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Cavitation Threshold Sensitivity to Nuclei in Accelerated Liquids

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ABSTRACT

Cavitation plays a crucial role in many fluid systems subject to pressure variations, with applications in hydraulic machinery, biological fluids, and auto-injector devices. The cavitation number is commonly used as a nondimensional parameter to assess the likelihood of cavitation under given pressure conditions. Previous studies on accelerated liquid environments revised the conventional cavitation number to account for the effects of unsteady motion. Despite these efforts, the cavitation number does not account for the presence of pre-existing microscopic nuclei. These weaknesses in the liquid are thought to be the principal driver of cavitation for environments governed by a mechanism of heterogeneous nucleation. This study investigates the sensitivity of the cavitation number to nuclei populations in accelerated liquids. Experiments are conducted using a tube arrest apparatus, where a liquid-filled container undergoes sudden deceleration, generating pressure waves that create localized low-pressure regions, leading to cavitation in the bulk liquid. The nuclei population is approximated by measurement of acoustic attenuation over a range of frequencies and adjusted by sonication and degassing. To characterize the pressure field, a spring-mass model is employed, capturing both the bulk motion of the liquid and the wave dynamics. Phase maps of cavitation numbers are analyzed with respect to the choice of critical pressure. The results of this work indicate that considering nuclei population as a parameter may provide useful refinements to cavitation studies in accelerated environments that traditionally rely on the cavitation number alone.