Oil Film Position Control via Phase-controlled Water Waves Induced by a Honeycomb-Structured Oscillator

Lee, Yeonho (School: Seoul Science High School)
Choi, Eugene (School: Seoul Science High School)

Purpose: Oil spills cause severe damage to marine life and ecosystems. In this research, we attempted to develop an efficient method that can control oil film movement and therefore manage oil spills. We tested the hypothesis that oil films reach static equilibrium at the antinodes of water waves. Procedure: Water waves were generated by vertically oscillating wave sources arranged in a lattice. A honeycomb lattice was employed because its interference patterns have two modes per unit cell, enabling diverse physical phenomena and precise control of node and antinode positions. By introducing a phase difference between wave sources in each sublattice of the honeycomb lattice, various water waves with different wave patterns were produced. The motion of a 1-cm-scale oil film was observed and analyzed using a Python-based tracking program. We also theoretically calculated the velocity potential and obtained the wave profiles using Wolfram Mathematica. Results: Static equilibrium of the oil film was observed when the unit cell vector length was 9 cm, the driving frequency was 7 Hz, and the phase difference between sublattices was 180 degrees. By comparing the theory and the experiment, we found that this equilibrium point coincides with the antinode positions of the water wave. Conclusions: Our findings partially verified the hypothesis that oil films can be trapped at antinodes of water waves. This study provides insight into wave-driven transport of oil films and improves understanding of complex fluid systems. Furthermore, this study suggests potential application of the phenomenon as a response strategy for oil spills.

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