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An axisymmetric flow in a cylindrical tank with a rotating bottom: a confirmation of theory by experimental data

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As a model for non-axisymmetric flows in the terrestrial and planetary atmospheres under axisymmetric circumstances, symmetric breaking of flows are realized by a very simple laboratory experiment where a cylindrical container is filled with water and the disk at the bottom is rotated rapidly. We have been reported on the analytical solution of the axisymmetric flow obtained using boundary layer theories, which is necessary as a basic flow for the analysis of the symmetric breaking processes. This theory can predict the parameters of the basic circular flows.

Similar theory was proposed by Tophøj et al. (2013), where they decide the basic axisymmetric flow under the condition that the angular momentum given from the rotating bottom disk should be balanced with that lost at the lateral boundary.

They estimated the momentum exchange with boundaries based on the assumption that it is proportional to the square of the relative velocity of the internal flow to the boundary.

We examined the data of the rotation rate of the regime transition and the change of the water depth which are obtained by the laboratory experiments, and compared them with the present theory and that by Tophøj et al. (2013).

The comparison shows that present theory well predict the experimental results.

The assumption that the momentum exchange is proportional to the square of the velocity difference is considered to underestimate the momentum exchange at the lateral boundary and consequently to overestimate the flow speed of the rotating water.

Keywords: rotating flow, boundary layer, axisymmetric flow, laboratory experiment