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Black–hole lasing action in laboratory Bose–Einstein condensates

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A recent experiment [1] infers the the production of Hawking radiation in an analogue black-hole laser, which consists of a Bose-Einstein condensate of about 5,000 ^{87}Rb atoms in a trap with a translating potential step. In the co-moving reference frame the flow velocity of the condensate exceeds the sound speed in a region confined between two sonic points, the analogue black and white hole horizons. We report simulations of that experiment based on the zero-temperature Gross-Pitaevskii (GP) equation that are consistent with the reported experimental results. The simulations show exponential growth of oscillatory modes trapped between the horizons, with a power spectrum consistent with expectations from the Bogoliubov dispersion relation, which saturates after an initial period. Quantum Hawking radiation occurs spontaneously in the vacuum, but in the presence of a coherent state of phonons it takes on a classical form captured by the zero-temperature GP equation. The growth of the trapped modes results from repeated super-radiant scattering from the black hole horizon, associated with emission of Hawking radiation to the exterior that is not well-resolved in the simulation.

[1] J. Steinhauer, *Nature Physics* **11**, 864 (2014)

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