

# Influence of boundary conditions on instabilities in free surface rotating flows

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The study of rotating flows in one of its most simple configurations (fixed cylindrical vessel, rotating disk at the bottom, free surface at the top) reveals much more complicated physics than expected. This flow, for low aspect ratios, is known to develop travelling instabilities as the angular velocity of the disk exceeds a finite threshold [1]. We revisit this flow case using distilled water experiments, direct numerical simulation and linear stability analysis. The comparison reveals a robust discrepancy in the instability thresholds. After a critical assessment of the possible issues in the experimental set-up, we eventually question the modelling of the free surface in the presence of water contaminants [2].

The influence of this numerical boundary condition was first tested by considering a new 'frozen' boundary condition where the radial velocity vanishes at the liquid interface [3]. In a second stage we generalise this new boundary condition into a linear combination of both 'free' and 'frozen' conditions, thereby introducing an additional free parameter  $\alpha$ .

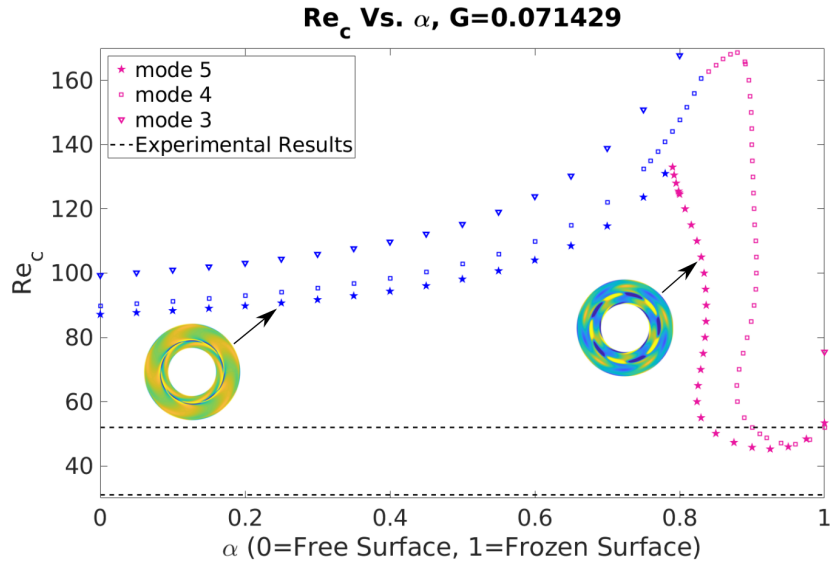


Figure 1: Evolution of the critical Reynolds number of three modes, for  $\alpha$  between 0 (ideal free surface condition) and 1 ('frozen' condition), and a geometrical aspect ratio  $G = 1/14$ .

The search for the critical Reynolds number, parametrized by  $\alpha$ , reveals a second branch of unstable modes with a lower critical threshold. The visual and quantitative agreement between this new instability mode and the experimentally observed structures (cf Fig. 2) is very encouraging.

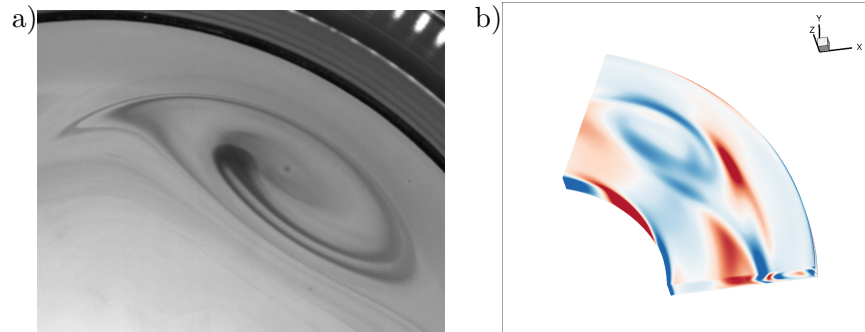


Figure 2: (a) Experimental visualization at  $Re \sim 30$ . (b) Axial vorticity computed at  $Re = 53$ , with frozen surface condition ( $\alpha = 1$ ).

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## References

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- [3] A. Spohn and O. Daube, *V Int. Conf. Computational Methods and Experimental Measurement*, 155-166, 1991.