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COMPLEXITY OF NONAUTONOMOUS DISCRETE SIMILARITONS AND FIRST-ORDER ROGUE WAVES IN ABLOWITZ-LADIK-HIROTA WAVEGUIDE

Mr.Narinder Kumar[1], Dr. Pawanjit Kaur[2]
[1,2]Guru Kashi University, Talwandi Sabo

Abstract

Rogue Waves (RW) are catastrophic natural physical phenomena that occur in the ocean. They are also known as monster waves or tremendous waves. Rogue waves have a wide range of applications in several fields since they can reveal fascinating stories. Rogue waves have amplitudes that are substantially higher than the usual wave crests in the area. The inhomogeneous ALH equation is used to simulate the stability of discrete similaritons and first-order rogue waves travelling across nonlinear waveguide arrays. These nonlinear solutions are obtained via a similarity transformation. CC is a CIM that studies the complexity and stability of spatially confined arrangements that are either discrete or continuous We found that at illustrative levels of the amplitude modulation parameter, the CC shows both saturation for a longer time for rogue waves and saturation for a shorter time for free waves. This means that the CC shows both saturation for a longer time for rogue waves and saturation for a shorter time for free waves. A low CC indicates that there is less space pressure and that a more prominent assortment of modes contribute similarly to the modular portion, which considers more data to be encoded.

Keywords:* *Complexity, Nonautonomous, Discrete, Rogue Waves, Ablowitz-Ladik-Hirot, Waveguide, etc

1. INTRODUCTION

The DNLSE is one of the most fundamental nonlinear dynamical models. It is used to describe extremely significant concepts in plasma physics, such as the electric field in optical fibres, self-focusing, and the collapse of Langmuir waves. The DNLSE's applications include light propagation through an array of optical waveguides, BECs in optical lattices deep enough to trap them, DNA double strand breaks, breathers in granular crystals and the dynamics of protein loops, molecular chains and atom chains are just a few of the things that happen. Because the ALH equation is a good approximation of NLSE, it is important for anharmonic waves. lattice analysis.

1.1 The combined Hirota-LPD equation with variable coefficients, nonautonomous rogue waves and 'catch' dynamics

Rogue Waves (RW) are catastrophic natural physical phenomena that occur in the ocean. They are also known as monster waves or tremendous waves. Rogue waves have a wide range of applications in a lot of different fields because they can tell interesting stories (thunderstorms, earthquakes, and hurricanes). Rogue waves have amplitudes that are much higher than the wave crests in the area usually have. This is why they can be dangerous. Higher-order nonlinear Schrodinger equations, such as the Hirota equation, are very important to understanding how waves move in weakly dispersive and weakly nonlinear media, such as water. It can be used in a lot of different ways in the real world, and because it's so general, there's been a lot of interest in finding accurate answers to the generalised

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NLSE. Find out if there are rogue waves or rational solutions to the higher-order NLSE is a fascinating project that can help explain novel physical phenomena.

Many studies examine rational solutions, such as the "Ma solitons" (MS) that are provided, and the "Akhmediev breathers" (ABs) that are discovered. The MS and ABs are rogue waves with the ability to form higher-order rational solutions and crash with solitons. Higher-dimensional rational solutions are more complicated, and new physical phenomena can develop in greater numbers. As a result, research into higher-dimensional rational solutions is critical. They may be able to unravel the enigma of rogue waves in the ocean, as well as help to make useful rogue waves in optical fibres. Rogue waves are getting a lot of attention right now because of how they are made. It's important to look at rogue wave solutions of the GrossPitaevskii (GP) equations to learn more. like transformation and direct ansatz: Yan used these two tools to solve a generalized non-autonomous NLSE. Furthermore, some researchers have used analytical and computational methods to examine the process by which a rogue wave of matter forms in Bose-Einstein condensates (BECs) with time-dependent interaction in a parabolic potential. For a wide range of physical problems, the NLSE with higher-order terms is a good way to think about them. It can be used in nonlinear optics, material science, and BECs, however these are only a couple. Up until this point, there hasn't been a lot of study into how non-independent rebel wave answers for the coupled Hirota-LPD condition with variable coefficients could be used to solve it.

2. REVIEW OF THE LITERATURE

Yu, Fajun (2015) using the generalised Darboux transformation, we investigate Schrodinger equation solutions with more complex terms. Using the Hirota-Lakshmanan-Porsezian-Daniel equation, some nonautonomous rogue waves are looked at analytically to see how they behave When we use the nonlinearity management function and gain/loss coefficient, we look at the things we can control in this nonautonomous rogue wave solution. It has been said that changing the nonlinear capacity and gain/misfortune coefficient can be utilized to "catch" rebel waves, but this is not true. Our method can offer a variety of ways to modify rogue waves, as well as potential applications for the wave.

Zhenya Yan and Chao-Qing Dai (2013) In the investigation of super short optical heartbeat engendering, higher-request dispersive and nonlinear impacts (otherwise called irritation terms) like third-request scattering, self-steepening, and self-recurrence shift are vital. These impacts are called irritation terms. Utilizing the summed up higher-request nonlinear Schr"odinger (NLS) condition, we take a gander at optical rebel wave arrangements and how they cooperate. The summed up higher-request NLS issue can be decreased to the integrable Hirota condition with consistent coefficients by transforming it in the correct manner. These careful arrangements of the summed up higher-request NLS condition can be connected to a wide scope of integrable arrangements of the Hirota condition by changing how we look at them. Here, we show how to use two solutions to the Hirota equation that are the lowest-order rational ones to make rogue wave solutions that are local in time but have a convoluted evolution in space, even if they don't have the differential increase or misfortune term. Based on these cutoff points, we just glance at the actual mechanics of the optical rebel waves that are made. At last, the mathematical dependability of the maverick wave arrangements that were found is investigated. Specialists have tracked down ways of causing rebel ripple effects, which could prompt

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new investigations and applications in nonlinear optics and other nonlinear fields, like Bose-Einstein condensates and oceanography.

Chao-Qing Dai, Guo-Quan Zhou, and Jie-Fang Zhang (2012) we use a transformation linked to the constant-coefficient Hirota equation to construct solutions to variable-coefficient higher-request nonlinear Schrödinger conditions that depict femtosecond beat engendering can be found logically. Whenever we have an intermittent circulated fiber framework and an outstanding scattering diminishing fiber, we talk about the proliferation ways of behaving of controllable rebel waves, like how they come back, how they die, and how they stay alive. Finally, we look into rogue wave nonlinear tunneling phenomena.

Wang, You-Ying, He, Jingsong, and Li, Yi-Shen (2011) The variable coefficient nonlinear Schrödinger (VCNLS) condition is planned to the traditional nonlinear Schrödinger (NLS) condition in this study utilizing a clever kind (or second sort) of change. Another kind of non-independent NLS condition with a t-subordinate potential is given as a specific example. Besides, the significant sorts of arrangements of a particular model of the novel non-independent NLS condition are tended to utilizing the new change and taking full advantage of the known soliton and rebel wave arrangements of the ordinary NLS condition. Another articulation, i.e., the non-sane recipe, of the rebel wave of a particular VCNLS condition is likewise gotten scientifically utilizing the new transformation. Three things summarize the main distinctions between the two types of transformations discussed above.

3. OBJECTIVES

- To examine Hirota-LPD equation with variable coefficients, nonautonomous rogue waves and 'catch' dynamics.
- To analyze nonautonomous discrete one-solitons and configurationally complexity for discrete onesoliton.

4. NONAUTONOMOUS DISCRETE ONE-SOLITONS AND ROGUE WAVES CONFIGURATIONAL COMPLEXITY

The inhomogeneous ALH equation is used to simulate the stability of discrete similaritons and first-order rogue waves travelling across nonlinear waveguide arrays. These nonlinear solutions are obtained via a similarity transformation. CC is a CIM that studies the spatial complexity and stability of spatially confined discrete or continuous arrangements.

4.1 The discrete one-soliton solution and the model equation

The DNLSE is used to represent wave propagation in modified ALH lattices with variable coefficients. The DNLSE's (1+1) Dimensional Form is as follows:

$$i\frac{\partial U_n}{\partial t} + [\lambda(t)U_{n+1} + \lambda^*(t)U_{n-1}](1 + h(t)|U_n|^2) \\ -2\nu_n(t)U_n + i\alpha(t)U_n + (\zeta(t) - \chi(t))U_n = 0. \quad (1)$$

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With n = 0, ±1, ±2,....., Un Un(t) signifies the amplitude of the intricate field at the nth spot in the grid is The complex-esteemed work (t) is utilized to show how much passage coupling there is between two spots. This can be composed as a(t)+ib(t), where a(t) and b(t) are genuine esteemed capacities. At the point when the time-regulated coefficients of intersite nonlinearity, reality balanced inhomogeneous recurrence shift, and time-adjusted gain or misfortune term are written out, they are called the "h" coefficients, "vn" coefficients, and "" coefficients. (t) and (t) are time functions, and they can be used to figure out how long things take. When you use the similarity transformation, you can get the discrete soliton solution of Eq. (1). This is how you get the standard discrete Hirota equation.

$$Un(t) = g(t)\exp[i\varphi_n(t)]\Psi_n(\zeta(t)),\ (2)$$

The phase φn(t) is a function of space and time, while the g(t) is a real-valued function of time. Assume the phase is a space-time polynomial with time-dependent coefficients.

$$\varphi_n(t) = C_1(t)_n + C_2(t),\ (3)$$

When Eqs (2) and (3) are substituted into Eq. (1), a set of first-order differential equations for the transformation parameters is derived, and the converted field Ψ satisfies the usual discrete Hirota equation.

$$i\frac{\partial\Psi_n}{\partial\zeta} + \frac{1}{2}[2(A+iB)\Psi_{n+1} + 2(A-iB)\Psi_{n-1}](1+M|\Psi_n|^2) - A\Psi_n = 0. \quad (4)$$

A set of nonlinear ordinary differential equations is used to link the parameters.

4.2 Configurational complexity calculation for discrete onesoliton

Eq. (5) corresponds to a position-space energy density of

$$U_n(n,\zeta) = \frac{g}{\sqrt{\epsilon}}\sinh(\frac{\kappa}{2})\mathrm{sech}\left(\frac{\kappa}{2}n + \frac{\xi}{2}\zeta + \log(\frac{\sqrt{\epsilon}}{2}\sinh(\frac{\kappa}{2}))\right)e_1e_2 \quad (5)$$

$$\rho(n,\zeta) = \frac{\kappa}{4}\mathrm{sech}\left(\frac{\kappa}{2}n - \frac{\xi}{2}\zeta + \log(\frac{\sqrt{\epsilon}}{2}\sinh(\frac{\kappa}{2}))\right)^2 \quad (6)$$

After examining parameters for (n,) that can be set in this way When we looked at the transverse direction and time of the single onesoliton, we found that CC is mostly affected by these two things: (t). For our tests, we set the other parameters to g0 = 1, M = 1 and A = 2. We also set the other values of the other parameters to the same values: = 1, g0 = 1, g A discrete soliton energy density (Eq) has been used to figure out the CC value.. (6)).

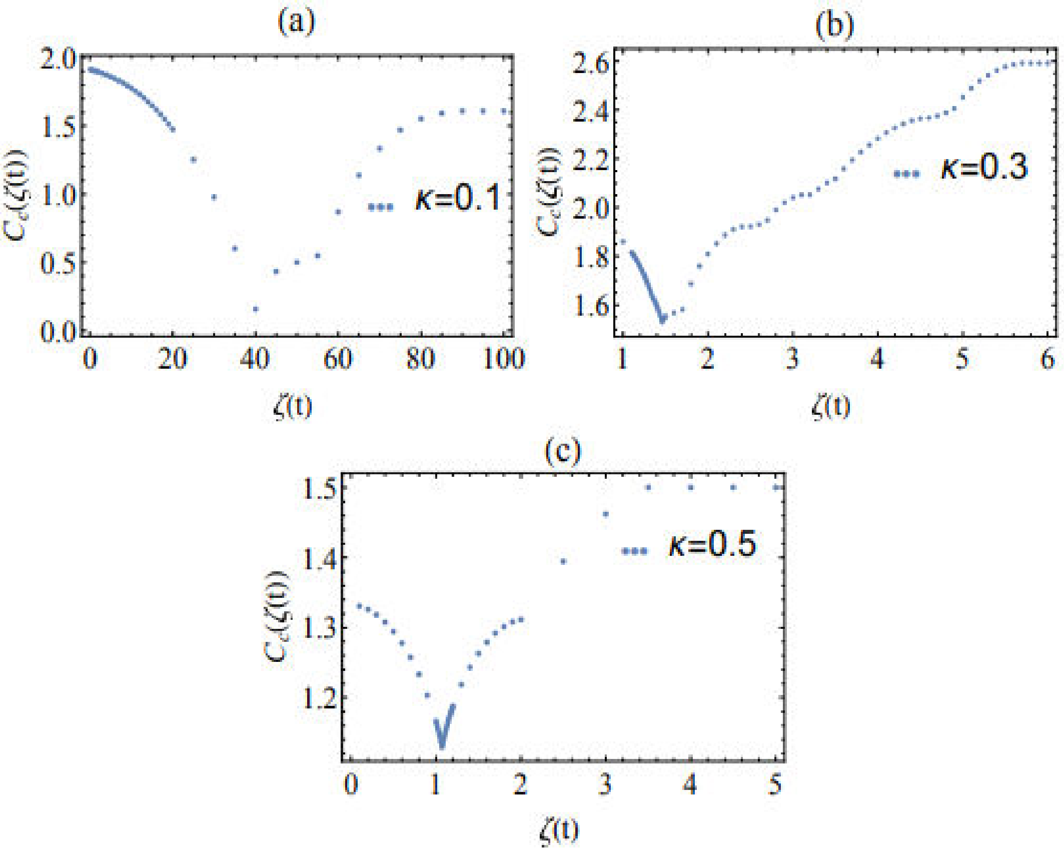

Figure 1: CC of discrete one-soliton $C_c(\zeta(t))$ for several values of transverse direction κ as a function of time variable ζ(t). The minimum value of $C_c(\zeta(t))$ varies with κ and occurs at (a) ζ(t) = 40.0, (b) ζ(t) = 1.47 and (c) ζ(t) = 1.07 for κ = 0.1, 0.3, 0.5, respectively

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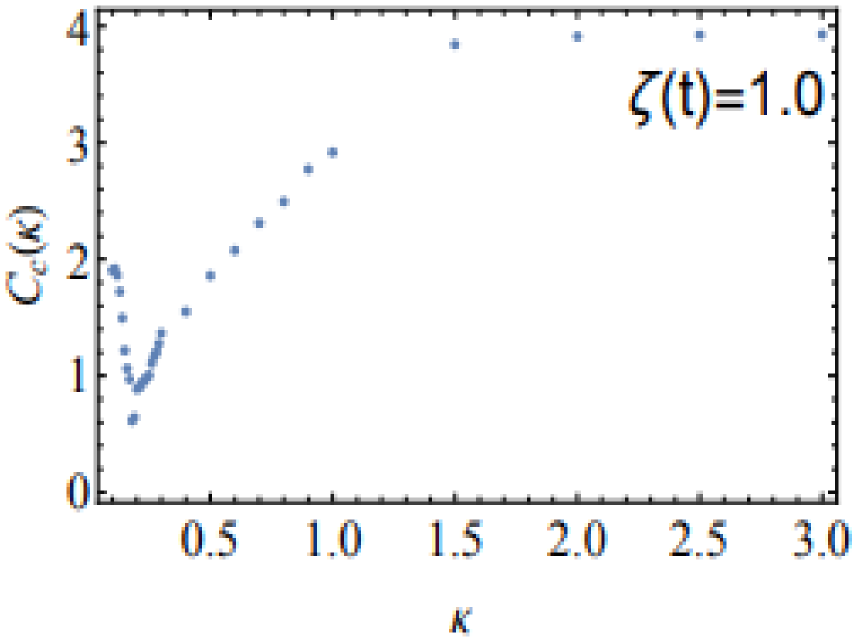

Figure 2: Snapshot of CC $C_c(\kappa)$ as a function of transverse direction κ of the discrete one-soliton. The minimum value of CC occurs at κ = 0.18

Figures 1 and 2 demonstrate CC profiles Time is a factor in how transverse direction and time parameters change. Cc(t) and Cc() both have a certain global minimum value. Plateau-like shapes can also be seen for small and large values of the variables shown in Fig. 1 (as well as for large values of). (Fig. 2). In time, there is no big change in the shape complexity of the soliton. This is because the asymptotic high plateaus show that the soliton has a lot of momentum modes that all contribute to the object at the same rate. In the literature about CIMs, it says that a low number of CC points to stability. In both of these diagrams, there is less space compression in these configurations, and more modes make up the modal percentage. Putting more information into the ALH lattice's one-soliton means that it can hold more information than it used to be able to.

5. NONAUTONOMOUS DISCRETE ROGUE WAVES CONFIGURATIONAL COMPLEXITY

Eq. (4)'s non-autonomous discrete one-rogue wave solution is written as

$$U_n(n,\zeta) = g\sqrt{\mu}\left[(1 - \frac{4(1+\mu)(1+2\iota\mu\zeta)}{1+4\mu n^2+16\mu^2+(1+\mu)\zeta^2})\right] e_1 e_7, \quad (7)$$

Where μ is the conditions amplitude and

$$e_1 = \exp[i(C_1 n + C_2)]$$

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$$e_7 = \exp[i(2\zeta((1+\mu)\sqrt{A^2+B^2}-A)+n\tan^{-1}(B/A)].$$

The transmitted position-space energy density is,

$$\rho(n,\zeta) = \frac{\left[\left(1-\frac{4(1+\mu)(1-2\iota\mu\zeta)}{e_8}\right)\left(1-\frac{4(1+\mu)(1+2\iota\mu\zeta)}{e_8}\right)\right]}{\left[1+\frac{8(1+\mu)^2(-\iota+2\mu\zeta)(\iota+2\mu\zeta)}{(e_9)(e_{10})}-\frac{4\sqrt{\mu}(1+\mu)(e_{11})}{(e_9)^{\frac{3}{2}}}\tan^{-1}\left[\frac{2\sqrt{\mu}}{\sqrt{e_9}}\right]\right]} \quad (8)$$

Where

$$e_8 = 1+4n^2\mu+16\mu^2(1+\mu)\zeta^2,$$

$$e_9 = 1+16\mu^2\zeta^2+16\mu^3\zeta^2,$$

$$e_{10} = 1+4\mu+16\mu^2\zeta^2+16\mu^3\zeta^2,$$

$$e_{11} = (-1+12\mu\zeta^2+12\mu^2\zeta^2).$$

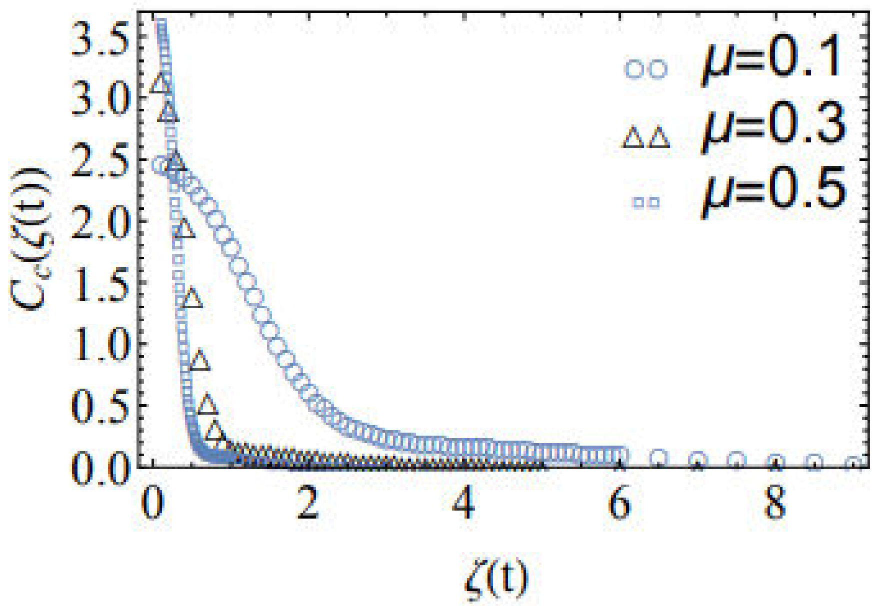

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Figure 3: CC $C_c(\zeta(t)$ of discrete one-rogue wave in the ALH lattice propagating in the $\zeta(t)$ time with background amplitude $\mu = 0.1, 0.3, 0.5$. Saturation ($C_c(\zeta(t) \rightarrow 0$) occurs earlier for larger values of μ

$g_0 = 1$, $\alpha_0 = 1$, $M = 1$, $A = 2$, $B = 0$ were set as the values for the various parameters. $\zeta(t)$With background amplitude values of 0.01 to 0.03 and 0.05 to 0.50, the configurationally saturated states were found at (t) = 2.21 to 1.01; for higher levels of background amplitude, saturation happens earlier in the propagation time (t) = 0.62 to 0.21. (Fig. 3).

6. CONCLUSION

Using a space complexity metric known as CC, we investigated ALH waveguides with one-soliton and rogue waves modelled with the DNLSE. The CC shows plateaus for various upsides of the cross over boundary as it pushes ahead on schedule for various solitons, with a sharp drop in the middle. Understanding: The high levels show that there are more spatial confinement and energy modes that help the article, however they don't represent the moment of truth data capacity productivity. A low CC demonstrates that there is less space pressure and that a more prominent assortment of modes contribute similarly to the modular part, which takes into account more data to be encoded. For instance, we tracked down that when the amplitude modulation parameter is set to an example level, the CC stays saturated longer for waves that aren't from the same source as the source. The most space compression for the right modulation saturation is a sign that the amplitude is high enough to start unstable waves. The dispersion of the configuration into free waves is also a saturation.

REFERENCES

1. Yu, Fajun. (2015). Nonautonomous rogue waves and 'catch' dynamics for the combined Hirota-LPD equation with variable coefficients. Communications in Nonlinear Science and Numerical Simulation. 34. 10.1016/j.cnsns.2015.10.018.

2. Yan, Zhenya & Dai, Chao-Qing. (2013). Optical rogue waves in the generalized inhomogeneous higher-order nonlinear Schrodinger equation with modulating coefficients. Journal of Optics. 15. 10.1088/2040-8978/15/6/064012.

3. Dai, Chao-Qing & Zhou, Guo-Quan & Zhang, Jie-Fang. (2012). Controllable optical rogue waves in the femtosecond regime. Physical review. E, Statistical, nonlinear, and soft matter physics. 85. 016603. 10.1103/PhysRevE.85.016603.

4. You-Ying, Wang & He, Jingsong & Yi-Shen, Li. (2011). Soliton and Rogue Wave Solution of the New Nonautonomous Nonlinear Schrödinger Equation. Communications in Theoretical Physics - COMMUN THEOR PHYS. 56. 995-1004. 10.1088/0253-6102/56/6/04.

5. Kumar, P. & Gupta, H.V. (2020). Debatesdoes information theory provide a new paradigm for earth science? Water Resources Research, 56, e2019WR026398, e2019WR026398 2019WR026398. 20, 53

ISSN- 2394-5125 VOL 08, ISSUE 02, 2021

6. Gleiser, M. & Jiang, N. (2018). Predicting atomic decay rates using an informational-entropic approach. International Journal of Theoretical Physics, 57, 1691. 22

7. Grant, W.P. (2018). On some shortcomings of shannon entropy as a measure of information content in indirect measurements of continuous variables. Journal of Atmospheric and Oceanic Technology, 35, 1011 – 1021. 20

8. Guang, J.L., Rong, Z.L., Zhang, Y.Z. & Ho, Y.K. (2017). Benchmark values of shannon entropy for spherically confined hydrogen atom. International Journal of Quantum Chemistry, 117, e25375. 19, 20

9. Ghosal, A., Mukherjee, N. & Roy, A.K. (2016). Information entropic measures of a quantum harmonic oscillator in symmetric and asymmetric confinement within an impenetrable box. Annalen der Physik, 528, 796. 19

10. Gleiser, M. & Jiang, N. (2015). Stability bounds on compact astrophysical objects from information-entropic measure. Physics Review D, 92, 044046. 23 ‘

11. Ikot, A., Antia, A., Akpan, I. & Awoga, O. (2013). Bound state solutions of schrodinger equation with modified hylleraas plus exponential rosen morse potential. Revista mexicana de physica, 59, 46. 36, 37

12. Gorbach, A.V. & Johansson, M. (2004). Gap and out-gap breathers in a binary modulated discrete nonlinear schr¨odinger model. The European Physical Journal D - Atomic, Molecular, Optical and Plasma Physics, 29, 77. 81