# HTL-Resummation of the Thermodynamic Potential

A. Peshier

*BNL, Bldg. 510A, Upton, NY 11973, USA*

*Presented by:* A. Peshier

**Abstract**

Due to their asymptotic nature, the accuracy of perturbative approximations cannot be improved, at large coupling, by higher-order terms. Therefore, nonperturbative approaches are required to describe, e. g., the thermodynamics of the quark-gluon plasma, as considered here, in the regimes of physical interest. Diagrams of all orders in the coupling, organized in thermodynamically selfconsistent sets, can be resummed in the so-called $\Phi$-derivable approximation scheme for the thermodynamical potential and the propagators. In the leading-loop order and approximating the propagators by their hard-thermal-loop (HTL) contributions, at the expense of exact selfconsistency, an expression for the QCD thermodynamical potential is derived which is gauge-invariant, UV-finite and consistent with the perturbative result to order $\mathcal{O}(g^2)$. By comparison to the scalar theory, which in the leading-loop approximation can be resummed selfconsistently, it is argued that the thermodynamical potential expressed in terms of the propagators comprises information not contained in a corresponding expression for the entropy derived recently by Blaizot et al. This explains, in particular, why the HTL-resummed approximation cannot reproduce the QCD lattice data below twice the transition temperature $T_c$. On the other hand, the agreement with the data above $2T_c$ is a remarkable improvement of the conventional perturbative results which are not predictive even orders of magnitude above $T_c$. This fact encourages the application of the approach for questions not yet tractable by lattice calculations, as for the equation of state at nonzero chemical potential.

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