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Effect of a variable bottom topography on surface water waves

We investigate the effect of the bottom topography on the evolution of surface waves. It is a problem of significance for ocean dynamics in coastal regions where waves are strongly affected by the topography. The literature on models of free surface water waves over a variable depth is extensive. In the presence of topography, there are several asymptotic scaling regimes of interest, including long-wave hypotheses for the evolution of the free surface, and short scale and/or long scale variations in the variable bottom. A central object in the analysis of the water wave problem is the Dirichlet-Neumann operator and our study concerns its spectrum in the context of the water wave system linearized near equilibrium in a domain with a variable bottom assumed to be a smooth periodic function. We use the analyticity of the Dirichlet-Neumann operator with respect to the bottom variation and combine it with general properties of elliptic systems and spectral theory for self-adjoint operators to develop a Bloch-Floquet theory and describe the structure of its spectrum. We find that, under some conditions on the bottom varia- tions, the spectrum is composed of bands separated by gaps which are zones of forbidden energies, and we give explicit formulas for their sizes and locations.