Title: **Modeling Soliton Dynamics in Nano-Optical Fibers and AI-Driven Photonics Using MEDAM**

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Abstract

The generalized nonlinear Schrödinger equation (GNLSE) is a key model in modern physics, especially for describing the propagation of optical pulses in nonlinear dispersive media. An important extension of this model is the Schrödinger–Hirota equation, which is widely used in optical communication systems to characterize solitary wave dynamics in optical fibers. In this study, we employ the modified extended direct algebraic method (MEDAM) to analyze both the GNLSE and the Schrödinger–Hirota equation. The method effectively generates a broad class of exact analytical solutions, including bright, dark, and singular solitons, as well as singular periodic, exponential, Weierstrass elliptic, and complexiton solutions.

These analytical results underscore the power and adaptability of MEDAM for solving nonlinear evolution equations. The considered GNLSE includes essential physical effects such as group velocity dispersion, dual-power law nonlinearity, and self-frequency shift, making it suitable for modeling wave propagation in nano-optical fibers. Beyond classical optics, the findings have potential applications in emerging AI-integrated photonic systems, such as optical neural networks and soliton-based computing architectures, where robust and controllable waveforms are crucial. Graphical illustrations of selected solutions are presented to visualize their physical behavior and validate the practicality of the proposed method.