Tunable guided surface plasmon-polariton using two-dimensional hyperbolic graphene metasurface

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We study the electromagnetic response of two dimensional hyperbolic materials, on which a dipole source can excite a confined and tunable surface plasmon polariton (SPP). The analysis is based on the Green function for an anisotropic two-dimensional surface, which requires the evaluation of a two-dimensional Sommerfeld integral. We show that for the SPP contribution this integral can be evaluated in a mixed continuous/discrete form as a continuous spectrum contribution (branch cut integral) of a residue term, in distinction to the isotropic case, where the SPP is simply given as a discrete residue term.

As an example of an anisotropic metasurface that can provide a hyperbolic response, an array of graphene strips is shown in the insert of Fig. 1. The dispersion of the proposed structure may range from elliptical to hyperbolic as a function of its geometrical and electrical parameters. The in-plane effective conductivity tensor of the proposed structure can be analytically obtained using effective medium theory (*Phys. Rev. Lett. 114, 233901 (2015)*). Fig. 1-a and c show σ_{xx} and σ_{zz}; this structure can exhibit a hyperbolic response (region 1), as well as implement a non-hyperbolic (region 2) anisotropic surface. In order to support a confined, low loss SPP, a genetic algorithm was used for design and optimization of this surface (*arXiv:1509.01544*). Fig. 1-c shows SPP propagation for two different levels of graphene biasing. The Green function is calculated using two methods, and the resulting SPP is directive and controllable via the chemical potential.

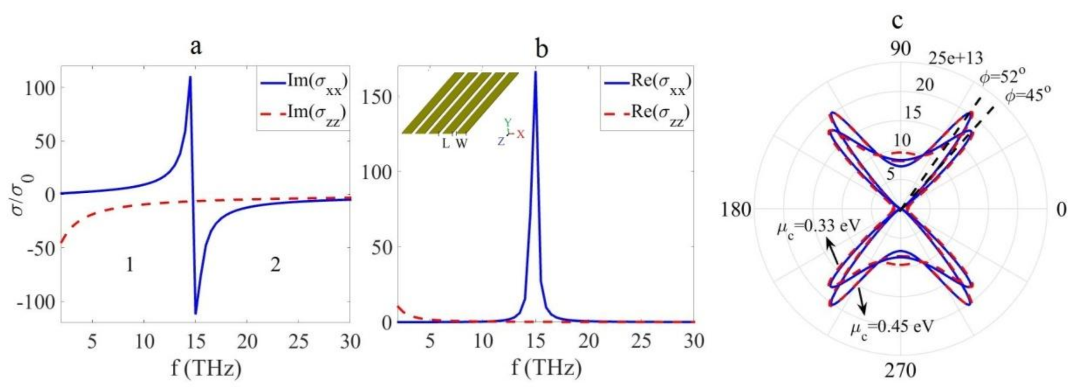

Fig. 1-a,b: Real and imaginary parts of σ_{xx} and σ_{zz} normalized to $\sigma_0 = e^2/4\hbar$, W=59 nm, L=64 nm and $\mu_c = 0.33$ eV. c: SPP obtained using real-line integration, solid blue line, and from branch cut calculation, dashed red line.