

## Dynamics of a two-fluid flow inside a rotating cylinder

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We are interested in the dynamics of two-phase vortex flows as can be encountered commonly in nature and industry (wake of ship propellers, intake vortices, etc.). We focus here on a simplified configuration, namely a confined straight water/air vortex within a horizontally oriented rotating cylindrical container, more easily obtained experimentally (L. Martin Witkowski, LMFA - Lyon - France) and numerically.

Our approach involves a first code dedicated to the computation of the steady base flow, which is characterized as a function of the flow parameters: Reynolds, Froude and Weber number as well as the gas/liquid volume fraction. These numerical results are compared to those of analytical models and two-dimensional direct numerical simulations using the Basilisk flow solver (Popinet 2009). We choose flow parameters for which a stationary state exists, and focus on the establishment of this state: trajectory of the lighter fluid towards the equilibrium state, and interfacial wave motions. Following Phillips<sup>1</sup> and Kozlov<sup>2</sup>, we propose an analytical solution in the inviscid and viscous framework, now taking into account surface tension effects. Excellent agreement is found between numerics and theory concerning steady states, but also interfacial wave propagation. In this study, surface tension effects are highlighted, prevailing when the volume of the denser fluid is enhanced and when the Weber number is higher.

A second code is devoted to the three-dimensional instabilities of two-phase axisymmetric vortices. Waves propagating along this flow are of two types: interface and Kelvin waves. Following the resonance mechanisms described by Moore & Saffman<sup>3</sup> and Eloy & Le Dizès<sup>4</sup>, the base flow can be decomposed into an axisymmetric flow and a stationary correction with an azimuthal wave number  $m = 1$ . This correction resonantly couples two modes associated with the axisymmetric part of the flow, whose azimuthal wave numbers differ by one ( $m_2 - m_1 = 1$ ). These interactions are analyzed at points where their dispersion relations intersect, characterized by identical axial wave numbers  $k_0$  and frequencies  $\omega_0$  (see figure 1). Among these points of intersection, we identify specific cases where resonance instabilities arise.

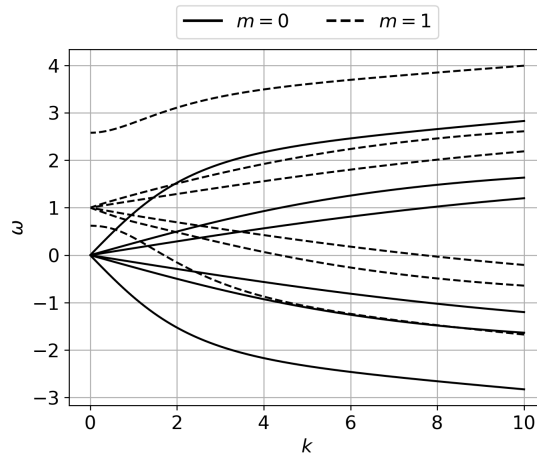


Figure 1: Dispersion relation of the Kelvin modes in the  $(k, \omega)$ -plane for  $m = 0$  (solid line) and  $m = 1$  (dashed line). Only the 6 first branches are represented. The configuration corresponds to an inviscid, single-fluid case with  $\rho_{in}/\rho_{out} = 0.001$ ,  $R_{in}/R_{cylinder} = 0.5$

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<sup>3</sup>D. W. Moore and P. G. Saffman, *Proceedings of the Royal Society of London. A. Mathematical and Physical Sciences* **346**, 413–425 (1975)

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