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Using acoustic streamlines to visualize energy flow across boundaries

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For spherical waves that radiate from a point source in a homogeneous fluid and propagate across a plane boundary into a dissimilar homogeneous fluid, the acoustic field may differ significantly from the geometric acoustics approximation if either the source or receiver is near the interface (in terms of acoustic wavelengths) or if the minimum-phase path is near the critical angle. Cross-boundary energy flow from a continuous-wave point source is visualized by tracing acoustic streamlines: those curves whose tangent everywhere is the average acoustic intensity vector. It is seen that the acoustic energy flow is not always in line with the "Snell's law" or minimum-phase ray path. Also, acoustic energy streamlines do not display unusual behaviour in the vicinity of the critical angle. Finally, it is shown that there exists a law of refraction of acoustic energy streamlines across density discontinuities, analogous to Snell's law of refraction of ray paths across sound speed discontinuities. Examples include water-to-seabed transmission and water-to-air transmission. [Work supported in part by ONR Code 32]