Advancements in Large-Scale, High-Efficiency Flat Optical Devices

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Abstract: We introduce a series of large-scale, high-efficiency flat optical devices developed in our NanoLight Lab (http://nanolight.psu.edu). These devices leverage the unparalleled capabilities of metasurfaces, which are subwavelength-scale artificial nanostructures, to control light. However, the limited size of optical metasurfaces and reduced efficiency due to diffraction loss have been significant barriers to their wider adoption. To address these challenges, we present several large-scale, efficient metasurface designs: (1) A large-aperture double-layer metalens with a 400 μm diameter, offering broadband achromatic focusing across the entire visible light spectrum, from 400 nm to 700 nm, (2) A 1-inch diameter metasurface corrector optimized for aberration correction, achieving over 90% efficiency in the visible light range, and (3) An expansive 80 mm-aperture near-infrared metalens, forming the basis for a telescope engineered for cosmic imaging with efficiencies exceeding 80%. These devices, achieved using a variety of design and fabrication methodologies, highlight our ability in meta-optical engineering. Poised to reshape the design of ultracompact optical systems, our devices have promising applications in fields such as computational imaging, remote sensing, biomedical imaging, and beyond.