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AtmoFlow – Experimental investigation of atmospheric flows under microgravity conditions

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The main objective of the AtmoFlow experiment is the investigation of convective flows in the spherical gap geometry that are of interest for geophysical, astrophysical and especially here for atmospheric research. The main feature of AtmoFlow is its spherical geometry. That is, at variance with experiments that are performed in planar, Cartesian geometries, AtmoFlow aims at observing flows in spherical geometries that are subjected to a central force field. Such a condition, obviously impossible to reach on ground, is achieved by simulating buoyancy driven convection through a central dielectrophoretic field in microgravity conditions, providing a benchmark for a rich variety of numerical problems which are still a challenge for scientific research.

Without losing its overall view on the complex physics, circulation in planetary atmospheres can be reduced to a simple model of the in- and outgoing energy (e.g. radiation) and rotational effects. Both input parameters are determined by the boundaries of the system. This strongly simplified assumption makes it possible to break some generic cases down to test models, which can be investigated by laboratory experiments and numerical simulations. Therefore, it is possible to study atmospheric circulations by means of spherical shell experiments, where varying differential rotation rates and temperature boundary conditions represent different types of planets. This is a very basic approach, but various open questions can be answered with that simplified setup. However, laboratory experiments are difficult to establish. The axial gravitational field of the Earth overlays any radial force field in the experiment, which makes it very difficult to deduce meaningful results. The projection of a hemisphere onto the cylinder is one way to overcome this problem (e.g. the baroclinic wave tank), however e.g. equatorial waves cannot be investigated with this setup. The most promising solution is a transfer of a spherical gap experiment with a dielectrophoretic radial buoyant force field into microgravity conditions, where the radial force field is independent from the Earth's gravity. By applying lateral temperature boundaries and differential rotation it is possible to simulate a deep planetary atmosphere, where features like planetary waves and cell formation can be studied. Indeed, the main advantage of this experiment is the full sphere setup, which is used to investigate symmetric patterns around the equator.

Two objectives are in the focus of the experiment: First, the study of planetary waves, like Kelvin- and Rossby waves, which transport a huge amount of momentum. These waves influence not only the stratosphere, but also accompanying instabilities. Second, we want to analyse the baroclinic instability, which triggers and influences large scale weather phenomena. The investigation of the baroclinic instability is fundamental for theories regarding the weather of the mid-latitudes. Large-scale circulations and pattern formation is found in nearly all planets of the solar system. Even the experiment will not cover all aspects of a realistic atmosphere, we are confident to capture generic features of atmospheric flows.