Transition and control in rotating-disk boundary-layer

Muhammad Ehtisham Siddiqui, Benoît Pier, Mukund Vasudevan, Julian F. Scott, Carlo Cossu, Alexandre Azouzi, Christian Nicot, Roger Michelet

Transition and control in rotating-disk boundary-layer

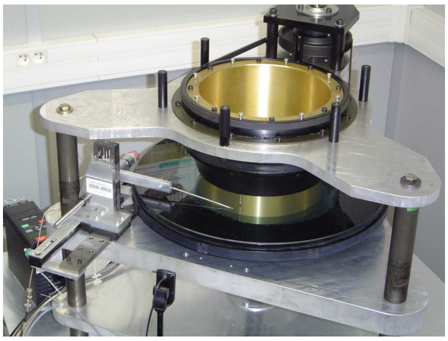
M. E. SIDDIQUI[*], B. PIER[*], MUKUND V.[*], J. SCOTT[*],
C. COSSU[†], A. AZOUZI[*], C. NICOT[*], R. MICHELET[*]

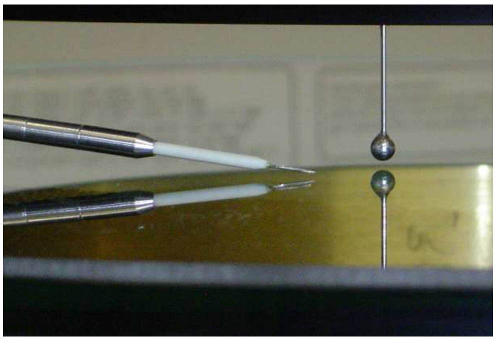
The flow due an infinite disk rotating in otherwise still fluid has served as the archetypical configuration for the study of three-dimensional boundary layers and is known to display a sharp transition from laminar to turbulent flow at a nondimensional critical radius $R \simeq 510$. Using linear stability analysis, this location was found by Lingwood[1] to precisely coincide with the onset of local absolute instability. More recently[2], a fully nonlinear analysis and a secondary stability analysis have further contributed to the understanding of the complex dynamics prevailing near the transition radius. An open-loop control strategy[3] has been theoretically shown[4] to be applicable in this context. The aim is to delay onset of secondary perturbations, and thus transition, by a controlled modification of the primary nonlinear state.

The present experimental investigation has been undertaken to confirm these predictions and to test the practical applicability of the control method.

The experimental arrangement consists of a 50 cm diameter glass disk that is rotated at constant angular speeds, up to 1500 rpm. Control is applied via a set of needles, evenly distributed on a cylinder placed above the disk. The forcing parameters are adjusted and optimized by changing the number of needles and the rotation rate of the cylinder (which can be varied independently of the disk rotation rate). A second technique, using microstructured roughness elements on the disk surface, is also currently being implemented.

The flow features, with and without control, are characterized by time-resolved local hot-wire measurements. The influence of the different control parameters and forcing strategies will be discussed and compared with theoretical predictions.





[*]Laboratoire de mécanique des fluides et d'acoustique; CNRS—Université de Lyon ; École centrale de Lyon ; 36 avenue Guy-de-Collongue ; F-69134 Écully cedex.

[†]Institut de mécanique des fluides de Toulouse ; CNRS—Université de Toulouse ; allée Camille-Soula ; F-31400 Toulouse.

[1]Lingwood, *J. Fluid Mech.* **299**, 17–33 (1995).

[2]Pier, *J. Fluid Mech.* **487**, 315–343 (2003).

[3]Pier, *Proc. R. Soc. Lond. A* **459**, 1105–1115 (2003).

[4]Pier, *J. Eng. Math.* **57**, 237–251 (2007).