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Soliton solutions and chaotic motions for the $(2+1)$-dimensional Zakharov equations in a laser-induced plasma. (English) Zbl 1443.82016

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Summary: The $(2+1)$-dimensional Zakharov equations arising from the propagation of a laser beam in a plasma are studied in this paper. Analytic soliton solutions are obtained by means of the symbolic computation, based on which we find that $|E|$ is inversely related to ω_{pe}, but positively related to m_i and c_s, while n is inversely related to ω_{pe} and ω_L, but positively related to n_0, with E as the envelope of the high-frequency electric field, n as the plasma density, while ω_{pe}, ω_L, n_0, m_i and c_s as the plasma electronic frequency, frequency of the laser beam, mean density of the plasma, mass of an ion and ion-sound velocity in the plasma, respectively. Head-on interaction is found to be transformed into an overtaking one with ω_{pe} increasing or n_0 decreasing. Also, period of the bound-state interaction decreases with ω_L decreasing. Considering the driving forces in the laser-induced plasma, we explore the associated chaotic motions as well as the effects of ω_L, ω_{pe}, k_L, n_0, m_i, c_s, ω_{F_1} and ω_{F_2}, where k_L is the wave number of the laser beam, ω_{F_1} and ω_{F_1} represent the frequencies of driving forces, respectively. It is found that the chaotic motions can be weakened with ω_{pe}, c_s and ω_{F_1} increasing, or with n_0, m_i and ω_{F_2} decreasing, and the periodic motion can occur when ω_{F_1} reaches the critical value 2π, while the chaotic motions are independent of ω_L and k_L.

MSC:

82D10 Statistical mechanics of plasmas
35C08 Soliton solutions
35L70 Second-order nonlinear hyperbolic equations
35Q55 NLS equations (nonlinear Schrödinger equations)
37K40 Soliton theory, asymptotic behavior of solutions of infinite-dimensional Hamiltonian systems

Keywords:

laser-induced plasma; $(2+1)$-dimensional Zakharov equations; soliton interaction; chaotic motions; symbolic computation

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