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# Metabathymetry: Restoring regular sloshing modes in irregular cavities

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Water wave metamaterials offer unprecedented control over the propagation and behavior of water waves[1]. Through manipulation of their composition and arrangement, these engineered structures hold immense potential for a wide range of practical applications by influencing wave characteristics such as frequency, amplitude, and directionality.

This study explores a novel application of metamaterials, focusing on restoring regular sloshing behavior within irregular cavities. This is achieved by designing an anisotropic medium using coordinate transformation theory and the homogenization of fully three-dimensional linear water wave problem[2]. This approach results in a much higher degree of anisotropy compared to previous models[3]. By transforming the bathymetry of irregular cavities, we enable them to exhibit resonant properties akin to regular cavities (Figure 1). We analyze the performance of these metamaterial-enhanced cavities both experimentally and numerically. Experimental investigations involve irregular cavities with metamaterial bathymetry (metabathymetry) and a reference case with flat bathymetry. To experimentally assess wave dynamics, we utilize Fourier transform profilometry[4] along with confocal displacement sensors for precise measurements of surface deformation in space and time.

Our findings highlight the ability of water wave metamaterials to recover regular sloshing modes within irregular cavities, presenting promising applications in fluid containment, improved energy absorption, and optimized structural integrity in marine and engineering contexts.

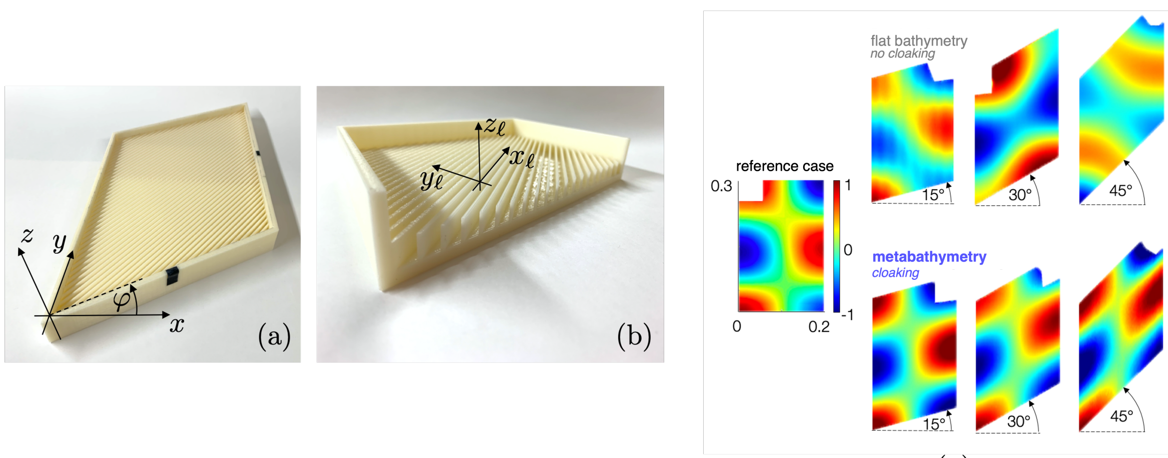

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Figure 1: (a) Irregular cavity with metabathymetry. (b) Side view of the metamaterial cavity with metabathymetry consisting of stratified structure at a subwavelength scale (c) Example of experimental results - elevation of the free surface $\tilde{\eta}(x,y)$ of the cavity's fifth eigenmode for different deformation angles $\varphi$, for the flat bathymetry (top right), and for the metabathymetry (bottom right). (left) The reference cavity ($\varphi = 0°$).

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