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The Gardner equation in nonlinear theory of extreme waves in stratified medium

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The Gardner equation is derived in the framework of the asymptotic theory for unidirectional long wave propagation in weakly dispersive media when quadratic and cubic nonlinear terms have the same order (stratified fluid, plasma and others). This equation is the full integrable nonlinear equation, and the solution of the Caushy problem can be obtained with use of modern approaches of the mathematical physics: Darboux, Backlund and Hirota transformations, inverse scattering technique, etc. The soliton solutions of the Gardner equation are discussed, their shape and polarity depends on the signs of nonlinear terms. Various scenario of the soliton interaction are demonstrated. Along with solitons the propagation of quasi-stable nonlinear oscillating wave packets (breathers) in the frames of the Gardner equation is predicted, and their behavior is analyzed. The solution of the "periodic" Gardner equation is obtained numerically, and the process of the generation of high-amplitude short-lived pulses ("freak" waves) is investigated in details. The Gardner equation is an appropriate model for propagation of wave of moderate amplitudes and it may be extended for influence of various factors such as variability of medium parameters, low-frequency dispersion and dissipation. The effects of soliton and breather transformation and breaking in the turning points (where nonlinear term, even quadratic or cubic, changes sign) are discussed based on the asymptotic and numerical solutions. The role of solitons and breathers in the dynamics of extreme waves is discussed using numerical simulation of the governing Euler equation of the stratified inviscid fluid.