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Nonlinear Transition of a Flow Driven by a Rotating Magnetic Field

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Non-normal nonlinear transition of a linearly stable liquid metal flow driven by a rotating magnetic field is simulated numerically. Three dimensional Navier–Stokes equations are solved by a highly accurate spectral methods. Response of the flow to noise is simulated introducing a random body force. We observe four flow regimes. At a low control parameter the flow response does not differ from the response of a fluid at rest. In the second regime the amplitude of response is considerably higher though it scales linearly with the noise amplitude. Nonlinear intermittent outbursts are observed in the third regime. Duration of outbursts increases with noise amplitude until they merge in a continuous series in the fourth regime. We demonstrate that direct numerical simulation of the flow response to random forcing can uncover mechanisms which lead to transition in linearly stable flows.

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