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Benjamin - Feir instability on the variable current.

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Modulational instability (Benjamin-Feir instability) is one of fundamental principles of nonlinear water wave dynamics. This phenomenon is of the utmost importance for description of dynamics and downshifting of energy spectrum among sea surface waves, formation of freak (or giant) waves in oceans and wave breaking.
As for surface gravity waves on deep water resonant interactions occur at the third order, BF-instability can be described at early stages of the process as interaction of three monochromatic wave trains: carrier, upper and lower side-band waves with a small differences in frequencies and wave numbers from carrier wave which form a resonant quartet. Side band instability of the initially monochromatic wave gives a rise of super- and sub-harmonics of the carrier Stokes wave. The latter stages of this process are much less investigated and many observed experimentally physical phenomena still need the extended theoretical analysis.
How modulation instability develops on the variable adverse or following current? This problem merges with another fundamental phenomenon which is still a big challenge in physical oceanography - interaction of waves with current. In spite of numerous numbers of papers devoting to the analysis of the phenomenon some very strong effects are still waiting for its clear description.
For example, modulated waves in linear theory will be blocked by strong enough adverse current. Nevertheless, experiments show something different: waves can be blocked only partly and overpass the opposite current barrier at the lower side band resonance frequency. This effect until now has no satisfactory theoretical description.
We derived the set of modulation equations to describe the resonance interaction of surface waves in the presence of the variable current. Analytical research of wave dynamics on adverse and following currents with horizontal-velocity gradient was conducted.
We describe the surface wave overpass the opposite current blocking barrier and frequency downshifting; investigate surface waves modulation on the co propagating decaying current; analyze the effect of initial wave steepness on the wave propagation, blocking and breaking; examine numerically a stationary solution for various special forms of horizontal current, corresponding to available experiments.
Theoretical results are compared with available experiments.