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Fluid-Structure Interactions of Structure-Borne Traveling Waves

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— Structure-Borne Traveling Waves (SBTWs) are a promising means of underwater propulsion, but the coupled fluid-structural dynamics are poorly understood. SBTWs operate by taking advantage of a structure's inherent modal properties (mode shapes and natural frequencies). This enables traveling wave generation using two actuation points instead of requiring a large array of actuators. However, the fundamental reliance of SBTWs on structural properties also introduces coupling with the surrounding fluid. This study extends SBTW generation to underwater and accounts for the two-way coupled, fluid-structure interactions. SBTWs are analytically and experimentally generated on a slender, cantilever beam in a quiescent fluid. An analytic model is developed coupling a linear Euler-Bernoulli beam with a potential flow solution for the surrounding fluid. The structural response is solved via a Galerkin-type solution. SBTWs are then generated by applying multi-input forcing to the coupled system. The model is experimentally validated against a cantilever beam in quiescent water. Experimental SBTWs are generated using flush-mounted piezoelectric actuators and the structural response measured using non-contact scanning laser vibrometry. Analytic and experimental SBTWs are compared at several frequencies and with varying waveforms (i.e. wavelength and wave speed). The results demonstrate that SBTWs can be generated in water and the fluid-structure interactions accurately captured.

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