ABOUT THE NATURE OF A SECONDARY PHENOMENON INSIDE A CAVITY SHEAR FLOW

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Abstract This study addresses the case of centrifugal instabilities in an open cavity flow driven by a shear-layer. In particular, we consider a secondary phenomenon which develops, for reproducible supercritical values of the control parameters, on a primary pattern formed of Taylor Görtler vortices in the spanwise direction of the inner-flow. Several interpretations of this phenomenon are addressed and discussed.

In this study, we are interested in 3D structures developping inside an open cavity in incompressible regime. The base state is characterized by a main recirculation around the spanwise axis. Beyond some critical value of the control parameters, centrifugal instabilities develop due to the curvature of the material path along the main recirculation. The bifurcated state is characterized by counter rotating pairs of vortices which are named Taylor Görtler [1, 2, 3]. The vortical structures look like tori around the main recirculation and depending on cavity configuration, they can drift towards the sidewalls. The bifurcated state composed of Taylor-Görtler vortices is referred to as the primary centrifugal instability.
A secondary phenomenon is observed [4] which looks like a secondary instability. It is characterised by a phase quadrature motion in the streamwise direction of two successive pairs of vortices with a periodic distribution along the spanwise axis. This phenomenon is rather new and the present study gives an overview of its possible nature by the mean of experimental measurments.

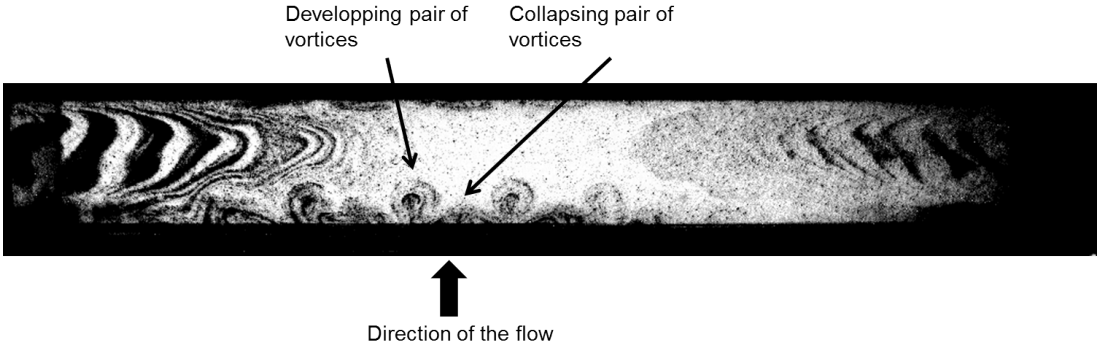

Figure 1. Top view of the cavity : smoke visualization of the secondary phenomenon.

One interpretation of this new phenomenon is that the primary structures undergo a secondary instability with respect to an oscillatory mode. A dynamical mode decomposition (DMD) is performed in order to isolate this oscillatory mode. No such mode is actually found. Instead, DMD extracts right and left travelling waves of Taylor Görtler vortices, some being already present in the primary state. The superimposition of a pair of right and left travelling waves, with close frequencies, actually results in a quasi-standing wave, which exhibits such an oscillatory phenomena. Then, another interpretation would be that before the secondary bifurcation, travelling modes would spatially exclude each others while after bifurcation they would coexist in space. Finally, another explanation relies on a modulation instability of the vortices. The wavelength of Taylor Görtler raws would become unstable with respect to side-band modes.
Our purpose will be to consider all three assumptions and discuss their possible relevance.

References

[1] C. Migeon. Details on the start-up development of the Taylor-Görtler-like vortices inside a square-section lid-driven cavity for 1,000 $\leq$ Re $\leq$ 3,200. *Exp Fluids* **602**: 33-594, 2002.
[2] Brès & Colonius. Three-dimensional instabilities in compressible flow over open cavities, *JFM* **599**:309-339, 2008.
[3] Th. Faure, P. Adrianos, F. Lusseyran, L. Pastur. Visualizations of the flow inside an open cavity at medium range Reynolds numbers. *Exp Fluids* **184**: 42-169, 2007.
[4] Th. Faure, L. Pastur, F. Lusseyran, Y. Fraigneau, D. Bisch . Three-dimensional centrifugal instabilities development inside a parallelepipedic open cavity of various shape. *Exp Fluids* **410**: 47-395, 2009.