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A refined empirical stability criterion for nonlinear Schroedinger solitons under spatiotemporal forcing

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We investigate the dynamics of travelling oscillating solitons of the cubic NLS equation under an external spatiotemporal forcing of the form $f(x,t) = a \exp [iK(t)x]$. For the case of time-independent forcing a stability criterion for these solitons, which is based on a collective coordinate theory, was recently conjectured. We show that the proposed criterion has a limited applicability and present a refined criterion which is generally applicable, as confirmed by direct simulations. This includes more general situations where $K(t)$ is harmonic or biharmonic, with or without a damping term in the NLS equation. The refined criterion states that the soliton will be unstable if the "stability curve" $p(\v)$, where $p(t)$ and $\v(t)$ are the normalized momentum and the velocity of the soliton, has a section with a negative slope. Moreover, for the case of constant K and zero damping we use the collective coordinate solutions to compute a "phase portrait" of the soliton where its dynamics is represented by two-dimensional projections of its trajectories in the four-dimensional space of collective coordinates. We conjecture, and confirm by simulations, that the soliton is unstable if a section of the resulting closed curve on the portrait has a negative sense of rotation.

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