Slow-light solitons in the Maxwell-Bloch model generated by evanescent fields

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Coupling a two-level medium, described by the Maxwell-Bloch (MB) equations, to an external cavity mode results in a prescribed boundary value for the electric field which can be tuned to the forbidden band gap of the medium. It is shown that there exists a threshold of energy density flux above which a soliton-like light pulse is generated and propagates in the medium at a fraction of the light velocity.

When the driving frequency gets close to the band gap edge, where the group velocity vanishes, the MB equations tend to the nonlinear Schrödinger equation which furnishes the theoretical ground to understand soliton generation by evanescent fields as a manifestation of nonlinear supratransmission, produced by an instability of the evanescent wave.

Moreover, the propagation at a fraction of light velocity is shown to result from a continuous periodic exchange between polarization (electromagnetic energy) and population (density of atoms in the excited level). The process is demonstrated to occur at twice the internal frequency of the generated gap soliton.

Last, when the medium spatial extension is of the order of the soliton dimension, an optical bistability is shown to occur at the supratransmission threshold allowing for different output intensities corresponding to a given input value.