Superoscillation and Super-resolution

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Rapid variations of intensity and phase can take place in complex, structured light fields at (sub)nanometre length scales far smaller than the commonly understood half-wavelength ($\lambda/2$) diffraction limit. Such fields, and their interactions with matter also structured at the nanoscale, offer important potential applications in imaging, spectroscopy, metrology, and opto-electronic/mechanical nanodevices, and in fundamental studies of light-matter interaction down to the pico- (i.e. atomic) scale.

This talk will review the story so far – from the generation of the first super-oscillatory optical fields containing sub-diffraction limited focal spots (Fig. 1a), to the realization of an 'optical ruler' enabling nanoscopic displacements of macroscopic objects to be measured via detection of small features in such fields (Fig. 1b); and new, emerging opportunities enabled by artificial intelligence-based analyses of coherent topologically-structured light scattering – whereby positional and displacement measurements of nano-objects with picometric (λ/10,000) resolution become possible (Fig. 1c, d).

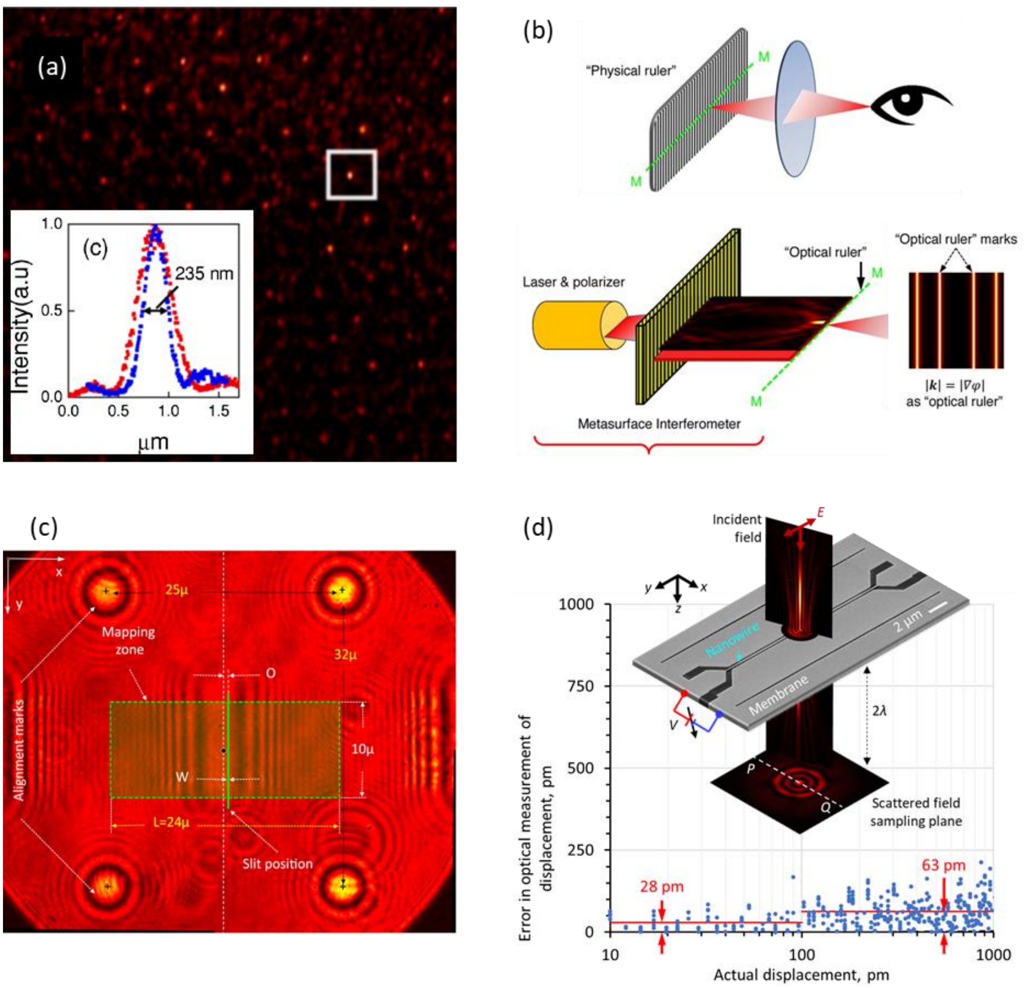

Fig. 1 (a) Sub-wavelength superoscillatory hot-spots formed by illumination of quasicrystal nanohole array [Huang & Zheludev, *Appl. Phys. Lett.* 90, 091119 (2007)]. (b) The 'optical ruler', an electromagnetic analogy of a physical ruler in which singularities serve as the marks on the scale, enabling displacement measurements with resolving power <1 nm [Yuan & Zheludev, *Science* 364, 771 (2019)]. (c) Deeply sub-wavelength non-contact optical metrology, providing for single-shot dimensional measurements with accuracy down to λ/260 via AI-enabled analysis of diffraction [Rendón-Barraza, *et al.*, *APL Photon.* 6, 066107 (2021)]. (d) Single-shot optical measurement of nanowire position with sub-Brownian absolute error down to ~30 pm using light at a wavelength of λ= 488 nm [Liu, *et al.*, arXiv:2205.01475 (2022)].