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Quantum-Origin of the Matter-Antimatter Asymmetry

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The standard models of particle physics and cosmology imply the absence of a sizable matter-antimatter asymmetry in the very early universe. Its existence, essential for the subsequent evolution of the universe, represents a major puzzle of present-day physics. Leptogenesis addresses this issue in an elegant way and can be realized in many standard model extensions. In this scenario a quantum interference in the lepton number violating decay of new heavy states leads to CP-violation. If the rapid expansion of the universe contributes a deviation from equilibrium this setting allows for the formation of an asymmetry. Remarkably, despite of the quantum-origin of this phenomenon, current computations are mostly still based on traditional Boltzmann equations. Newer calculations start from non-equilibrium quantum field theory since it allows to describe the quantum field theoretical interference and the different kinetic processes in the early universe in a consistent way. It accounts for finite density effects which have been shown to yield relevant corrections in the limit of hierarchical heavy neutrino masses. If these additional heavy states reside at the TeV scale leptogenesis is still viable provided that the self-energy contribution to the asymmetry is resonantly enhanced, i.e. if their masses are degenerate. In this case particular attention needs to be paid to the computation of the asymmetry as Boltzmann equations are in general not applicable.

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