TOWARDS A CONTROLLED STUDY OF THE QCD CRITICAL POINT

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The phase diagram of QCD, as a function of temperature T and baryon chemical potential μ_B, may contain a critical point (μ_E, T_E) whose non-perturbative nature makes it a natural object of lattice studies. However, the sign problem prevents the application of standard Monte Carlo techniques at non-zero baryon density. We have been pursuing an approach free of the sign problem, where the chemical potential is taken as imaginary and the results are Taylor-expanded in μ/T about $\mu = 0$, then analytically continued to real μ [1,2].
Within this approach we have determined the curvature of the pseudo-critical temperature $dT_c/d\mu^2|_{\mu=0}$, which we can compare to the experimentally determined freeze-out curve [3].
We have also determined the sensitivity of the critical chemical potential μ_E to the quark mass, $d(\mu_E)^2/dm_q|_{\mu_E=0}$. Our study indicates that the critical point moves to *smaller* chemical potential as the quark mass *increases* [3,4]. This finding, contrary to common wisdom, implies that the deconfinement crossover, which takes place in QCD at $\mu = 0$ when the temperature is raised, will remain a crossover in the μ-region where our Taylor expansion can be trusted. If this result, obtained on a coarse lattice, is confirmed by simulations on finer lattices now in progress, then we predict that no *chiral* critical point will be found for $\mu_B \lesssim 500$ MeV, unless the phase diagram contains additional transitions.

References

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