Universidad Carlos III de Madrid

Seminario del Instituto Gregorio Millán

Finite-length effects in Taylor-Couette flow

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Abstract

The term Taylor-Couette flow refers to fluid flow between rotating concentric cylinders. The onset of cellular motion in such flow—in particular, the remarkable agreement Taylor obtained between experiment and a theoretical stability analysis—played a central role in the history of fluid mechanics. More recently, this excellent agreement has come to seem confusing, in light of attempts to reconcile the fact that experiments are performed in an apparatus of finite length while Taylor's analysis considered an infinite apparatus. In an infinite apparatus, steady flows with secondary circulation in cells bifurcate from the trivial solution when the Reynolds number Re exceeds a critical value Re_c. Because of translational invariance, the bifurcation is symmetric, as sketched in Figure 1. Based on the feeling that in a long apparatus end effects ought to be small, researchers sought to understand experiments as a slightly perturbed bifurcation, such as sketched in Figure 2. Thus, in an experiment in a finite-length apparatus, the onset of cells is smeared out, compared to the abrupt onset in Figure 1, and only one of the two solution branches (the so-called normal modes) can evolve if the rotation speed is increased quasi-statically from rest. However, provided the apparatus is long, then one also expects that

1. The onset of cellular motion will be only slightly smeared out, with cells beginning close to Re_c, and
2. Amonolous-mode solutions should exist and be stable for Reynolds numbers slightly larger than Re_c.

Point 2 is not verified in experiments—anomalous modes are indeed observed, but only for large Re, two or three times Re_c. In other words, no matter how long the apparatus may be, end effects represent a large perturbation of the flow. By contrast, Point 1 is verified; thus, end effects are quite small for normal modes, but how this happens is somewhat mysterious. In this lecture we attempt to explain this situation in terms of a different broken symmetry, an approximate symmetry between two normal-mode flows with large, and nearly equal, numbers of cells.

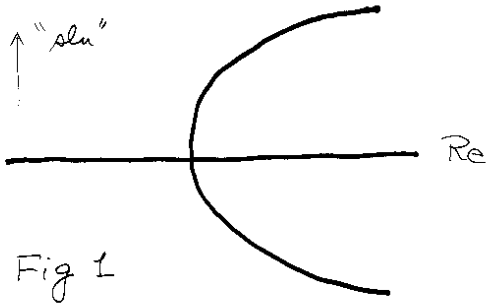

Fig 1

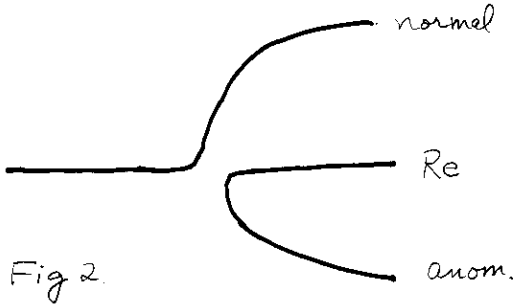

Fig 2

- DÍA Y HORA: **Miércoles 17 de febrero de 2010** a las **12:30**
- LUGAR: **Edificio Sabatini. Aula 2.1.D04**