Modulation Instability Analysis of a Nonautonomous (3+1)-Dimensional Coupled Nonlinear Schrödinger Equation

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Research Article

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Abstract

We investigate the modulation instability (MI) analysis of a nonautonomous (3+1)-dimensional coupled nonlinear Schrödinger (NLS) equation with time-dependent dispersion and phase modulation coefficients. By employing standard linear stability analysis, we obtain an explicit expression for the MI gain as a function of dispersion, phase modulation, perturbation wave numbers and an initial incidence power. The nonautonomous coupled NLS equation is found to be modulationally unstable for the same sign of dispersion and phase modulation coefficients. This equation is modulationally stable for zero dispersion and or phase modulation coefficients. But non-zero dispersion coefficient, it is modulationally stable/unstable on distinct bandwidth of wave numbers. The trigonometric, exponential, algebraic function of time and constant have been chosen as test functions for dispersion and phase modulation to find the effect on the MI analysis. The effect of focusing and defocusing medium on the MI analysis has also been investigated. The MI bandwidth in the focusing medium is found to be larger than defocusing medium. It is found that the modulation instability of the equation can be managed by proper choice of the dispersion and phase modulation parameters.

Full Text

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Figures

(a)

(b)

(c)

Figure 1

Variation of the MI gain in Eq. (10) for $A(t) = \sin t$; and $B(t) = \cos t$ for different value of U_0 , V_0 , L and M : (a – b) with time t and wave number K ; (c) contour plot.

(a)

(b)

(c)

(d)

Figure 2

Please see the Manuscript PDF file for the complete figure caption.

(a)

(b)

(c)

(d)

Figure 3

Variation of the MI gain in Eq. (10) for $A(t) = \sin t$ and $B(t) = \cos t$ for different value of U_0 , V_0 and M : (a) and (c) plots with time t and wave numbers K and L ; (b) and (d) contour plots.

(a)

(b)

(c)

Figure 4

Variation of the MI gain in Eq. (10) for $A(t) = \sin t$; and $B(t) = -\exp(t)$ for different value of U_0 , V_0 , L and M : (a – b) with time t and wave number K , (c) contour plot.

(a)

(b)

(c)

(d)

Figure 5

Please see the Manuscript PDF file for the complete figure caption.

(a)

(b)

Figure 6

Variation of the MI gain in Eq. (10) for $A(t) = \sin t$; and $B(t) = -\exp(t)$ for different value of U_0 , V_0 and M :
 (a) with time t and wave numbers K and L , (b) contour plot.

(a)

(b)

(c)

Figure 7

Please see the Manuscript PDF file for the complete figure caption.

(a)

(b)

(c)

Figure 8

Please see the Manuscript PDF file for the complete figure caption.

(a)

(b)

(c)

(d)

Figure 9

Please see the Manuscript PDF file for the complete figure caption.

(a)

(b)

(c)

Figure 10

Please see the Manuscript PDF file for the complete figure caption.

(a)

(b)

(c)

(d)

Figure 11

Please see the Manuscript PDF file for the complete figure caption.

Figure 12

Comparison of the MI gain G in Eq. (10) for a nonautonomous (3+1)-dimensional coupled NLS equation with [36] for fixed values of $L = 0$, $M = 0$, $A(t) = B(t) = 1$.