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Miniature meta-device for dynamic control of Airy beam

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Dynamic control of Airy beam has been attracting scientists' attention due to its potential applications in imaging, optical manipulation and laser manufacturing. However, traditional way of dynamic tuning of free space Airy beam usually requires bulky optics and will inevitably limit its practical applications. To solve this issue, a recent work proposes to use a compact meta-device which consists of two cascaded dielectric metasurfaces working in the visible regime.

Keywords: Airy beam; dielectric metasurface; meta-device

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Optical Airy beam[1–3], which exhibits diffraction-free, self-accelerating, and self-healing properties, has been attracting scientists' interests due to its potential applications in various fields including high-resolution imaging[4], optical manipulation[5], laser manufacturing[6], and so on. In the past years, generation of surface and free-space Airy beams have been successfully demonstrated by using spatial light modulator (SLM)[2], diffractive optical elements[7], metasurface[8–14], electric field poled nonlinear crystal[15] and so on. It should be noted that the dynamic control of Airy beam is highly desirable in various application scenarios. To realize this target, liquid crystal based SLM encoded with time sequenced phase profiles can be used to generate the tunable Airy beams. However, the commercial SLMs usually suffer from low pixel resolution, low diffraction efficiency and the bulky configurations.

The emergence of metasurface opens new routes for manipulating the amplitude, phase, and polarization of light by utilizing the concept of geometric phase, propagation phase and so on. In the last decade, various metasurface diffractive optical elements, such as metalens, hologram and beam splitters have been developed to realize many useful optical functionalities. By encoding a cubic phase and specific phase gradients into the metasurfaces, one can easily control the trajectories of the generated Airy beams in a static way. However, once the metasurfaces are fabricated, the dynamic control of the propagation behaviors of the Airy beams remains challenging.

In a recent work published in *Opto-Electronic Advances*[16], J. Zhang et al show that a meta-device can be used to dynamically control the trajectories of the generated Airy beams by rotating two cascaded dielectric metasurfaces that form the meta-device (Fig. 1). The focal lengths of the two metasurfaces are opposite to each other and the focal spots have opposite in-plane displacements. This is achieved by encoding the corresponding cubic phase and off-axis Fresnel lens phase profiles into the two metasurfaces. The metasurfaces are composed of titanium dioxide meta-atoms which are fabricated on glass substrate by using electron beam

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lithography and plasma etching process. In the optical experiments, it is shown that both the focal spots and the trajectories of the Airy beams at wavelength of 532 nm agree well with the calculated ones.

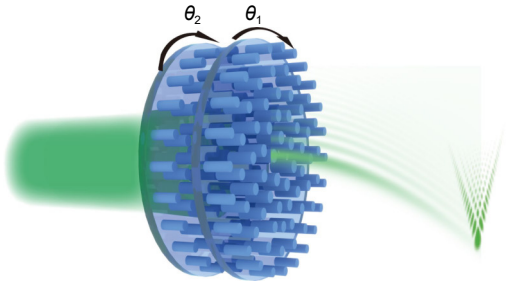

Fig. 1 | Schematic diagram of the cascaded metasurfaces utilized to dynamically control the generated Airy beam[16].

In summary, the proposed miniature meta-device which consists of two cascaded metasurfaces represents a novel platform for manipulating the properties of the Airy beams. The mechanical rotation offers a new degree of freedom to control the synthetic phase of the metasurface optical elements. Similar concepts can be easily applied to different working wavelengths and developed various optical functionalities.

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