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The influence of spacetime curvature on spontaneous emission in optical analogues to gravity

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Quantum vacuum fluctuations on curved spacetimes cause the emission of entangled pairs. The most remarkable instance of this effect is Hawking radiation from black hole horizons, which can however not be observed in astrophysics. Fortunately, it is possible to recreate the kinematics of waves on curved spacetimes in the laboratory to study horizon emission. Here we investigate and demonstrate the role of laboratory horizons for the production of entangled pairs. We develop a field theoretical description based on an optical analogue system in the Hopfield model to calculate the scattering matrix that completely describes mode coupling leading to the emission of pairs in various kinematic configurations. We find that horizons lead to an order of magnitude increase in the pair production, a simplification and increase of the quantum correlations, and a characteristic shape of the emission spectrum. The findings clarify a number of open questions towards the detection of the Hawking effect in these dispersive systems. Furthermore, they will be relevant in numerous optical and non-optical systems exhibiting horizons.

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