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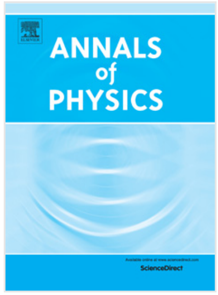

Acoustic scattering of a Bessel vortex beam by a rigid fixed spheroid

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Acoustic scattering of a Bessel vortex beam by a rigid fixed spheroid

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Abstract – Partial-wave series representation of the acoustic scattering field of high-order Bessel vortex beams by rigid oblate and prolate spheroids using the modal matching method is developed. The method, which is applicable to slightly elongated objects at low-to-moderate frequencies, requires solving a system of linear equations which depends on the partial-wave index n and the order of the Bessel vortex beam m using truncated partial-wave series expansions (PWSEs), and satisfying the Neumann boundary condition for a rigid immovable surface in the least-squares sense. This original semi-analytical approach developed for Bessel vortex beams is demonstrated for finite oblate and prolate spheroids, where the mathematical functions describing the spheroidal geometry are written in a form involving single angular (polar) integrals that are numerically computed. The transverse ($\theta = \pi/2$) and 3D scattering directivity patterns are evaluated in the far-field for both prolate and oblate spheroids, with particular emphasis on the aspect ratio (i.e., the ratio of the major axis over the minor axis of the spheroid) not exceeding 3:1, the half-cone angle β and order m of the Bessel vortex beam, as well as the dimensionless size parameter kr_0. Periodic oscillations in the magnitude plots of the far-field scattering form function are observed, which result from the interference of the reflected waves with the circumferential (Franz') waves circumnavigating the surface of the spheroid in the surrounding fluid. Moreover, the 3D directivity patterns illustrate the far-field scattering from the spheroid, that vanishes in the forward ($\theta = 0$) and backwards ($\theta = \pi$) directions. Particular applications in underwater acoustics and scattering, acoustic levitation and the detection of submerged elongated objects using Bessel vortex waves to name a few, would benefit from the results of the present investigation.

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