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Remarks on the applicability of Gardner equation to describe ISWs in a three-layer liquid system

Recently, we have examined the conjugate states and limiting internal solitary waves (ISWs) in a three-layer liquid system and found regimes of parameters where mode-1 solitary-wave solutions with different polarities can coexist. When using weakly nonlinear theory to describe the ISWs in such physical system, it is well known that, for the special case of a symmetric configuration (Boussinesq approximation + equal density increments across the layers + same thickness of the top and bottom layers), the quadratic nonlinear coefficient of the KdV equation vanishes, although solutions of opposite polarities are predicted by the mKdV equation if the thickness of the intermediate layer is sufficiently large, in which case the cubic nonlinear coefficient is positive. This result agrees both with the strongly and fully nonlinear theories. Using strongly nonlinear theory, we investigate when mode-1 solutions with different polarities can coexist, in general, and check whether the Gardner equation (with both quadratic and cubic nonlinear coefficients) is able to make accurate predictions.

References:

[1] Doak, A., Barros, R., Milewski, P.A. 2022 Large mode-2 internal solitary waves in three-layer flows. J. Fluid Mech. 953, A42

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