Spirals and Standing Waves in counterrotating Taylor-Couette Flow

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ABSTRACT

Boundaries play an important role in physical systems. As a consequence of physical boundaries the translational symmetry of Taylor-Couette flow is broken. We present an extensive experimental study of bifurcation scenarios resulting from the first pattern forming instability in finite counterrotating Taylor-Couette flow [1]. Two types of standing waves, denoted as SW_0 and SW_π, are observed to be the primary oscillatory patterns appearing via supercritical Hopf-bifurcation from the basic laminar flow for sufficient counterrotation rates [1]. Both types of standing waves have the form of rotating waves in azimuthal and standing waves in axial direction [2]. They both have an azimuthal wave number $m = 1$ but different symmetries. While SW_π has a spatio-temporal glide-reflection symmetry SW_0 is purely spatially reflection symmetric. Spiral vortices which are travelling waves in infinitely extended flow [3] apear either from a secondary or a higher instability depending on the control parameters. In the former case a supercritical stationary bifurcation to up- or downwards travelling spirals is observed. The latter case implicates the appearance of stable modulated waves which leed to a motion on a two-dimensional torus in phase space. A general agreement of the observed bifurcation structure with theory of Hopf bifurcation with broken translational symmetry [4] could be found. The agreement includes not only the appearence of two different types of standing waves having different symmetries but holds also up to details such as secondary sub- or supercritical steady bifurcations to spiral vortices and also modulated waves resulting from a secondary Hopf bifurcation in the subcritical case.

REFERENCES

[1] J. Langenberg, G. Pfister, J. Abshagen: submitted, 2003.

[2] R. Tagg, W. S. Edwards, H. L. Swinney, P. S. Marcus: *Nonlinear Standing waves in Couette Taylor flow*, Phys. Rev. A **39**, 3734, 1989.

[3] C. D. Andereck, S. S. Liu, H. L. Swinney: *Flow regimes in circular Couette systems with independently rotating cylinders*, J. Fluid Mech. **164**, 155, 1986.

[4] W. S. Langford, E. Knobloch: *Oscillatory bifurcation with broken translation symmetry*, Phys. Rev. E **53**, 3579, 1996.