

Exploring soliton patterns and dynamical analysis of the solitary wave form solutions of the (3+1)-dimensional Wazwaz–Benjamin–Bona–Mahony equation

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Received 6 July 2024

Accepted 1 November 2024

Published 9 January 2025

In this work, the dynamical structure for the extended equation is analyzed through unified Riccati equation expansion (UREE) and the Lie isomorphism method for the (3+1)-dimensional Wazwaz–Benjamin–Bona–Mahony (WBBM) equation. This equation represents the unidimensional propagation of short amplitude long waves on the water's surface in a medium. These employed techniques are the most powerful and effective ways to obtain different sets of new and more generalized exact soliton solutions of the WBBM equation. Furthermore, what distinguishes this study from other studies is that it not only acquires a variety of analytical wave solutions for the studied models but also, demonstrates the interaction phenomena for these results as they propagate over time. Also, shows various meaningful graphs of the processes that provide valuable wisdom for understanding their behavior. The UREE method directly provides various new exact soliton solutions with some novel dynamical properties. We perform a detailed Lie symmetry analysis to governing equation that leaves the system invariant. The Lie group method explores six Lie isomorphism groups to study the WBBM equation. First, we find infinitesimal transformations employing the one-parameter Lie symmetry method. Second, we solve the infinitesimal generator and reduce the order of the equation. Moreover, we illustrate some two-dimensional (2D), three-dimensional (3D), and contour diagrams of the obtained results and compute the exact analytical solution utilizing the used methods. To find novel solutions, the Adomian method is also used, where the Adomian polynomials are utilized to deal with nonlinear terms. Variety of new analytical solutions with different types of dynamical behavior are analyzed by utilizing the computational software like *Mathematica*. These new analytical exact wave solutions are demonstrated in various dynamical structures of periodic wave soliton, interaction periodic wave and kink wave soliton, lump wave

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