Intuitive Idea and Summary of the Main Result

We present a description of the Hawking effect as a local process using the tunneling picture. In this framework, the Hawking particle tunnels through the horizon on a complex path. Following the example of the black hole, the tunneling picture allows to generalise the Hawking effect to all dynamical trapping horizons. The idea is to identify the classically forbidden direction of horizon crossing which differs from setup to setup. Although classically not allowed, this direction might serve as a tunneling path for the Hawking effect. Pursuing this logic further, we find that the Hawking effect manifests itself as an absorption for past outer horizons (e.g. white holes) and future inner horizons (e.g. inner horizons of black holes) and is confirmed to be an emission for future outer horizons (e.g. black hole horizon) and past inner horizons (e.g. Hubble sphere).

Thermality of Quantum Effects

**Principle:** The Hawking effect describes horizon crossings on imaginary paths which are classically forbidden but quantum-theoretically allowed. ⇒ Sufficient and necessary to perceive a Hawking effect: \( \text{Im}(S_\omega) > 0 \).

To assign a temperature one needs to look careful at the process itself. Consider the production of a Hawking pair: particle with \( \omega > 0 \) and partner particle with \( \omega < 0 \).

**Comparison of \( WKB \) with the Boltzman distribution \( \rho_B(E) = e^{-E/T} \):**

\( \Gamma \sim e^{\text{sign}(\omega)\text{sign}(S_\omega)} - 1 \) probability of having a particle less at fixed \( E \) is suppressed.

For inner horizons \( \kappa_{H} < 0 \) but a compensating sign arises from the changed direction of the tunneling path.

**Absorption:** Counting less particles with \( \omega > 0 \) in the normal region ⇔ tunneling of partner with \( \omega < 0 \) in the normal region (FITH/PITH).

Prospective of having a particle less at fixed \( E \) is suppressed.

Note: The legitimacy for a thermal interpretation roots in the QFT description. Whenever a certain horizon is present the state will acquire thermal properties (KMS state). The dynamics of the horizon create additional terms in \( \text{Im}(S_\omega) \) which depart from an equilibrium configuration.

Illustrations

Illustration of the Hawking process: Blue arrows denote the classically allowed direction, while red ones the forbidden ones. Dashed blue paths symbolise complexified (tunneling) paths of the Hawking effect.

Conclusions

⇒ The tunneling picture allows to describe the Hawking effect as a local phenomenon which is generalisable for dynamical horizons.

⇒ All dynamical horizons are subjected to a Hawking process with positive temperature \( T = k_{H}/2\pi \).

⇒ Quantum effects across horizons can be unified within the tunneling picture.

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