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Whitham modulation theory for a class of dispersive hydrodynamic equations.

Unidirectional dispersive hydrodynamic models typically consist of a conservation law modified by a conservative, integro-differential operator. In his 1967 paper, Whitham put forth a weakly nonlinear scalar model that matched the dispersion relation for unidirectional waves. We propose a generalization of Whitham's model consisting of a general nonlinear flux function and a general linear dispersion relation.

A multiple scales calculation yields the modulation equations, a system of three conservation laws that describe the slow evolution of the periodic traveling wave's wavenumber, amplitude, and mean. In the weakly nonlinear limit, explicit criteria that depend on the nonlinear flux function and linear dispersion relation are presented that establish the strict hyperbolicity and genuine nonlinearity of the modulation equations. These criteria indicate the onset of modulational instability of the finite amplitude wavetrain, and they are interpreted as a generalization of the Lighthill criterion. (Received August 16, 2021)