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Conservation Laws of Generalized Calogero–Bogoyavlenskii–Schiff Equation

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Introduction

The goal of this research is to apply the Lie symmetry approach to study the generalised Calogero-Bogoyavlenskii-Schiff equation (GCBSE). Solitons theory has been used to use the GCBS equation to describe wave profiles. Bogoyavlenskii and Schiff developed GCBSE in distinctive methods. We have calculated the symmetry generators of the GCBSE and commutation relation using Lie symmetry analysis. The commutator table revealed that translational symmetries create an Abelian algebra. The similarity variables are then employed to transform the purported nonlinear partial differential equation (NLPDE) into a nonlinear ordinary differential equation using the Lie theory (NLODE). We must identify some fresh wave profiles of GCBSE in the new auxiliary method (NAM).

Description

In recent years, interest in the study of higher-dimensional nonlinear systems, in particular integrable systems, has skyrocketed. Numerous scientific fields, including telecommunications, transport phenomena, ocean waves, quantum mechanics, plasma physics, nonlinear fibre optics, and many more, find use for the solitary waves theory [1]. Recent years have seen an increase in interest in the study of creating higher-dimensional integrable equations, with a number of integrable models being developed in the context of (2+1) and (3+1)-dimensional equations. In order to understand the true nature of nonlinearity in scientific fields and to reveal its scientific origin, it is essential to explore the domain of integrable equations. In addition, the interest in the two-soliton solution is due to its application, such as the development of the structure of soliton turbulence in integrable systems, as well as the soliton molecules in contemporary nonlinear optics. Nonlinear fluid waves and optical systems both exhibit similar soliton breathing behaviour. Studying the interaction of two solitons and associated structures is crucial, according to earlier studies. In this work, we show how two soliton-like solutions interact and degenerate along with their relationships to the breather solutions. Some classifications are also made in accordance with the distinct causes of the creation of Peregrine rogue waves [2].

Nonlinear partial differential equations (PDEs), which play a crucial role in nonlinear research, are used to simulate a wide range of chemical, biological, and physical processes. It offers a wealth of physical information and a deeper comprehension of the physical aspects of the issue, leading to more applications. In recent years, many tracks have been built for physical problems in order to find precise solutions for nonlinear PDEs using contemporary computer technologies. There are several successful methods [3], such as the extended modified auxiliary equation mapping method, the Riccati-Bernoulli Sub-ODE technique, the auxiliary equation technique, the (G′/G)-expansion technique, the homotopy perturbation technique, the unified technique, the generalised unified technique, and the modified simple equation method. In the early nineteenth century, the Norwegian mathematician Sophis Lie promoted Lie symmetry analysis, one of the most effective techniques for analysing nonlinear partial differential equations and locating their analytical solutions [4]. It can be used for many different things, including as linearizing some nonlinear equations, creating novel solutions out of simple ones, creating integrator factors, reducing order, and reducing the independent variables. The first thorough studies of symmetries admitted by fractional differential equations, concentrating on Riemann-Liouville and Caputo derivatives, were initiated by Gazizov et al. Wang and Xu looked at the symmetry characteristics of the time-fractional KDV equation. It is important to note that Yusuf examined the fluid flow equation [5].

The classical Lie symmetry theory is widely applied in many scientific and technical fields. Mathematician Sophus Lie first put forth this concept in the early nineteenth century. Applications in nonlinear PDEs have greatly risen, and it has been useful in many different differential equation domains. The main goal of Lie group theory is to construct similarity and solitary wave solutions by using the nonlinear PDEs' invariance requirement to arrive at the similarity variable and reduction equation. These answers clarify an important and fundamental physical phenomenon. The Lie symmetry method has lately been used to study a variety of models, including the Chen-Lee-Liu equation, Sawada-Kotera equation, Boussinesq equation, and many more [6]. The (2+1)-dimensional Calogaro-Bogoyavlenskii-Schiff equation has new exact solutions that are provided. Bogoyavlenskii and Schiff constructed this equation for the first time in their own special approaches; whilst Bogoyavlenskii utilised the modified Lax formalism, Schiff used the same equation by lowering the self-dual Yang Mills equation. By using the multiplier approach, we can also construct conserved vectors for the aforementioned equation.

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Conclusion

They are used as mathematical models to describe natural phenomena in fields like astronomy, fluids, plasmas, solid-state materials, meteorology and climate, operations research, system theory and control, continuum mechanics, and oceanography, to name a few, non-linear differential equations continue to be crucial in today's society. One example of such a model is the pair transition coupled non-linear Schrödinger equations, which are used to show how optical waves spread in an isotropic medium; the Boussinesq equation, which results from the vibrations of a non-linear string; the Boiti-Leon-Manna-Pempinelli equation, which models incompressible fluid.

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