Invisibility cloaking to shield floating objects from waves

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A new approach to invisibility cloaking may one day be used at sea to shield floating objects – such as oil rigs and ships – from rough waves. Unlike most other cloaking techniques that rely on transformation optics, this one is based on the influence of the ocean floor's topography on the various "layers" of ocean water.

At the American Physical Society's (APS) Division of Fluid Dynamics (DFD) meeting, being held November 18-20, 2012, in San Diego, Calif., Reza Alam, assistant professor of mechanical engineering at the University of California, Berkeley, will describe how the variation of density in ocean water can be used to cloak floating objects against incident surface waves.

"The density of water in an ocean or sea typically isn't constant, mainly because of variations in temperature and salinity," explains Alam. "Solar radiation heats the upper layer of the water, and the flow of rivers and the melting of ice lowers the water density near the surface. Over time, these effects add up to form a stable density stratification of two layers – with the lighter fluid layer on top and the more dense fluid layer below it."

Stratified waters, much like regular surface waves, contain "internal waves," which are gravity waves that propagate between the two layers of water. For the same frequency of oscillation, however, internal waves travel at a much shorter wavelength and slower speed than surface waves.

Both wave types "feel" the ocean floor's influence, which generates an energy transfer.

Zeroing in on this energy transfer, Alam used computer simulations to transform a surface wave into internal wave as it approaches an object – meaning that the wave will pass beneath the object rather than crashing into it. And once the internal wave moves beyond the object, it can be transformed back into a surface wave.

This would be achieved by creating "corrugations" or wavy ripples that are tuned to a specific wavelength on the ocean floor in front of the floating object to be cloaked.

"Cloaking in seas by modifying the floor may play a role in protecting near-shore or offshore structures and in creating shelter for fishermen during storms," says Alam. "In reverse, it can cause the disappearance and reappearance of surface waves in areas where sandbars or any other appreciable bottom variations exist."

More information: meeting.aps.org/Meeting/DFD12/APS_epitome

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