SpaceOps meets Science: GeoFlow

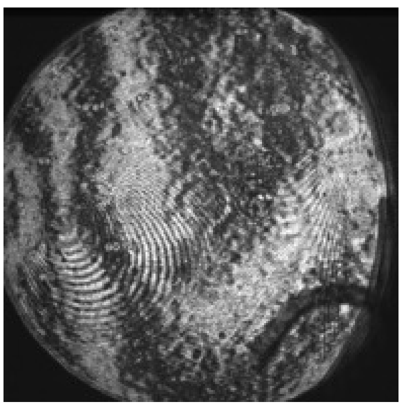
GeoFlow – How the Earth turns.

GeoFlow stands for "*Geo*physical *Flow* simulation". Our present knowledge about the structure, flows and processes of the innermost core of the earth is based on indirect seismic experiments and nobody in the near future will be able to probe the 6370 km to the center of the earth directly. Since thermal convection is a central objective in geo- and astrophysical research Prof. Christoph Egbers of the University of Cottbus (BTU) developed an approach based on modeling the thermal convection in the inner earth with a rotating concentric sphere arrangement creating a fluid filled gap between the two spheres. The prototype flight of his model experiment took place in 1995 on the first converted intercontinental ballistic rocket provided by the Russians and proofed successful.

For investigating convection dynamics with the GeoFlow experiment the focus is on the fluid motion in the gap between the two transparent concentric spheres, with the inner spherical shell heated and the outer shell cooled allowing to simulate the actual conditions of the particular inner earth layer in a scaled down way. A core centered symmetrical force field is set-up by means of a high voltage potential and use of a dielectric liquid as working fluid in the spherical gap. In order to realize a self-gravitating force field experimentally microgravity conditions to reduce unidirectional influence of acceleration due to gravity dominating fluid flow in a laboratory is required.

Those specific conditions are available in the Columbus Fluid Physics Lab (FSL). A laser-interferometer is part of the FSL to provide an analysis of the resulting convections and a video camera transfers the interference patterns for direct monitoring to the University Cottbus acting as User Home Base (UHB) for GeoFlow.

During the GeoFlow I experiment conducted between July 2008 and January 2009, the gap between the shells was filled with a fluid having approximately constant viscosity, i.e., silicone oil. Influences by convective motion of the Earth’s outer core patterns of convection and their spatial-temporal behavior have been observed, recorded and compared to predictions.



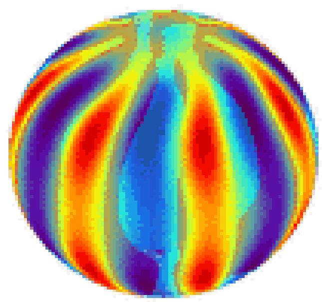


Figure 1: First GeoFlow Interferometric Image

Figure 2: Interferometric Computer Simulation

For the planned second mission GeoFlow II (end of 2010) the working fluid will be an alcanole having a temperature dependent viscosity, i.e., nonanol. Thus, experimental modeling of mantle convection is going to be of prime interest.

SpaceOps News (**SoN**) had the opportunity to talk to the prime investigator of GeoFlow, **Prof. Dr.-Ing. Christoph Egbers**, **Head of Aerodynamics and Fluid Mechanics**, **Technical University Cottbus** (http://www.tu-cottbus.de).

Figure 3: GeoFlow Experiment Package

SoN: In your field of expertise some research and experimentation activities took place already during the past years. What is the particular new capability of the Columbus/ISS research facility for your discipline?
Egbers: With Columbus and the Fluid Science Laboratory you have the possibility for the first time to receive your experiment data directly at your User Home Base (UHB) at your university: telemetry data can be monitored online and pictures are downloaded 2 days later.

SoN: Since GeoFlow was operated as one of the first experiments after Columbus activation, have you been able to get any promising results during the first year of operations?
Egbers: Very good picture quality of interferograms coming out of the experiment with very high accuracy rate, that means more than 99 % of data could be used to analyze the flow- and temperature field inside of GeoFlow. All the data are compared with numerical predictions at the time.

SoN: What would be the "breakthrough" if your research expectations would be fulfilled completely, i.e., what kind of unresolved knowledge would be gained?
Egbers: May be that we can show a basic configuration set of parameters which is responsible in principle for reversals of large scale convective motions inside the liquid outer core.

SoN: What could be the follow-up steps to reach final conclusions?
Egbers: Data analysis is running and numerical simulations in parallel as well. For some parameter ranges analysed up to now, we have a very good agreement between 3D Computational Fluid Dynamics (CFD) prediction and the GeoFlow space experiment. Further investigations are running now on the prograde or retrograde drift of the large scale motion and on chaotic up to turbulent motion.

SoN: Would there be any practical (application) aspect from the results?
Egbers: Yes, indeed, we can use the same dielectrophoretic force field applied on the spherical system in GeoFlow as well in other geometries like cylindrical systems and this has a more practical background for flow control in heat exchangers, micro-dosing systems, micro pumps, etc.
Experiments with cylindrical geometries are planned to be carried out on parabolic flight campaigns first (scheduled for autumn 2010 with a DLR campaign).

SoN: Are you getting the appropriate institutional/commercial funding for your experiment program?
Egbers: We get funding from DLR for science preparation and data evaluation during the mission. ESA is financing the Topical Team staff for GeoFlow.

SoN: Is the support by the operations infrastructure satisfactorily or would you have suggestions for improvements?
Egbers: It might be much easier to work with the Columbus Control Center (Col-CC) at Oberpfaffenhofen directly in the case of a German space experiment. In our case (Fluid Sciences) people in Europe were also involved (Mars Centre in Naples for EM operations, UHB in Madrid).

SoN: Is the available experimentation time sufficient to reach the expected goals during the planned time horizon?
Egbers: In our case the time was sufficient to perform all planned parameter variations.

SoN: Could the Experiment facilities on board the ISS be maintained at the expected technical state-of-the-art for the next 5 years?
Egbers: Synchronization of telemetry and video data inside the FSL should be realized as well as micro-g measurements inside the FSL close to the experiment container.

SoN: Would you expect a continuation of microgravity experimentation in your filed of expertise 5 years from now?
Egbers: Yes, indeed, we are planning the second mission of GeoFlow (mantle convection in contrast to liquid outer core convection) for end of next year. Upload of the new equipment will be with ATV. Besides our experiment, there is a certain number of new experiment containers in the field of fluid physics to be installed in FSL during the next 5 years.

SoN: If so, what are the long term science goals in your field of expertise?
Egbers: Geophysical fluid flows, flow control, emulsions, boiling, free surface flows, reactive flows, etc.

Professor Egbers, thank you very much for your time and the very interesting information you provided during the interview and good luck for the future experiments.

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