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# Propagators and phase structure of $N_f = 2$ and $N_f = 2 + 1$ QCD

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We study quantum chromodynamics (QCD) at finite temperature $T$ and chemical potential $\mu$ by solving the Dyson-Schwinger equations (DSEs) for the quark and gluon propagators.

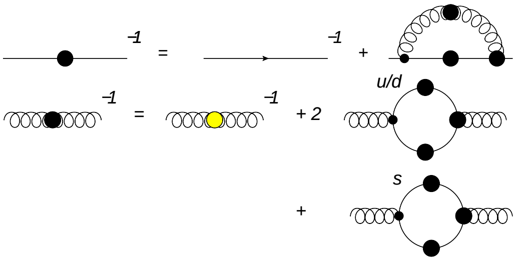


Figure 1: The coupled system of Dyson-Schwinger equations for the quark (upper line) and gluon (lower line).

This set of equations is shown in Fig. 1, where we show the quark DSE in the upper line and the gluon DSE in the lower line. For the gluon we use an approximation where the Yang-Mills part of the equation is substituted by quenched gluon propagators obtained from lattice simulations [1]. To account for unquenching effects, we add the quark loop as it appears in the gluon DSE. This truncation has been introduced in Ref. [2] with bare quarks in the quark loop, and with fully dressed light and strange quarks in Ref. [3]. This is the first $N_f = 2 + 1$ calculation in the Dyson-Schwinger framework of QCD.

From solutions of the DSEs we can extract the quark condensate and the dressed Polyakov loop order parameters for chiral symmetry breaking and confinement. The chiral condensate, shown in Fig. 2 at $\mu = 0$ is in good agreement with lattice data [4] for $2 + 1$ flavours. This is only possible when the back-reaction of quarks and gluons is carefully taken into account, since this leads to a steeper crossover compared to simpler truncations. From the condensate we identify the (pseudo-)critical temperature as a function of $\mu_q$. At $\mu_q \approx 190$ MeV we find a critical end-point. The position of this point is again strongly affected by the back-reaction of quarks and gluons.

From the dual condensate we extract a pseudo-critical temperature for the deconfinement transition. This transition always stays close to the chiral transition, with almost equal transition temperatures above $\mu_q \approx 125$ MeV. Our findings are summarised in the phase diagram shown in Fig. 3. We also show results for two flavours. The impact of strange quarks is evidently a reduction of $T_c$ by almost 50 MeV, while the relative position of the critical end-point is hardly affected.

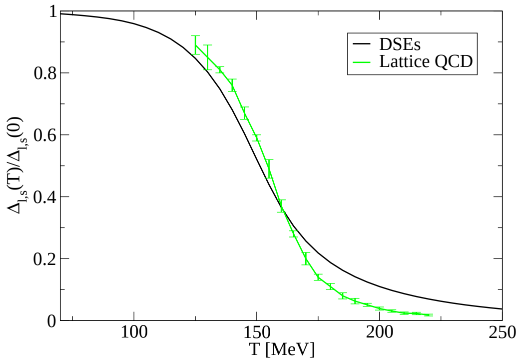


Figure 2: The condensate compared to lattice data.

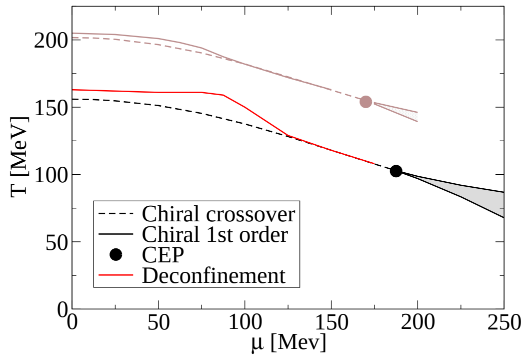


Figure 3: The resulting phase diagram for $N_f = 2 + 1$ and $N_f = 2$ (lighter colours).

## References

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[4] S. Borsanyi *et al.* JHEP **1009** (2010) 073