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Jordan Wilson-Gerow - Decoherence by warm horizons

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Recently Danielson, Satishchandran, and Wald (DSW) have shown that quantum superpositions held outside of Killing horizons will decohere at a steady rate. This occurs because of the inevitable radiation of soft photons (gravitons), which imprint an electromagnetic (gravitational) "which-path" memory onto the horizon. Rather than appealing to this global description, an experimenter ought to also have a local description for the cause of decoherence. One might intuitively guess that this is just the bombardment of Hawking/Unruh radiation on the system, however simple calculations challenge this idea – the same superposition held in a finite temperature inertial laboratory does not decohere at the DSW rate. In this work we provide a local description of the decoherence by mapping the DSW set-up onto a worldline-localized model resembling an Unruh-DeWitt particle detector. We present an interpretation in terms of random local forces which do not sufficiently self-average over long times. Using the Rindler horizon as a concrete example we clarify the crucial role of temperature, and show that the Unruh effect is the only quantum mechanical effect underlying these random forces. A general lesson is that for an environment which induces Ohmic friction on the central system (as one gets from the classical Abraham-Lorentz-Dirac force, in an accelerating frame) the fluctuation-dissipation theorem implies that when this environment is at finite temperature it will cause steady decoherence on the central system. Our results agree with DSW and provide a complementary local perspective.

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