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Unitarity, thermal corrections, and higher-order CP asymmetric reaction rates in leptogenesis

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We present novel diagrammatic methods for perturbative asymmetry calculations and the inclusion of thermal corrections. Unlike the standard approach based on Cutkosky rules, the unnatural splitting of the amplitude into couplings and imaginary parts of the loop integrals is avoided. Moreover, the presented framework allows for a unified treatment of the usual asymmetries and real-intermediate-state-subtracted reaction rates (traditionally introduced to avoid double-counting in the Boltzmann equation). The S-matrix unitarity and CPT symmetry constraints between the asymmetries of different reactions are derived systematically at any order in coupling constants. They remain valid even when thermal corrections are taken into account via winding the propagators in Feynman diagrams on a cylindrical surface before the cutting is performed. The resulting thermally corrected source-term for the lepton number asymmetry is equivalent to the outcome of the closed-time-path formalism of non-equilibrium quantum theory. As an example, we use the asymmetric reaction rates in the seesaw type-I leptogenesis to demonstrate how the method works. The talk is primarily based on arXiv:2104.06395, arXiv:2102.05914.

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