Quantum-Classical Analogies of Wave Phenomena in Surface Gravity Waves

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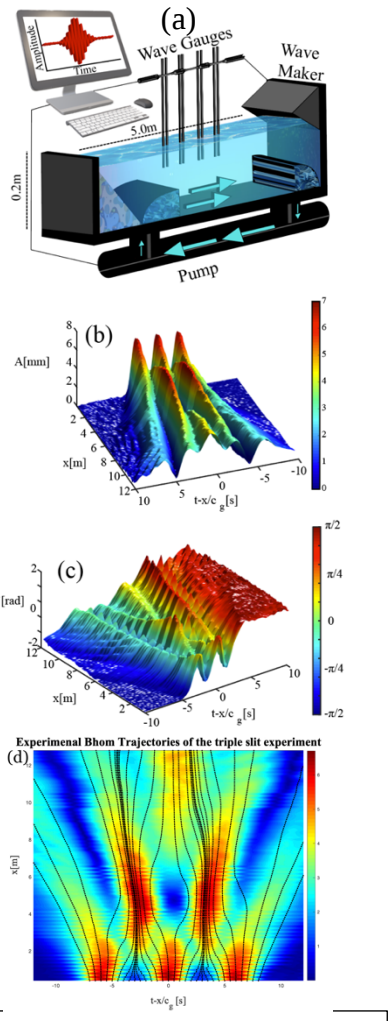
The time evolution of a wave function in quantum mechanics is analogous to that of surface gravity deep water wave pulses along the propagation coordinate. Moreover, an effective linear potential can be infused in the water tank using a computer-controlled pump. This experimental setup represents the hydrodynamic analog to a freely falling quantum mechanical particle in a gravitational potential. Recently, we have measured for the first time the cubic *Kennard phase* predicted in 1927 [1] for both Gaussian and Airy wave packets [2,3].

Inspired by these successful experiments, we now explore other analogies between quantum mechanics and gravity water waves, for instance, the propagation of periodic input wave packets, also known as the quantum Talbot carpets, and Bohm trajectories.

The de Broglie–Bohm theory, being an alternative interpretation with respect to the Copenhagen interpretation of quantum mechanics, assumes that the propagation dynamics (in time or in space) can be obtained by forming a potential, which is determined by the wave function and guides particles along specific trajectories. The Bohm trajectories for a single photon in a two-slit experiment have been studied earlier in weak value measurements [4]. Here instead we utilize the full knowledge (both amplitude and phase) of the wave function at each location in the tank and derive the Bohm trajectories for the cases of the single-, double- and triple-slit experiment.

In my talk, I will explain in detail the intriguing analogy between surface gravity water waves and quantum mechanics, present our setup and experimental observations of the Kennard phase, quantum Talbot carpets, and Bohm trajectories.



(a) Experimental setup for generating and measuring different wave packets in water tank. (b) Amplitude of 3-lobe quantum carpet analog. (c) Phase of quantum carpet analog. (d) The Bohm trajectories for the triple lobe experiment.

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