Noise sustained vs. self-sustained structures in rotor-stator flow

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Rotor-stator flows are known to exhibit instabilities in the form of circular and spiral rolls. While the origin of the latter is known to be a supercritical Hopf bifurcation, the origin of the circular rolls is still unclear. In the present work we propose an explanation for the circular rolls as a linear response of the axisymmetric system to external forcing. Using the singular value decomposition of the resolvent operator [1] the optimal response is computed and takes the form of circular rolls. The optimal energy gain is found to grow exponentially with the Reynolds number (based on the rotation rate and interdisc spacing H), in connection with huge levels of non-normality. The results for both types of forcing are compared with former experimental works [2] and previous numerical studies [3]. The linear response is also compared with the self-sustained states found recently for the unforced problem [4] by the means of Harmonic Balance Method and Self Consistent Model [5]. Additionally the range of forcing amplitudes at which the nonlinearity plays an important role is characterised. Our findings suggest that the circular rolls observed experimentally are the combined effect of the high forcing gain and the roll-like form of the leading response of the linearised operator.

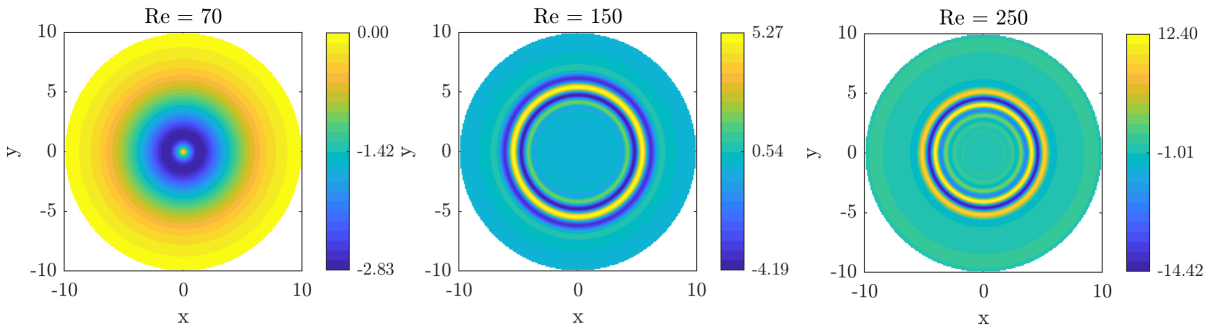

Figure 1. Azimuthal velocity u_θ for the optimal bulk response of the flow for $Re = 70,\ 150,\ 250$ (from left to right) in a plane a quarter gap below the stator.

Références

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