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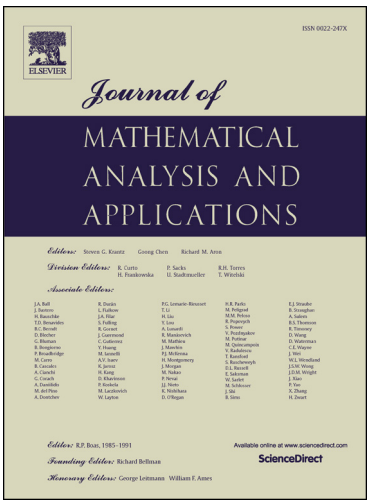

Darboux transformation and rogue wave solutions for the variable-coefficients coupled Hirota equations

Xin Wang, Chong Liu, Lei Wang

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Darboux transformation and rogue wave solutions for the variable-coefficients coupled Hirota equations

Xin Wang[a], Chong Liu[b], Lei Wang[c]

[a] *Department of Mathematics, Zhongyuan University of Technology, Zhengzhou, 450007, China*

[b] *School of Physics, Northwest University, Xi'an, 710069, China*

[c] *Department of Mathematics and Physics, North China Electric Power University, Beijing, 102206, China*

Abstract

We construct the Lax pair and Darboux transformation for the variable-coefficients coupled Hirota equations. Based on modulation instability and by taking the limit approach, we derive two types of Nth-order rogue wave solutions with different dynamic structures in compact determinant representations. The explicit first-order rogue wave solution is presented, prolific vector rogue-wave patterns such as the dark-bright, composite, three-sister, quadruple and sextuple rogue waves with multiple compression points are demonstrated. In particular, in contrast to the standard Peregrine combs, unusual vector rogue wave combs such as the dark-bright and composite rogue wave combs are revealed by choosing sufficiently large periodic modulation amplitudes. Further, some wave characteristics such as the difference between light intensity and continuous wave background, and pulse energy evolution of the dark rogue wave solution that features multiple compression points are discussed in detail.

Keywords: Integrable system; Darboux transformation; rogue wave; variable-coefficients coupled Hirota equations.

1. Introduction

Originally termed to describe monstrous sea wave events in oceanography [1, 2], rogue waves have been at the center of considerable research activity to a great extent due to their emerging relevance in a great variety of realms. These includes, the nonlinear optics [3], Bose-Einstein condensates (BEC) [4], atmosphere [5], surface plasma [6], and even econophysics [7]. They suddenly emerge with an amplitude significantly larger than that of the surrounding wave crests and vanish without slighting trace, and can be generally expressed by rational polynomials in mathematics [8]. Nowadays, it is widely accepted that the modulation instability (MI) is the fundamental mechanism for the generation of the rogue waves [9].

The foremost description of a single rogue wave is the Peregrine solution [10], a rational solution of the nonlinear Schrödinger (NLS) equation which features a localized peak whose amplitude is three times larger than that of the average height. Subsequently, the more complicated rogue waves which can be represented by higher-order rational functions have been systematically investigated for the NLS equation [11–13]. Additionally, recent experiments in a water tank indicate that the actual dynamics of these extreme waves can be commendably described by the analytic solutions [14, 15].

*Corresponding author.

Email address: wangxinlinzhou@163.com (Xin Wang[a])