Electromagnetic wave propagation in nonlinear metamaterials

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Abstract:

We develop a generalized version of the invariant imbedding theory of electromagnetic wave propagation in various kinds of stratified nonlinear optical media. The main idea of the method is to transform the boundary value problem of the original wave equation into an equivalent initial value problem of coupled ordinary differential equations. This allows an exact and very efficient numerical calculation of all wave propagation characteristics. We demonstrate the advantages of our method by applying it to several interesting problems in optics. In the first case, we apply the method to the propagation of electromagnetic waves in nonlinear metamaterials. We solve the electromagnetic wave equations in arbitrarily inhomogeneous stratified media where both the dielectric permittivity and magnetic permeability depend on the strengths of the electric and magnetic fields. We apply our method to a uniform nonlinear slab and find that in the presence of strong external radiation, an initially uniform medium of positive refractive index can spontaneously change into a highly inhomogeneous medium where regions of positive or negative refractive index as well as metallic regions appear. We also study the influence of nonlinearity on the lateral shift associated with surface plasmon excitations in metal-dielectric multilayer systems and on the mode conversion phenomena in inhomogeneous plasmas.

References:

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