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Probing the Big Bang with Quantum Fields

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The singularity theorems of Penrose and Hawking are based on geodesic incompleteness and predict the occurrence of classical singularities under rather general circumstances. In general relativity, these singularities represent absolute boundaries where space-time ends.
Physically, however, this criterion refers to the fate of point like classical test particles. We raise the question: What if one uses quantum fields instead? Intuitively, quantum probes are much more fundamental and bear a richer structure. We will begin with the proof that one can unambiguously evolve quantum fields across them in a rigorous sense. Thus when probed with quantum fields, the big bang is not an absolute boundary where physics breaks down. Additionally we will discuss the behavior of composite operators such as the expectation values of renormalized products of fields and the renormalized stress-energy tensor and show that they too remain well-defined as distributions.
The overall conclusion is twofold: first quantum mechanical considerations provide more refined tools to probe classically singular structures, and second, the big bang singularity of classical general relativity is tamer when seen from a quantum perspective.

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