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Optical super-oscillations as a way to sub-wavelength localizations of light without evanescent waves

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Here for the first time we demonstrate experimentally and theoretically that the Talbot effect on a quasi-periodic array of nano-holes may be used to achieve sub-wavelength field localizations and well-isolated `hot spots' of high electromagnetic energy concentration.

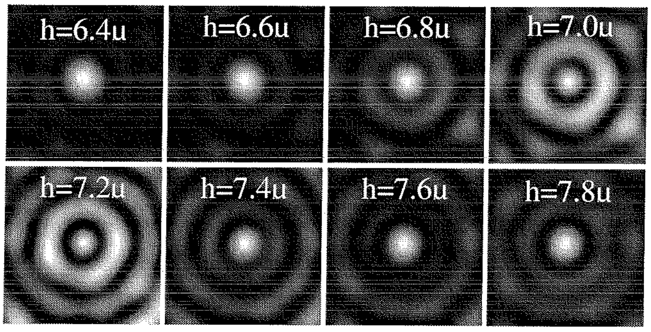

Fig.1 Far-field hot spot created by a quasi-periodic array of nano-holes at different distances h from the array. The size of all images is 1.5×1.5 μm^2, λ=500 nm. At the "focal distance" h = 7.2 μm the hot-spot diameter is only 160nm

It is commonly believed that far-field optical resolution is fundamentally limited by diffraction at the wavelength level because evanescent waves carrying sub-wavelength-scale information from an object dissipate in the far field. A recent remarkable theoretical discovery suggests that evanescent fields may not be needed to achieve sub-wavelength resolution: Berry and Popescu [1] predicted that a grating structure could create sub-wavelength localizations of light that propagate further into the far field than more familiar evanescent waves. They relate this effect to the fact that band-limited functions are able to oscillate arbitrarily faster than the highest Fourier components they contain, a phenomenon called super-oscillation.

Here we report on how a quasi-periodic array of holes creates sub-wavelength localizations of light without evanescent waves and how the fields created by such diffraction fall into the class of super-oscillating fields [2]. This effect offers a new way to achieve sub-wavelength imaging in the far field.

References

[1] M. V. Berry and S. Popescu, J. Phys. A: Math.Gen. **39**, 6965 (2006).

[2] F. M. Huang, Y. Chen, F. J. Garcia de Abajo, and N. I. Zheludev, APL (in press).