Polygons on a Rotating Fluid Surface

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We report a novel and spectacular instability of a fluid surface in a rotating system. In a flow driven by rotating the bottom plate of a partially filled, stationary cylindrical container, the shape of the free surface can spontaneously break the axial symmetry and assume the form of a polygon rotating rigidly with a speed different from that of the plate. With water we have observed polygons with up to 6 corners. It has been known for many years that such flows are prone to symmetry breaking, but apparently the polygonal surface shapes have never been observed. The creation of rotating internal waves in a similar setup was observed for much lower rotation rates, where the free surface remains essentially flat. We speculate that the instability is caused by the strong azimuthal shear due to the stationary walls and that it is triggered by minute wobbling of the rotating plate. The slight asymmetry induces a tendency for mode-locking between the plate and the polygon, where the polygon rotates by one corner for each complete rotation of the plate.

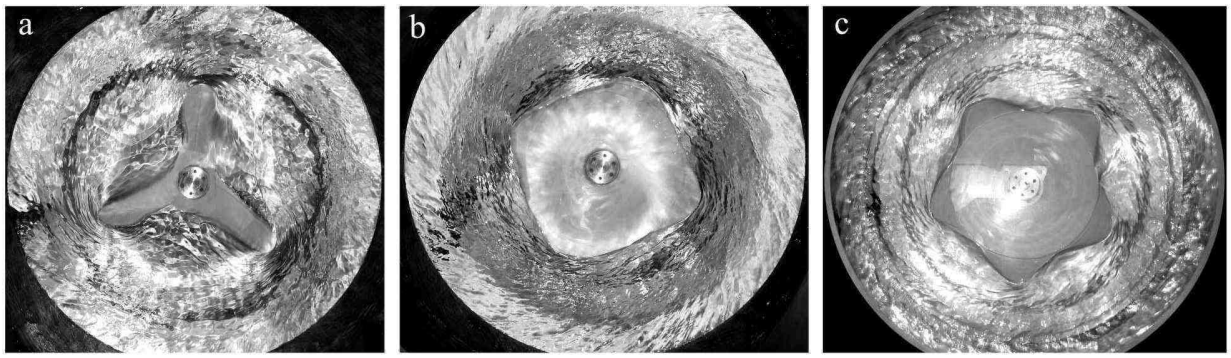

Figure 1: Setup consisting of a stationary plexiglass cylinder of radius 19.4 cm with a circular plate that is rotated by a motor. Water or ethylene glycol is filled to the level H above the plate. At sufficiently large rotation frequencies f the axially symmetric surface becomes unstable and assumes the shape of a regular, rigidly rotating polygon.