Controlling the reversal of the large-scale circulation in thermal turbulence

Yi-Zhen Li*, Ao Xu*, and Heng-Dong Xi*†

Spontaneous and random flow reversal is prevalent in various geometric and astrophysical systems, including the magnetic poles of the Earth and the stars, and the atmospheric convective wind. A paradigm for studying the mechanism of flow reversals is the Rayleigh–Bénard (RB) convection, which is a fluid layer heated from the bottom and cooled from the top. In the turbulent RB convection, a large-scale circulation (LSC) that spans the size of the convection cell exists. The LSC may temporally vanish, followed by a restart in a new direction. If the new LSC rotates in the opposite direction as that of the original LSC, it is called a flow reversal event. We controlled flow reversals in turbulent RB convection through the local perturbation. We explored the relationship between the perturbation amplitude and the perturbation time, and found the perturbation energy required to trigger flow reversal is a constant. Furthermore, we analyzed the scaling law between perturbation energy and the Rayleigh number, and found that the scaling exponent matches that between the global average kinetic energy and the Rayleigh number.

*School of Aeronautics and Institute of Extreme Mechanics, Northwestern Polytechnical University, Xi'an, 710072, China

†Email: hengdongxi@nwpu.edu.cn