# Non-paraxial Traveling Solitary Waves in Layered Nonlinear Media

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**Abstract:**

The dominant underlying model governing Solitary Wave (SW) formation and propagation in spatially inhomogeneous structures is the NonLinear Schrödinger (NLS) equation with spatially varying coefficients. Although this model is analytically tractable, it is a result of an important assumption with far-reaching consequences. The NLS equation is derived from the Maxwell's equations under the paraxial approximation, that restricts drastically the domain of applicability of the NLS equation excluding various applications where either the dimensions of the inhomogeneous structures are small in comparison to the wavelength or the angle of incidence is large. Although there exist a huge number of studies on NLS soliton formation and dynamics in inhomogeneous media, the investigation of the respective phenomena and the exploration of novel features of SW dynamics, is yet to be followed up in the non-paraxial regime. [1,2,3]

For the case of layered media, the original Maxwell's equations, under no approximation, lead to a scalar NonLinear Helmholtz (NLH) equation with coefficients that are piecewise constant functions of the transverse coordinate and an intensity-dependent refractive index, when the electric field is assumed to be monochromatic and linearly polarized. The NLH equation has fundamental mathematical differences with NLS, resulting in the description of qualitatively different phenomena of wave propagation. In this work, we derive a large class of exact analytical traveling SW solutions in a variety of inhomogeneous structures consisting of linear and nonlinear layers. The solutions are related to a spatial resonance condition and describe reflectionless and radiationless SW propagation for arbitrary angles and spatial widths in the nonparaxial regime. The generality of the results facilitates their experimental observation of the solutions in planar dielectric structures having the form of finite or infinite waveguide arrays for layer dimensions ranging from several wavelengths to sub-wavelength. Finally, these solutions are applicable and provide physical intuition for the formation of traveling SW in layered media occurring in other branches of physics beyond nonlinear optics.

**References:**

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