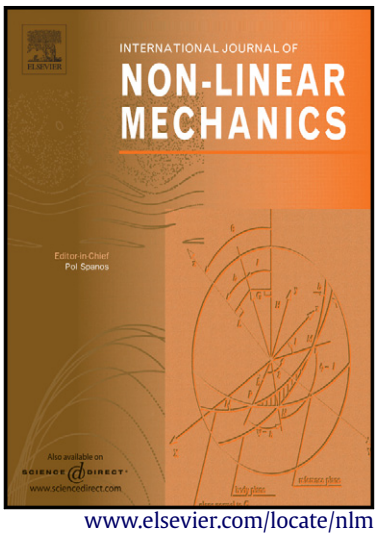

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PII: S0020-7462(14)00145-0
DOI: http://dx.doi.org/10.1016/j.ijnonlinmec.2014.07.007
Reference: NLM2342

To appear in: *International Journal of Non-Linear Mechanics*

Received date: 18 May 2014
Revised date: 9 July 2014
Accepted date: 31 July 2014

Cite this article as: Mehdi Nadjafikhah , Reza Dastranj , Symmetry analysis and conservation laws of an extended wave equation in the bubbly liquid, *International Journal of Non-Linear Mechanics,* http://dx.doi.org/10.1016/j.ijnonlinmec.2014.07.007

Symmetry analysis and conservation laws of an extended wave equation in the bubbly liquid

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Abstract

This study deals with symmetry group properties and conservation laws of an extended Kudryashov-Sinelshchikov (K-S) equation in the bubbly liquid. We study the Lie symmetries, symmetry reductions and exact solutions of the nonlinear wave equation. By applying direct method the local conservation laws associated to the (K-S) equation are also obtained.

Keywords: An extended equation for the description of nonlinear waves in a liquid with gas bubbles, Lie symmetry analysis, Invariant solutions, Conservation laws. MSC 58J70, 76M60, 35L65.

1. Introduction

In this paper, we study the following equation

$$v_t + \alpha v v_x + \beta v_{xxx} - \mu v_{xx} - \nu (v v_x)_x + \gamma v_{xt} = 0, \tag{1}$$

where α, β, μ, ν and γ are parameters. This equation was introduced by Kudryashov-Sinelshchikov in[1]. The nonlinear differential equation is for the description of long waves in a liquid with gas bubbles taking into account higher order terms in the asymptotic expansion. Painlev test has been carried out on equation (1), which shows that equation (1) is Painlev integrable under additional conditions on parameters.

The symmetry group of a system of differential equations transform solutions of the system to other solutions of the system. For constructing the solutions of nonlinear partial differential equations, Lie symmetry group theory can be regarded as one of the most powerful methods in the theory of nonlinear partial differential equations.

A conservation law of a given differential equation system is a divergence expression that vanishes on all solutions of the differential equation system. In the study of systems of differential equations, the concept of a conservation law plays an very important role in the analysis of essential properties of the solutions, particularly, investigation of existence, uniqueness and stability of solutions.

This work is organized as follows. In Section 2, we present group classification of the (K-S) equation. Section 3 is devoted to reductions to ordinary differential equations and exact solutions. In Section 4, the conservation laws associated to the wave equation are computed via direct method. The conclusions are presented in Section 5.

Symbolic software package GeM for Maple [2, 3] was used for all symmetry and conservation law computations.

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