Investigation of Ultrasonic Wave Scattering Effects using Computational Methods

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Abstract

Advances in computational power and expanded access to computing clusters has made mathematical modeling of complex wave effects possible. We have used multi-core and cluster computing to implement analytical and numerical models of ultrasonic wave scattering. We investigate wave behavior in fluid and solid media (acoustic and elastic waves). We begin by implementing complicated analytical equations that describe the force upon spheres immersed in inviscid and viscous fluids due to an incident plane wave. Two real-world applications of acoustic force upon spheres are investigated using the mathematical formulations: emboli removal from cardiopulmonary bypass circuits using traveling waves and the micromanipulation of algal cells with standing waves to aid in biomass processing for algae biofuels. We then move on to consider wave scattering situations where analytical models do not exist: scattering of acoustic waves from multiple scatterers in fluids and Lamb wave scattering in solids. We use a numerical method called finite integration technique to simulate wave behavior in three dimensions. The 3D simulations provide insight into experimental results for situations where 2D simulations would not be sufficient. The diverse set of scattering situations explored in this work show the broad applicability of the underlying principles and the computational tools that we have developed. Overall, our work shows that the movement towards better availability of large computational resources is opening up new ways to investigate complicated physics phenomena.