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Lie symmetry analysis and generalized invariant solutions of (2+1)-dimensional dispersive long wave (DLW) equations

Sachin Kumar[1,3], **Amit Kumar**[2] and **Harsha Kharbanda**[1]

[1] Department of Mathematics, Faculty of Mathematical Sciences, University of Delhi, Delhi-110007, India
[2] Department of Mathematics, Sri Venkateswara College, University of Delhi, Delhi-110021, India

E-mail: sachinambariya@gmail.com, amitk@svc.ac.in and ssdn0112@gmail.com

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Abstract

This present work applies the Lie group of point transformation method to construct the generalized invariant solutions for the (2+1)-dimensional dispersive long wave (DLW) equations under some constraints imposed on infinitesimal generators. In this connection, Lie point symmetries, vector fields and commutation relation for DLW system are well established and then the system is reduced into number of nonlinear ODEs through various symmetry reductions. An optimal system of one dimensional subalgebras of the Lie invariance algebra is formed. We exhaustively carry out symmetry reductions on the basis of these subalgebras. All the obtained solutions are more general in terms of arbitrary functions, and completely different from the previous work of the Sharma *et al* 2019, *Phys. Scr.* (Physica Scripta, 2019). Wherever possible, the relative comparison of our findings with the previous work is exhibited. Furthermore, we discuss the dynamic behavior of general solutions like annihilation of single soliton, nonlinear wave profile, curved shaped multisoliton and annihilation of doubly soliton through their evolutionary profiles.

Keywords: (2+1)-dimensional DLW equation, exact solutions, generalized invariant solutions, soliton solutions

(Some figures may appear in colour only in the online journal)

1. Introduction

Nonlinear partial differential equations (PDEs) occur in different fields due to their broad applications in science and engineering such as rheology plasma physics, signal processing, fluid dynamics, visco-elasticity, continuum mechanics, control theory, differential geometry and optics, etc [1–33] Many nonlinear physical occurrences have been construed by finding group invariant solutions for nonlinear PDEs. This physical phenomenon, which can be framed using PDEs, depends on the space variables x and y, and time instant t. For this aim, there are many transformation methods to obtain exact solutions of NPDEs and some of these are Bäcklund transformation method, Riccati–Bernoulli method, hyperbolic tangent method, inverse scattering method, homogeneous balance method, Lie symmetry method and many more mathematical techniques.

Lie symmetry method is an efficient and reliable technique for obtaining the exact solutions of nonlinear partial differential equations [2, 4, 16, 30–33]. This method helps us to reduce the number of independent variables in NPDEs by the means of similarity forms This method, in recent times, is used numerous significant research problems in mathematical sciences, engineering and physics [6–11].

Lie group of point transformation method is applied to seek the exact and group invariant solutions of the (2 + 1)-dimensional dispersive long wave (DLW) system which is of the establish form [14]

$$\begin{aligned} u_{yt} + v_{xx} + (uu_x)_y &= 0, \\ v_t + u_x + (uv)_x + u_{xxy} &= 0. \end{aligned} \tag{1}$$

[3] Author to whom any correspondence should be addressed.

