TKK Young Scientist Award in Information Technological Sciences

Harnessing Chaos to Control the Momentum of Light

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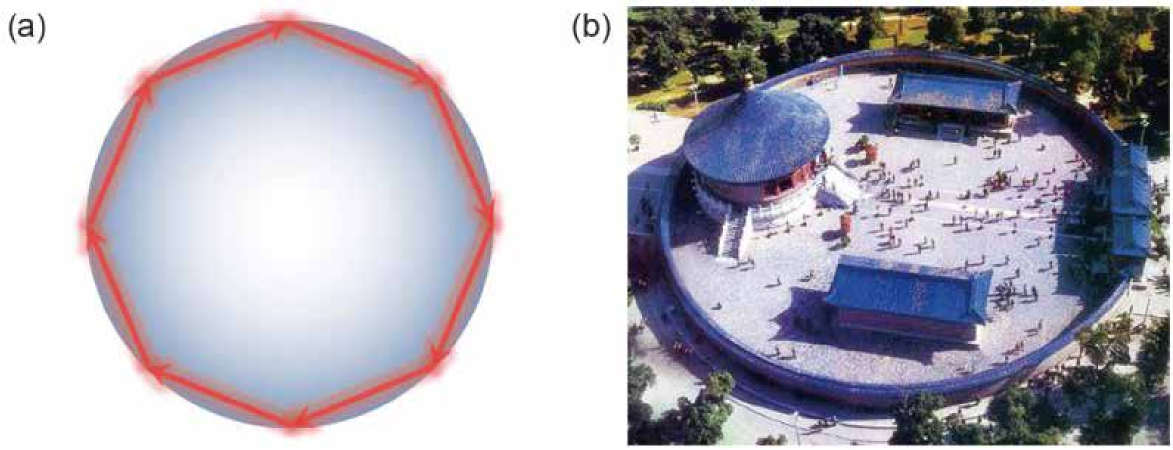
The 2020 TKK Young Scientist Award in Information Technological Sciences went to XIAO Yunfeng, a physicist from Peking University, for his achievements in micro-cavity optical physics and devices.

Optical microcavities can locally trap light within a confined space, which forms a significant energy accumulation effect and thereby enhances the interaction between light and matter. Therefore, microcavities have been extensively applied to fundamental studies of optical physics and photonic devices.

In particular, optical whispering-gallery-mode (WGM) microcavities, confining light by total internal reflection, act as the frontier of the state-of-art



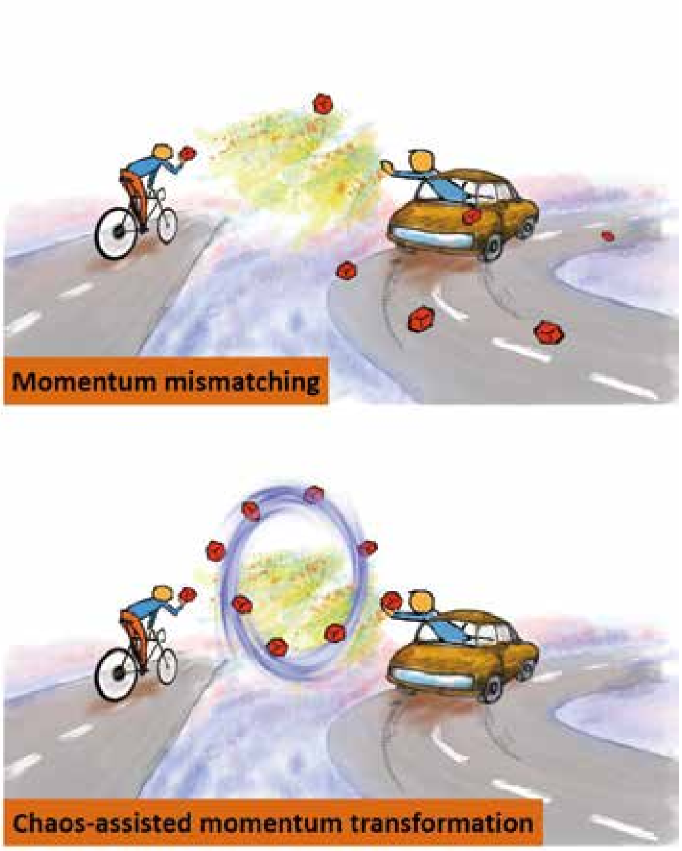
Schematic illustration of optical whispering gallery mode (WGM). (a) Light ray propagates along the surface inside the cavity by total internal reflection. (b) Echo wall at Temple of Heaven in Beijing. (Image by XIAO's Lab) microcavity studies. How light travels in a WGM is analogous to an interesting acoustic phenomenon that occurs in a whispering gallery, such as the Echo Wall in the Temple of Heaven in China, where an acoustic wave circulates inside a cavity, allowing a whisper on one side to be heard on the other.

To excite an optical WGM, scientists need to couple the light into the cavity through evanescent coupling, which usually depends on an external component for controlling the momentum of light. However, the fact that light travels at different speeds (or momentum) between the WGM cavity and the external coupler poses a serious challenge.

To resolve this difference in momentum, XIAO and his collaborators found an innovative way by deforming the shape of an optical WGM to create and harness so-called chaotic channels that can be used to control the momentum of light.

They demonstrated that the resonator could be designed to match momentum between the waveguide and the WGM microcavity, thus to produce coupling that was broadband and efficient. The chaotic motion of the light within the deformed microcavity could transform optical modes of different angular momenta within a few picoseconds.

They believe that the observed broadband and fast momentum transformation could find use in applications such as multicolor lasers, optical frequency microcombs, broadband memories and multiwavelength optical networks.



Coupling the optical fields from waveguides to the optical fields in whispering galleries in photonic circuits is like trying to transfer a package between a bike and a car on a highway. Without the chaos, coupling photons to an optical mode is inefficient (*top*). With the chaos, the photons could be efficiently delivered to the optical mode (*bottom*). (Image by the courtesy of Yin Feng and Xuejun Huang)