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The S-matrix and Infrared Divergences in Quantum Gravity GAUTAM SATISHCHANDRAN, ROBERT WALD, University of Chicago — We study the construction of an "infrared finite" S-matrix in Quantum Gravity. Infrared divergences in Quantum Gravity (and QFT) are a direct consequence of a classical observable known as the Memory Effect. The memory effect implies that "out" scattering states live in an uncountably infinite set of unitarily inequivalent Hilbert spaces (one for each memory effect). In order to construct an "IR finite" S-matrix we seek a "in" and "out" Hilbert space of scattering states which is (1) separable, (2) invariant under the asymptotic symmetry group and (3) preserved under scattering. The analogous problem in QED is solved by building a Hilbert space of "dressed states". We clarify that this procedure fails in Quantum Gravity and we argue that, in contrast to QED, there is no natural Hilbert space of "in" and "out" scattering states in any IR finite description of Quantum Gravity. Nevertheless, the "in" and "out" Algebra of Observables are well defined and, in the absence of a preferred Hilbert space, an IR finite description of Q.G. requires the formulation of an "S matrix" as a map on algebraic states. We present some progress towards this construction.

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