Nonlinear dynamics of closed axisymmetric rotor-stator flow

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Rotor-stator flows have been studied extensively in the past. There have been many experimental observations of coexistence of both circular rolls and spiral arms[1,2]. The origin of the latter is well understood[3], while that of the former is not. Such rolls display chaotic and sometimes transient dynamics[4]. Linear stability analysis[5] for a height/radius ratio of 0.1 revealed a Hopf bifurcation around $Re = 3000$, a value much higher than found experimentally, and the existence of a subcritical branch. We revisit this transitional flow using numerical simulation and dynamical systems tools. Additional results concerning the first axisymmetric Hopf bifurcation will be presented. For lower values of Re, at least three flow regimes are identified - base flow, turbulent state and an edge state separating the two. Contrarily to expectations, this edge state features several incommensurate frequencies, involves inertial waves, and does not originate directly from the Hopf bifurcation point. The turbulent solutions (top branch in figure 1a) are also investigated. Evidence will be shown that lifetime distributions are exponential above some value of Re. We will review the analogies in the subcritical transition process between this flow and more common three-dimensional open shear flows such as pipe and channel flows.

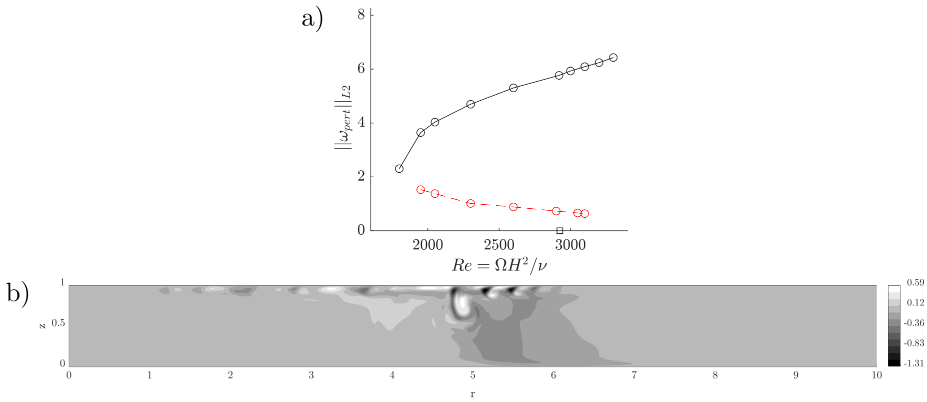

Figure 1: (a) Bifurcation diagram, azimuthal vorticity perturbation norm versus Reynolds number based on height H, critical Re marked with a black square (b) Meridian cut of the azimuthal perturbation velocity of the turbulent roll regime (axis on the left, rotating wall at the bottom, shroud rotating).

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