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Soliton solutions of the nonlinear Helmholtz equation: propagation properties, interface effects and new families of exact solutions

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The properties of spatial optical solitons are most often studied using nonlinear Schrödinger (NLS) equations. These model the slow modulation of its envelope a linear wave solution experiences when propagation takes place in a weakly nonlinear medium. This slow variation must fall within the range of validity of the paraxial approximation which permits to derive an NLS equation from a more general nonlinear Helmholtz (NLH) equation [1, 2, 3]. Therefore, the analyses based on NLS equations are limited to beams propagating along a definite axis, or infinitesimally close to it, and which are broad when compared to the wavelength, thus, preserving the weakly nonlinear nature of the propagating disturbance.

The restrictions on the propagation angle can be released using the corresponding NLH equation which restores the spatial symmetry required when angular considerations are fundamental. This is the case when spatial solitons collide [1] or when they impinge on a nonlinear interface [2]. In recent works [3], new families of exact Helmholtz soliton solutions have also been obtained and the properties of the novel solutions have been analysed both numerically and analytically. The studies cover the types of nonlinearities which can be found in most materials with a practical interest. A detailed account of the recent progress in the field will be presented.

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