Observation of topological valley transport of sound in sonic crystals

Subject Code: A04

Supported by the National Natural Science Foundation of China, a research group from Wuhan University, led by Profs. Liu Zhengyou (刘正猷) and Qiu Chunyin (邱春印), demonstrated the topological valley transport of sound in sonic crystals, which was published in *Nature Physics* (2017, 13: 369—374).

Valley pseudospin, labeling electronic states of energy extrema in momentum space, is attracting tremendous attention because of its potential in constructing new carriers of information. Compared with many exciting non-topological bulk valley transports, the observation of topological valley transport in phase domain walls is extremely challenging owing to the inter-valley scattering inevitably induced by atomic scale imperfectness. The topologically protected domain wall modes, encoded with distinguishable valley information, are also of general interest and great importance for classical wave systems in both fundamental and applied research.

This paper reported a direct observation of the topological valley transport of sound in sonic crystals. The phase transition between two distinct acoustic valley Hall insulators has been realized by simply rotating meta-atoms. Benefiting from the macroscopic nature of sonic crystals, the domain wall samples can be flexibly designed. In addition to a direct confirmation of the valley-selective edge modes through spatial scanning of sound field, negligible reflection has been observed successfully in a sharply curved domain wall.

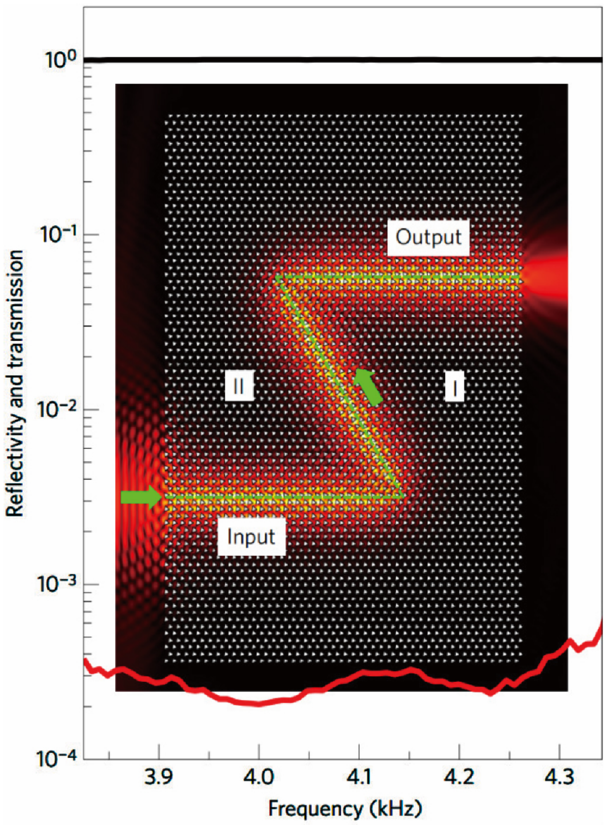

Figure Reflection immunity of the valley-projected acoustic edge modes from sharp corners.

It is worth noting that the rotating-atom mechanism enables easily tunable operation bandwidth and reconfigurable shape of the domain wall. These merits, plus the intriguing valley transport properties, absent in the conventional waveguides, could be very useful in designing exceptional devices. Our finding may also pave the way for exploring controllable topological phases and valley-dependent phenomena in various classical systems, which have been proved to be excellent macroscopic platforms in revealing topological properties proposed originally in electronic systems, for example, quantum Hall insulators, topological insulators, and topological semimetals. Finally, the study provides a special insight into realizing topological insulators that require internal degrees of freedom, which is particularly important for neutral scalar sound that lacks an intrinsic polarization and is uncoupled from external fields.