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An order-unity correction to Hawking radiation

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When a black hole first forms, the properties of the emitted radiation as measured by observers near future null infinity are very close to the 1974 prediction of Hawking. However, deviations grow with time, and become of order unity after a time $t \sim M_i^{7/3}$, where M_i is the initial mass in Planck units. After an evaporation time the corrections are large: the angular distribution of the emitted radiation is no longer dominated by low multipoles, with an exponential falloff at high multipoles. Instead, the radiation is redistributed as a power law spectrum over a broad range of angular scales, all the way down to the scale $\Delta\theta \sim 1/M_i$, beyond which there is exponential falloff. This effect is is a quantum gravitational effect, whose origin is the spreading of the wavefunction of the black hole's center of mass location caused by the kicks of the individual outgoing quanta, discovered by Page in 1980. The modified angular distribution of the Hawking radiation has an important consequence: the number of soft hair modes that can effectively interact with outgoing Hawking quanta increases from the handful of modes at low multipoles l, to a large number of modes, of order $\sim M_i^2$. We argue that this change removes on of the primary objections to the Hawking-Perry-Strominger proposed mechanism for purifying the Hawking radiation.

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