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All optical control of electromagnetic waves by Second Harmonic Generation

Sergio G. Rodrigo[1, 2]
[1] Centro Universitario de la Defensa, Ctra. de Huesca s/n, E-50090 Zaragoza, Spain
[2] Instituto de Ciencia de Materiales de Aragón and Departamento de Física de la Materia Condensada, CSIC-Universidad de Zaragoza, E-50009, Zaragoza, Spain
sergut@unizar.es

Second Harmonic Generation (SHG) is a nonlinear process through which two photons with the same frequency generate a new photon with twice the initial frequency [1]. We recently investigated SHG in the context of extraordinary optical transmission [2]. We found the radiation pattern and the transmission efficiency of second harmonic light in metallic arrays of rectangular holes strongly depends on the electromagnetic modes excited at both the fundamental and second harmonic frequencies. We found that the symmetry properties of the second harmonic fields are crucial in near-to-near field and near-to-far field coupling process.

Here we theoretically demonstrate how surface plasmon polaritons can be actively controlled by SHG in such structures, namely in metal films drilled by finite number of slits periodically distributed. The method we use has been recently introduced for controlling the intensity and directionality of light scattering (instead of evanescent plasmonic modes) from single metallic nanoparticles [3]. A holey film when illuminated from one side by a polarized light source, it scatters electromagnetic fields in the opposite side and for high intensity light sources efficiently produce SHG. We show how by mixing the fields scattered by the system from a weak beam at λ wavelength with the second harmonic fields generated by a high intensity 2λ beam, a destructive interference of surface plasmons in one direction occurs, while surface plasmons are enhanced along the opposite direction. We show that the unidirectional launching of surface plasmons is due to the different properties of symmetry at λ whether they are linearly or nonlinearly generated.

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