Emulating black holes using surface gravity waves

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It is the occurrence of a logarithmic phase singularity in the proximity of a horizon that lies at the heart of Hawking and Unruh radiation. Recently, these effects have been related to a simple quantum system with a parabolic barrier [1]. Here we demonstrate experimentally that freely propagating waves can also display a horizon and a logarithmic phase singularity. While black hole singularities have already been related to various analog systems, such as hydraulic and acoustic black holes, as well as thermal BEC black holes [2]. In contrast to these experiments, our results indicate that a simple physical system is sufficient to provide fundamental insights into a very complex problem. We tackle this problem by utilizing Weber wave packets, which are the eigenstates of the inverted harmonic oscillator system. An interesting observation is that even without a potential, an initial state that is an energy eigenstate of the inverted harmonic oscillator (i.e., a Weber wave packet) would evolve in free space until it reaches an amplitude singularity, accompanied by a logarithmic phase singularity. These experiments predict that similar physics can be observed for optical, acoustic, and matter waves [3]. In my talk, I will review the intriguing analogies between quantum mechanics, surface gravity waves, and optical systems, as well as present our latest results on several topics, and discuss new measurements and directions.

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