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Wave-attractors and mean flow in a spherical shell due to time-modulated rotation

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In geophysical fluids, such as the atmosphere, the oceans or the liquid core of the earth, periodic flows can be found on all scales. For planetary scales, such flows are caused by tidal forces which initiate waves of smaller scales. In rotating systems, inertial waves play a decisive role. These waves are the result of a subtle interplay between inertial and Coriolis forces. In case of multiple reflections, e.g. on the curved boundaries of a spherical shell, wave rays follow certain orbits [1,2], called wave-attractors. Generally they point to internal boundary layers that are detached from the boundaries. Inertial waves also generate mean flows [3]. Wave-attractor related internal boundary layers have been studied experimentally since about 10 years. However, no experiment has been realized for spherical geometry. Previous experimental studies of wave-attractors were performed in a rotating box [1], or a rotating cylindrical gap [4].

In contrast, we suggest to conduct a laboratory experiment that consists of two co-rotating and concentric spherical shells. The rotation of the shell is varied in form of a sinus curve forcing the particles to be deflected from their rest position. Coriolis forces drive particles back to their initial position where they overshoot due to inertia. This mechanism gives rise to oscillations called inertial waves. Tilgner [3,5] showed in his numerical investigations that in fast rotating spherical shells attractors occur and also two attractors can coexist for certain frequencies. In addition, he showed that decreasing the radius of the inner sphere, the number of attractors is also decreasing. Later, he showed that a zonal flow can be excited by an interaction of inertial waves.

For comparison with the numerical investigation we specify different visualization and measurement techniques. Wave-attractors can be identified by velocity, kinetic energy or vorticity. Longtime-LDA measurements can determine whether a wave driven mean flow arise.

References

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