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Boundary condition influence on instabilities in a low Reynolds free surface rotating flow

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The study of a rotating flow in one its most simple configuration (fixed cylindrical cavity, rotating bottom disk, free top surface) reveals a much more complicated physics than expected. While we tried to validate our experimental setup with both publication¹ and numerical result, we were able to obtain the right unstable modes, but at much lower Reynolds. After several investigation on possible issue in our experience, we finally suspected free condition surface to deeply influence both base flow and instabilities.

We first used a condition introduced in², that we call “Frozen condition”, and that consists in setting the surface radial velocity to 0. But if this condition lowered the critical Reynolds, Stability analysis was no more able to predict the right mode. So we built a new top boundary condition as an α weighted sum of free and frozen conditions.

A search for critical Reynolds depending on α reveals a second unstable branch, with a lower critical Reynolds, and better visualization agreement 1(c) with instabilities that are experimentally observed 1(b).

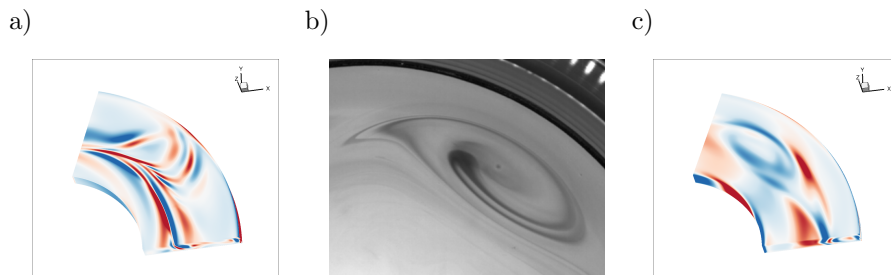


Figure 1: (a) Axial vorticity computed at $Re = 95$, with free surface condition. (b) Experimental visualization at $Re \sim 30$. (c) Axial vorticity computed at $Re = 53$, with frozen surface condition

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¹Poncet and Chauve, *J. Flow Visual. Image Process* **14**, 85-105 (2007).

²Spohn and Daube, *V Int. Conf. Computational Methods and Experimental Measurement*, 155-166 (1991).