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Theory of Spatial Optical Solitons in Metallic Nanowire Materials

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Arrays of metallic nanowires stand as one of the most exciting structures in the metamaterial realm due to their applications in the electromagnetic field manipulation and transport in the nanoscale. Nanowire materials can also lead to interesting physics in the context nonlinear optics, and in particular previous works have shown that stable subwavelength solitons can be formed in arrays of metallic nanowires embedded in a Kerr-type material. Such solitary waves can have an important impact in nanophotonics and in the realization of ultra-compact devices. Thus, it would be highly interesting to characterize them using an effective medium approach, because this can highlight the relevant physical processes and simplify the numerical modeling. In this talk, we derive an effective medium theory that describes the dynamics of the macroscopic electromagnetic fields in a nanowire array embedded in a Kerr-type dielectric. We apply such a theory to the characterization of optical solitons, and unravel the physical mechanisms that enable the formation of stable subwavelength solitary waves in nanowire arrays. It is shown that because of the exotic hyperbolic dispersion of the photonic states in a nanowire material, the effective medium behaves as a self-focusing material when the nanowires are embedded in a self-defocusing dielectric host.