L'ÉLECTROMAGNÉTISME, 150-1
UNE SCIENCE EN PLEINE ACTION !

Cosine-Gauss Plasmon Beam : A localized Long-Range Nondiffracting Surface Wave

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Scanning Nearfield Optical Microscope, Hyperspectral imaging, Surface plasmon polaritons, Bessel Beam
Microscopie en champ proche optique, Imagerie hyperspectrale, Plasmons de surface, Faisceaux de Bessel

Using a scanning near-field optical microscope operating with a hyperspectral detection scheme, we report the direct observation of the mirage effect within an on-chip integrated artificial material made of a two dimensional graded photonic crystal. The light rainbow due to the material dispersion is quantified experimentally and quantitatively compared to three dimensional plane wave assisted Hamiltonian optics predictions of light propagation.

The expansion of the transverse dimension of a propagating wave, a phenomenon originating from diffraction, is ubiquitous for all kinds of waves including sound, electromagnetic, and even matter waves. In optics, several techniques have been proposed to counterbalance this effect, for example, by considering the family of so-called diffraction-free beams which have a transverse intensity distribution independent of the propagation distance. Because of their wave nature, surface plasmon polaritons (SPPs) also undergo diffraction in the plane of the interface, which is an additional source of coupling loss between onchip components. To address this issue, plasmonic Airy beams (PABs) have recently been introduced [1]. PABs propagate without spreading for a finite distance, but their trajectory bends, severely limiting possible device applications.
In this work, we introduce a new surface wave, the Cosine-Gauss beam [2], which does not diffract while it propagates in a straight line and tightly bound to the metallic surface for distances up to 80 µm.
The generation of this highly localized wave is shown to be straightforward and highly controllable, with varying degrees of transverse confinement and directionality, by fabricating a plasmon launcher consisting of intersecting metallic gratings. Cosine-Gauss beams have potential for applications in plasmonics, notably for efficient coupling to nanophotonic devices, opening up new design possibilities for next-generation optical interconnects.

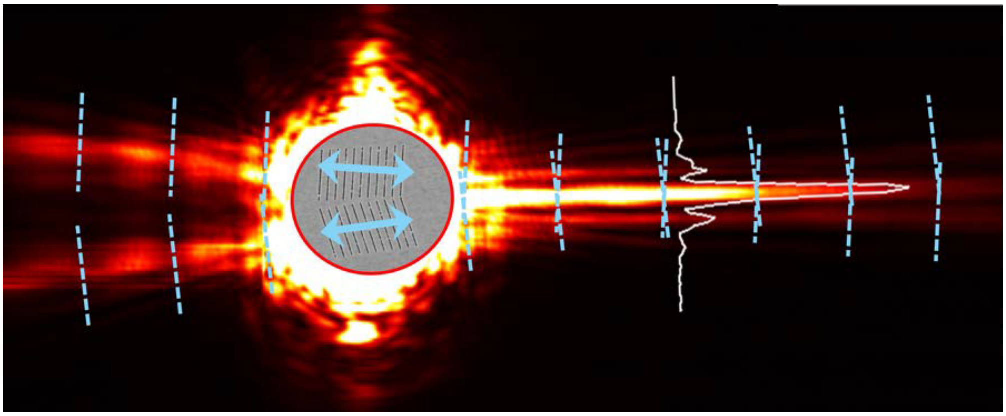

***Fig. 1:** SPP field distribution a localized Cosine gauss beam using a near-field scanning optical microscope (SNOM)*

[1] A. Minovich, A. E. Klein, N. Janunts, T. Pertsch, D. N. Neshev et Y. S. Kivshar, « Generation and near-field imaging of airy surface plasmons », *Phys. Rev. Lett.*, **107**, 116802 (2011).
[2] J. Lin, J. Dellinger, P. Genevet, B. Cluzel, F. de Fornel et F. Capasso, « Cosine-gauss plasmon beam : A localized long-range nondiffracting surface wave », *Phys. Rev. Lett.*, **109**, 093904 (2012).