Realization of the anti-parity-time symmetry in diffusive systems

With the support by the National Natural Science Foundation of China and the Bird Nest Plan of HUST, the research team led by Assoc. Prof. Zhu XueFeng (祝雪丰) at the School of Physics and Innovation Institute, Huazhong University of Science and Technology, demonstrated the anti-parity-time (APT) symmetry with heat convection in two counter-moving channels, which was published in *Science* (2019, 364 (6436): 170—173).

Parity-Time (PT) symmetry ensures the eigenvalues of the non-Hermitian Hamiltonian to be real numbers even though the gain or loss has been introduced into these systems, which arouses great interests in scientific communities. In the past decades, PT-related physics and potential applications have been extensively studied in wave systems, including optics, acoustics and microwave systems. However, APT-related research is rather lacking because it is difficult to realize the imaginary couplings in wave systems.

Before they obtained the breakthrough of realizing APT symmetry in diffusive systems, Assoc. Prof. Zhu's group had widely investigated the PT-related phenomena in acoustics and optics. They have studied the extraordinary scattering characteristics and designed the unidirectionally transparent PT-symmetric acoustic cloaks, which was published in *Physical Review X*, and studied the anisotropic reflection oscillation patterns in periodic PT-symmetric multilayer structures, which was published in *Optics Express*. All of these findings are also supported by the National Natural Science Foundation of China and the Bird Nest Plan of HUST.

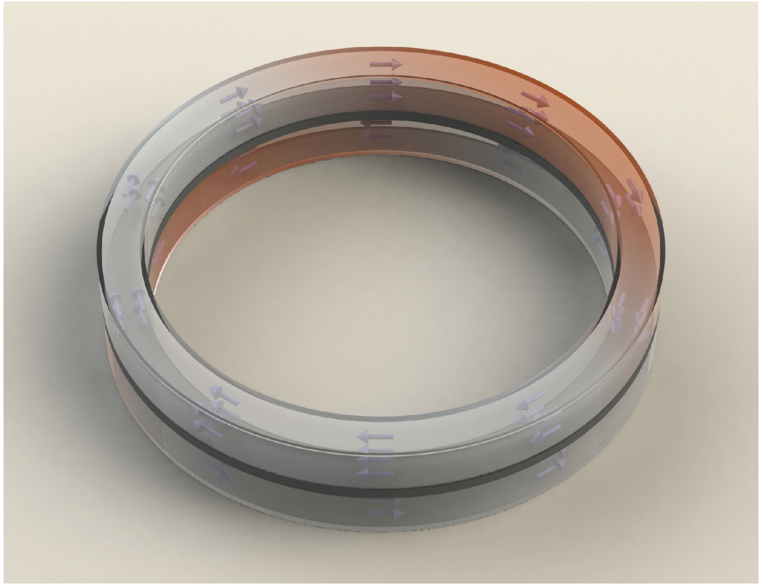

Figure Heat convection in two counter-moving channels.

Cooperating with Shanhui Fan's group at Stanford and Cheng-Wei Qiu's group at the National University of Singapore, they recently profoundly proposed a new route to realize APT symmetry with heat convection in two counter-moving channels. Furtherly, they experimentally demonstrated the spontaneous symmetry breaking in a phase transition from motionless temperature profiles (APT symmetric phase), despite the mechanical motion of the background, to moving temperature profiles (APT broken phase). In contrast to the wave systems governed by the homogenous Helmholtz equations, heat transfer is described by the non-homogenous diffusion equations. Thus the ratio of the heat exchange between two channels, corresponding to the coupling coefficient in wave systems, is imaginary in the effective Hamiltonian. The profound physics and experimental results of the *Science*'s findings would open opportunities for using diffusive dynamics to study PT-related physics and provide insights into the development of control mechanisms in the broad area of nonequilibrium mass or energy transport.