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Spontaneous Sign Reversals in Self-Organized States of Forced Two-Dimensional Turbulence on a Bounded Square Domain

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The inverse energy cascade present in two-dimensional (2D) turbulence leads to the formation of large-scale flow structures. In the case of decaying 2D turbulence on a square domain with no-slip walls the flow usually shows self-organization into a single domain-filling circulation cell with an associated increase in the total angular momentum of the flow – a process referred to as “spontaneous spin-up”. Subsequently, this organized state may persist until all energy is depleted by viscous dissipation and the fluid eventually comes to rest. In contrast, if the energy of the flow is maintained by some external forcing mechanism, a spectacularly different behaviour may be observed. Boundary layers present at the domain walls can destabilize the organized state, such that the dominating circulation cell collapses, and the self-organization process may start anew. Most strikingly, the circulation may even show sign reversal. This flow behaviour has been investigated by high-resolution numerical simulations based on spectral techniques.

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