# Observation and computation of breathers in solitary wave - cnoidal like wave interactions

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## Abstract

Breathers are localized disturbances exhibiting two distinct time scales: one associated with propagation and the other associated with internal oscillations. In integrable systems and some apparently non-integrable equations, breather solutions can be constructed from the nonlinear superposition of a solitary wave and a periodic traveling wave, e.g. cnoidal-like wave, solution. But the experimental confirmation of this superposition is lacking. In this work, theoretical and experimental studies of breathers are performed in the strongly nonlinear regime of a viscous fluid conduit. Interfacial waves generated by the time-varying, buoyant injection of a miscible, Stokes fluid into another Stokes fluid with high viscosity contrast are shown to exhibit bright and dark breathers resulting from the interaction of solitary waves and cnoidal-like waves. Reliable, local generation of nonlinear, cnoidal-like periodic traveling waves and solitary waves as well as limitations therein are demonstrated to be accurately modeled by the conduit equation. Four-parameter families of stable bright and dark breather solutions of the conduit equation are obtained using Newton-method type fixed point iterations and compared with the observed strongly nonlinear breathers quantitatively. Additionally, breather interactions and breather trains are observed, motivating future studies of the generalized Riemann problem and soliton gases.