Shaping of light in metamaterials and plasmonic structures

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Abstract

We review our recent theoretical and experimental results on the light shaping in plasmonic structures and nano-structured metamaterials. In particular, we discuss several effects associated subwavelength nanofocusing and shaping of light in plasmonic structures, nanofocusing of polychromatic plasmon beams, and the generation of Airy plasmons.

Nonlinear transverse self-action of plasmon beams propagating in tapered metal-dielectric-metal waveguides with the Kerr-type nonlinear dielectric [1]. We demonstrate that in contrast to light focusing in straight waveguides, an appropriate choice of the taper angle allows an effective compensation of attenuation with the propagation of a spatial plasmon soliton. For larger tapering angles, significant soliton narrowing is observed, it leads to 3D spatial light nanofocusing of the soliton beams.

Nanofocusing and spatial shaping of polychromatic plasmonic beams [2]. We introduce the concept of polychromatic plasmonics and demonstrate several functionalities of the so-called broadband plasmonic lens based on a metal-dielectric-metal curved structure. We utilize quadratic modulation of the dielectric layer thickness in transverse direction to produce a parabolic optical potential which is practically wavelength independent. We develop analytical descriptions and employ simulations to show capability of three-dimensional subwavelength manipulations and beam shaping, including nanofocusing, self-collimation, and optical pendulum effects. The nanofocusing of our lens is demonstrated over a bandwidth exceeding an optical octave (>500nm) thus allowing for polychromatic plasmon nanofocusing.

Generation and near-field evolution of Airy plasmons [3]. We demonstrate experimentally generation, shaping, and near-field mapping of the propagating Airy plasmons earlier discussed theoretically by D. Christodoulides et al. These self-accelerating Airy plasmons exhibit self-healing properties and enable novel applications of plasmonics, including selective surface manipulation of nanoparticles.

In addition, we hope to discuss a variety of other intriguing effects and phenomena associated with the negative index of refraction and the specific properties of backward waves, including (i) dramatic suppression of Anderson localisation, (ii) unusual dynamics of Bloch oscillations in metamaterial and metal-dielectric superlattices, (iii) magnetoelastic nonlinearity in metamaterials, and also (iv) parametric effects for the plasmon frequency conversion

References

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