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Gravitational Holography

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The asymptotic number of states in an appropriately defined region in any theory of quantum gravity which reduces to Einstein gravity at large distances is equal to one quarter of the area in Planck units. A non-redundant description therefore requires only a hologram at the boundary of the region. The holographic properties of the states in quantum gravity lead to a mixing of the usual concepts of ultraviolet and infrared. This mixing is at odds with various properties of local quantum field theory such as the Heisenberg uncertainty relation as well as the upper bound on the fixed angle inclusive cross section in very high energy collisions. The holographic properties of gravity also imply that quantum contributions to the vacuum energy are finite and parametrically at most of order the classical value from which the infrared curvature scale is determined. Gravitational holography therefore provides a technically natural solution to the cosmological constant problem which plaques any local quantum field theory description of gravity.