Introduction to finite temperature quantum field theory

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This course offers an introduction to thermal field theory (TFT), the extension of quantum field theory to systems at finite temperature. Beginning with a review of quantum statistical mechanics, it develops the imaginary-time (Matsubara) formalism to describe scalar and gauge fields in a thermal background. Topics include the computation of thermal propagators and self-energies, the appearance of thermal masses and Debye screening, and the emergence of collective plasma modes. The limitations of naive perturbation theory and the formulation of Hard Thermal Loop resummations are discussed in detail. Applications to QED, QCD, and early-universe cosmology illustrate how TFT provides the theoretical foundation for understanding hot quantum matter from the quark–gluon plasma to cosmological phase transitions.