Resonance of a floating object in a wave field

Wilson Reino[1,2], Sébastien Kuchly[3], Stéphane Perrard[3], Giuseppe Pucci[2], Antonin Eddi[3]

[1] Dipartimento di Fisica, Università della Calabria, Via P. Bucci, Cubo 31C, 87036 Rende (CS), Italia.
[2] Consiglio Nazionale delle Ricerche - Istituto di Nanotecnologia (CNR-NANOTEC), Via P. Bucci 33C, 87036 Rende (CS), Italy.
[3] PMMH, CNRS, ESPCI Paris, Université PSL, Sorbonne Université, Université de Paris Cité, F-75005, Paris, France.
`wilson.reino.c@gmail.com`

The evolution of the Earth's climate is causing a gradual decline in sea ice coverage in the Arctic and Antarctic. As the ice diminishes, it becomes increasingly vulnerable to environmental stresses such as winds, ocean currents, and waves. These factors contribute to ice fracturing and to the formation of the Marginal Ice Zone (MIZ), a complex region where various physical phenomena occur, including ice floes, clusters, and wave damping among others [1,2]. Studying how a single floe deflects and attenuates incoming waves provides valuable insights into the complex processes governing the evolution of the marginal ice zone and their implications for the climate.

We designed a laboratory-scale experiment using floating plastic cylinders that simulate ice floes. Each cylinder behaves as a dynamic resonator within the wave field, absorbing energy from surrounding waves. We analyzed the interaction between surface waves and the floating object using Fast Checkerboard Demodulation (FCD), a surface reconstruction technique that extracts the pixel displacement field from a sequence of images, and enables surface topography reconstruction via the refraction at the air-liquid interface [3,4].

We determined the resonance frequency of the floating cylinders through controlled impacts and analyzed their impulsive response in terms of the generated wave field. We mapped out the resonance frequency as a function of height and radius of the cylinders. We then explored the behavior of these plastic ice floe while interacting with incoming waves generated by a linear motor. By systematically varying the frequency of incoming waves, we quantified the response wave field generated by the floating object, identified by its maximum wave amplitude. Remarkably, we observed a distinct attenuation in this response wave field in the vicinity of the previously determined resonance frequency, indicating minimal wave generation by the floating object approximately at these frequencies. Furthermore, in this same regime the waves experienced minimal deviation near the cylinders compared with other frequencies.

These observations suggest efficient energy transmission to the object's motion when the incoming waves oscillate at the object's resonance frequency, resulting in minimal wave generation by the plastic floes when they interact with incoming waves.

References

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