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Gravitational Waves and Black Hole perturbations in Acoustic Analogues

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In 1981 Bill Unruh established an analogy between hydrodynamic flow with a supersonic region and a black hole, initiating the research field of analogue gravity. One possibility to exploit this hydrodynamics/gravity analogy is to create analogue black holes within Bose-Einstein condensates. At sufficiently low temperatures, phonons, which are low-energy collective excitations of the condensate, propagate as a massless scalar field on an emergent acoustic metric tensor. This metric tensor, in turn, is determined by the characteristics of the condensate. Specifically, an acoustic black hole is created by a transonic fluid, and concepts like the event horizon are applicable. At this acoustic horizon, quantum fluctuations result in a thermal radiation of phonons, which is the acoustic equivalent of Hawking radiation. Remarkably, this emission near the acoustic horizon has been simulated numerically and verified experimentally with atomic Bose-Einstein condensates.
This talk builds upon the above field of research in analogue gravity: the goal is to design a system where an acoustic horizon is excited by a gravitational wave-like perturbation. As a first step, I will present a way to reproduce a gravitational wave perturbation on a flat background acoustic metric emergent from a Bose-Einstein condensate. Secondly, I will demonstrate how to realize an impinging gravitational wave-like perturbation to an acoustic horizon. Then, I will show how the horizon of the above system is perturbed by such an analogue gravitational wave. Finally, possible implications and perspectives stemming from this work are discussed, including the study of reflectivity, quasi-normal modes, shear viscosity and entropy density of a perturbed acoustic horizon. Notably, all these interesting research directions could be probed in a real experiment performed, for example, in ultra-cold quantum gas platforms.

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