Resonant Control of Envelope Solitons

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Various nonlinear objects, such as solitons, are of great theoretical interest today. However, difficulties in generation and control of solitons may restrain their practical application and even experimental observation. A class of nonlinear waves possessing internal oscillating degrees of freedom can be effectively generated from trivial initial conditions using so called autoresonance phenomenon [1]. In this work we extend this approach to the problem of control of a given (pre-exited) solitary wave.

We studied the control of solitons in the perturbed nonlinear Schroedinger equation

$$iu_t + \tfrac{1}{2}u_{xx} + |u|^2 u = \varepsilon f(x,t),$$

which is often used to describe dynamics of the envelope solitons in various areas of nonliear wave physics. The amplitude and velocity of a soliton solution of this equation are independent and are subject of control. The amplitude alone can be controlled by a one-phase perturbation with slowly varying frequency [2]. Simultaneous control of both parameters can be achieved by using two-phase perturbation – a superposition of two waves with different frequencies and wave-numbers [3]:

$$f(x,t) = \exp(i\psi_1(t)) + g\exp(ikx + i\psi_2(t)).$$

Threshold conditions for amplitudes and variation rates of the driving required for the control of both the amplitude and the velocity of the soliton are found. Numerical simulations demonstrate that the method allows to control solitons for a long time according to a given scenario while the threshold conditions are fulfilled locally. It is found that soliton does not radiate while the control occurs.

The results can be applied to soliton stabilization, amplification and control in optical fibers [4] and magnetics [5].

References

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