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Sound Scattering by Thin Shells: Are the Thin-Shell and Thick-Shell Theories Consistent?

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Analytical description of scattering of underwater sound by shells is complicated and leads to rather cumbersome equations, the physical implications of which are not immediately obvious. The well-established thin shell theory [1] offers valuable simplifications of the equations of shell vibrations in the acoustic field and the resulting mathematical model of sound scattering. However, a recent application of the thin-shell theory to sound scattering by spherical balloons in the context of passive suppression of underwater noise [2] revealed that some predictions of the thin-shell model are unphysical and can be misleading in the selection of shell materials for noise suppression. Moreover, the thin-shell theory fails to reproduce the thin-shell limit of the sound scattering by thick spherical shells in the particular cases previously considered by Goodman and Stern [3] and McNew et al. [4]. This paper re-derives from the first principles the equations of motion of thin, fluid-loaded spherical shells. The scattering amplitudes calculated using the corrected thin-shell theory are shown to reduce to exact solutions in several test cases and agree with the corresponding limit of the thick-shell theory predictions.

Keywords: ICTCA 2023; noise suppression; spherical shell; sound scattering.

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