Magnetorotational instability breaks rotational symmetry in the laboratory

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The standard magnetorotational instability (SMRI) has been regarded as the sole viable instability responsible for the turbulence required to explain the fast accretion observed across the Universe. However, unlike other fundamental plasma processes such as Alfvén waves and magnetic reconnection which have been subsequently detected and studied in space and in the laboratory, SMRI remains unconfirmed even for its existence long after its proposal, despite its widespread applications in modeling including recent black hole imaging. Its direct detection has been hindered in observations due to its microscopic nature at astronomical distances, and in the laboratory due to stringent requirements and interferences from other processes. Here we report the first direct evidence showing that SMRI indeed exists in a novel laboratory setup where a uniform magnetic field is imposed along the axis of a differentially rotating flow of liquid metal confined radially between concentric cylinders and axially by copper endrings. As predicted the observed SMRI exists only at sufficiently large rotation rates and moderate field strengths, but surprisingly with its symmetry broken about the rotation axis. The nonaxisymmetric nature of SMRI is important in generating large-scale magnetic fields, as detected recently. Our results show that the axisymmetric presumption is oversimplified in past studies on SMRI, which calls for future investigations.

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