46th Annual Iranian Mathematics Conference
25-28 August 2015
Yazd University

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Lie group classification of the Kuramoto-Sivashinsky equation

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Abstract

In this paper, the Lie symmetry analysis is performed for Kuramoto-Sivashinsky equation(KS). The exact solutions and similarity reductions generated from the symmetry transformations are provided. Furthermore, the all exact explicit solutions and similarity reductions based on the Lie group method are obtained, some new method and techniques are employed simultaneously. Such exact explicit solutions and similarity reductions are important in both applications and the theory of nonlinear science.

Keywords: Similarity solutions, Lie symmetry, Kuramoto-Sivashinsky equation, Invariant solution, Optimal system.
Mathematics Subject Classification [2010]: 22E70, 81R05, 70G65, 34C14.

1 Introduction

Symmetry is one of the most important concepts in the area of partial differential equations, especially in integrable systems, which exist infinitely many symmetries. To find the Lie point symmetry of a nonlinear equation, some effective methods have been introduced, such as the nonclassical method and the direct method . In this paper we will consider the following variable coefficients KuramotoSivashinsky equation (KS) by using the compatibility method.
The Kuramoto-Sivashinsky (KS) equation

$$u_t + uu_x + u_{xx} + u_{xxxx} = 0 \tag{1}$$

is a simple nonlinear PDE which exhibits complex spatio-temporal dynamics. It has been derived in the context of plasma ion mode instabilities by LaQuey et al. reaction-diffusion systems by Kuramoto and Tsuzuki, laminar flame fronts by Sivashinsky and viscous liquid flows on an inclined plane by Sivashinsky and Michelson.

2 Main results

In this section, we will perform Lie symmetry analysis for Eq.(1) firstly.The vector field associated with the group of transformations can be written as

$$V = \xi_1(x,t,u)\frac{\partial}{\partial x} + \xi_2(x,t,u)\frac{\partial}{\partial t} + \phi(x,t,u)\frac{\partial}{\partial u} \tag{2}$$

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