Quantum strong energy inequality and the Hawking singularity theorem

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Hawking's singularity theorem concerns matter obeying the strong energy condition (SEC), which means that all observers experience a nonnegative effective energy density (EED), thereby guaranteeing the timelike convergence property. However, all quantum fields violate the SEC. Therefore there is a need to develop theorems with weaker restrictions, namely quantum inequalities, weighted local averages of energy densities. We have derived a lower bound of the EED in the presence of the non-minimally coupled quantum scalar field. This bound takes the form of a state-dependent quantum energy inequality valid for the class of Hadamard states. Finally, we discuss how this lower bound is applied to prove a Hawking-type singularity theorem asserting that, along with sufficient initial contraction at a compact Cauchy surface, the spacetime is future timelike geodesically incomplete. The talk is based on: 10.1103/PhysRevD.99.045001 and a manuscript in preparation.