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An Effective Field Theory for Large Oscillons

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We consider oscillons - localized, quasiperiodic, and extremely long-living classical solutions in models with real scalar fields. We develop their effective description in the limit of large size at finite field strength. Namely, we note that nonlinear long-range field configurations can be described by an effective complex field $\psi(t, \mathbf{x})$ which is related to the original fields by a canonical transformation. The action for ψ has the form of a systematic gradient expansion. At every order of the expansion, such an effective theory has a global U(1) symmetry and hence a family of stationary nontopological solitons - oscillons. The decay of the latter objects is a nonperturbative process from the viewpoint of the effective theory. Our approach gives an intuitive understanding of oscillons in full nonlinearity and explains their longevity. Importantly, it also provides reliable selection criteria for models with long-lived oscillons. This technique is more precise in the nonrelativistic limit, in the notable cases of nonlinear, extremely long-lived, and large objects, and also in lower spatial dimensions. We test the effective theory by performing explicit numerical simulations of a $(d + 1)$-dimensional scalar field with a plateau potential.

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