3D FLOW INSTABILITIES ON DISKS OF DIFFERENT ASPECT RATIOS

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Summary: We studied experimentally the instabilities of the flow behind a disk and described in a very quantitative fashion, the bifurcation diagrams for disks of different aspect ratios, in the range of Reynolds number, lying between 50 and 500. This study is performed with flow visualisation and with measurements of the longitudinal component of the vorticity, measured with Particle Image Velocimetry. The azimuthally decomposition of this component allows to describe the evolution of the main spatial modes as a function of the Reynolds number. We described the successive bifurcations from the initial stationary one to the higher instabilities showing vortex shedding in the form of hairpins. The results are compared with recent theoretical nonlinear models of transition.

The flow behind spheres [1], disks [2], cubes and others 3 Dim. bluff bodies, shows similar instabilities at moderate Reynolds numbers. The scenario instability is characterized by an initial stationary bifurcation from the base flow, to another flow showing stationary streamwise weak vortices. Subsequent bifurcations are transitions to unsteady flows. These unsteady flows include peristaltic oscillations of the counter-rotating streamwise vortices, vortex shedding with hairpins, regular and erratic rotation of the separation plans, etc (Figure 1).

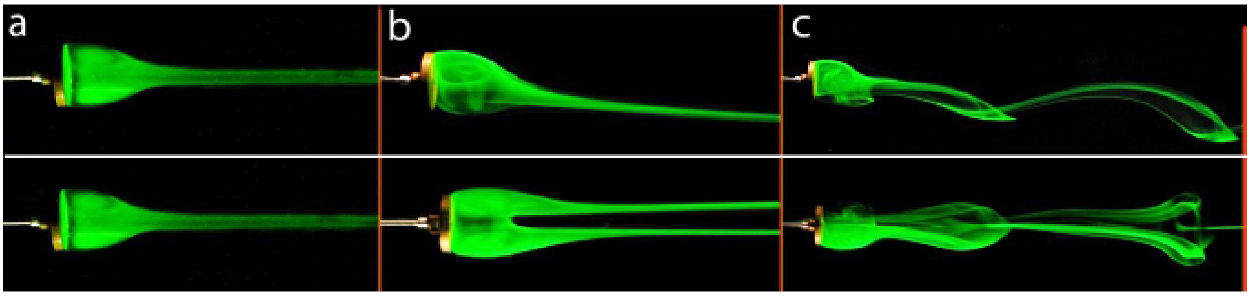

Figure 1: *Visualisation patterns for different flow regimes. Images on top and bottom are side view and top view respectively: a. steady axisymmetric flow, b. steady flow with planar symmetry, c. unsteady flow with hairpin shedding*

We described, in this communication, our experiments on the flow around a disk, mounted normally at the stream direction. We used disks of different aspect ratios $AR = d/h$, where d is the diameter and h the thickness of the disk. These experiments were performed in a low velocity water channel and the investigated range of Reynolds numbers, lies between 50 and 500. Laser Induced Fluorescence method with Fluorescein, as dye, has been used to visualize the flow. Measurements of the velocity field were made using Particle Image Velocimetry in a plane perpendicular to the mean flow, at a distance of 1,25d, behind the disk. Owing to these measurements has been obtained the value of the longitudinal component of the vorticity, which allows making a full quantitative description of the instability process.

We present here the experimental bifurcation diagram, showing the evolution of the maximum of the longitudinal vorticity magnitude as a function of the Reynolds number for disks of different aspect ratios (Figure 2). The obtained values of the vorticity component are filtered, using a polar azimuthally Fourier decomposition, in order to study its spatial distribution [3] (Figure 3). This analysis gives more detailed description of the bifurcation branches, showing the evolution of the spatial properties of the instability, with the Reynolds number. We discussed, during this presentation, the main features of the spatial and temporal behaviour observed from this particular decomposition, in order to understand the nonlinear evolution of the instability. We studied the role of the shear intensity, which depends of the aspect ratio of the disk. We compared our experimental results to the results of recent numerical [2,4] and theoretical studies [5-7]. These nonlinear analysis of the flow stability predicted different temporal behaviour, particularly by respect to the rotation of the symmetry plans.

The work presented here, which is the more complete experimental description of the flow instabilities behind a disk, is also compared with previous numerical and experimental studies of flow instabilities behind spheres and other 3 Dim. bluff bodies.

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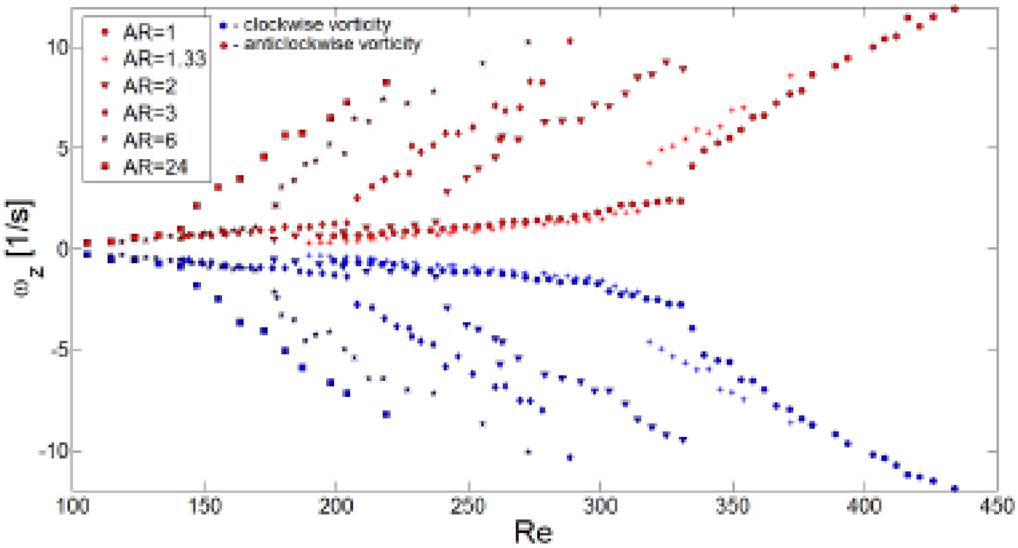

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Figure 2: Bifurcation branches for the maximum of the longitudinal component of the vorticity, for different aspect ratios

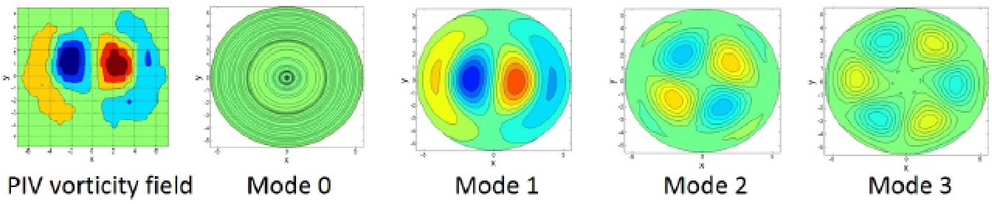

Figure 3: PIV vorticity field and mode patterns for hairpin shedding ($d = h = 2; Re = 353$)

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