Graphene supports the propagation of subwavelength optical solitons

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Nonlinear optical materials have fascinated physicists for decades, due to the fundamental interest of the unique phenomena that they display (such as frequency mixing, supercontinuum generation, and optical solitons) [1,2], as well as their important applications, such as higher-harmonic generation and optical signal processing [3,4]. Recently, a very high nonlinear response has been theoretically predicted [5, 6] and experimentally verified [7] in monolayer graphene. In this work we show that the large intrinsic nonlinearity of graphene at optical frequencies enables the formation of quasi onedimensional self-guided beams (spatial solitons) featuring subwavelength widths at moderate electricfield peak intensities [8]. We illustrate this capability by analyzing two arrangements leading to solitons with different polarizations: a graphene monolayer embedded into a conventional dielectric waveguide and a graphene sheet placed on top of a metal-dielectric structure. We also demonstrate a novel class of nonlinear self-confined modes resulting from the hybridization of surface plasmon polaritons with graphene optical solitons. We analyze in detail the formation of spatial solitons and the relation between soliton width and input power, showing that the subwavelength scale can be reached by using values for the beam peak intensity below the laser-induced damage threshold of graphene. Finally, we also develop a quasi-analytical model that is able to capture the basic ingredients of the numerical results.

References

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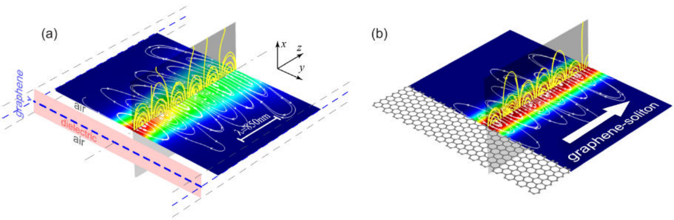

Figure 1: An optical beam propagates inside a dielectric waveguide including a graphene monolayer located in the center, for low (a) and high (b) input powers. Panels (a) and (b) show slices of the beam intensity evaluated at the graphene layer, the yellow lines represent magnetic vector field whereas white lines depict the electric vector field.