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Intensity-Enhanced Super-Resolution Amplitude Apodization Effect on the Non-Spherical Near-Field Particle-Lenses

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Abstract : A particle can function as a refractive lens to focus a plane wave, generating a narrow, high intensive, weak-diverging beam within a sub-wavelength volume, known as the 'photonic jet'. Refractive index contrast (particle to background media) and scaling effect of the dielectric particle (relative-to-wavelength size) play key roles in photonic jet formation, rather than the shape of particle-lens. Waist (full width of half maximum, FWHM) of a photonic jet could be beyond the diffraction limit and smaller than the Airy disk, which defines the minimum distance between two objects to be imaged as two instead of one. Many important applications for imaging and sensing have been afforded based upon the super-resolution characteristic of the photonic jet. It is known that apodization method, in the form of an amplitude pupil-mask centrally situated on a particle-lens, can further reduce the waist of a photonic nanojet, however, usually lower its intensity at the focus due to blocking of the incident light. In this paper, the anomalously intensity-enhanced apodization effect was discovered in the near-field via numerical simulation. It was also experimentally verified by a scale model using a copper-masked Teflon cuboid solid immersion lens (SIL) with 22 mm side length under radiation of a plane wave with 8 mm wavelength. Peak intensity enhancement and the lateral resolution of the produced photonic jet increased by about 36.0 % and 36.4 % in this approach, respectively. This phenomenon may possess the scale effect and would be valid in multiple frequency bands.

Keywords : apodization, particle-lens, scattering, near-field optics
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