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Quantum effects in cosmological free-streaming

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We calculate the energy density and pressure of a scalar field after its decoupling from a thermal bath in the spatially flat Friedman–Lemaître–Robertson–Walker space-time, within the framework of quantum statistical mechanics. By using the density operator determined by the condition of local thermodynamic equilibrium, we calculate the mean value of the stress-energy tensor of a real scalar field by subtracting the vacuum expectation value at the time of the decoupling. If the expansion rate is comparable or larger than mass or the decoupling temperature, both energy density and pressure get strong quantum corrections which substantially modify their classical dependence on the scale factor a(t) and drive pressure to large negative values.

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