of rotating stars are strongly influenced by Coriolis forces (due to rotation) and by buoyancy forces (due to gravity), which drive thermal circulation. The resulting flow structures show a rich variety of

different types of instabilities, which depend strongly on different parameters as rotation rate, temperature gradient, gap width, material functions and others. The model of a spherical gap flow experiment should help to understand such phenomena as the zonal bands of Jupiter, the origin of extremely high winds in the tropics and subtropics of Jupiter, Saturn and Neptune, the persistent differential rotation of the Sun, the complex patterns of convection in the slowly-rotating mantle of the Earth, and the rapidly rotating flows in the Earth's core. Figure 1 shows a schematic cross section of the Earth. The convective motions of the molten iron alloy in the outer core generate the main geomagnetic field. Microgravity experiments on thermal convection with a simulated central dielectrophoretic force field are important for the understanding of these large scale geophysical motions. An experimental set-up is performed to investigate the problems of thermal convection in the fluid shell between two concentric spheres with and without rotation and also with differentially rotating spheres. A central symmetric force field similar to the gravity field acting on planets can be produced by applying a high voltage between the inner and outer sphere using the effect of the dielectrophoretic force field. To turn off the unidirectional gravitation under terrestrial conditions, these experiments require an environment of microgravity.

The numerical investigation of the thermal convection in the spherical gap under central force field with the influence of rotation has been performed as well. This research yields the numerical basis for the GEOFLOW experiment. The convection problem is solved for different radius ratios, as well as Rayleigh-, Taylor- and Prandtl-numbers. Various flow states are considered. First, the basic flow is evaluated. The stability of this flow was investigated due to the linear stability theory. After that, 3D states are received. The first 3D state can be described due to constant amplitude. The following 3D state is time dependent and has a periodic nature. The chaotic flow can be observed for enough high Rayleigh numbers. Complex time-dependent dynamics were found for spherical and wave mode interaction, too. In particular, heteroclinic cycles which connect relative equilibria can exist in the GEOFLOW framework. The bifurcation analysis was undertaken and reveals an important role of the spherical symmetry. The validation with the direct numerical code is currently working. The numerical investigation is performed due to fully pseudospectral method in all three directions.