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Lattice QCD and the phase diagram of strong interaction matter

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In the chiral limit strong interaction matter undergoes a phase transition from a low temperature, chiral symmetry broken phase to a chirally symmetric high temperature phase - the quark gluon plasma. Although there seems to be compelling evidence from lattice QCD calculations that this transition is second order, it is a theoretical issue that still is not settled unambiguously. Similarly it is an open question whether at physical values of the light and strange quark masses the pseudo-critical (crossover) transition at vanishing baryon number density turns into a true second order phase transition at non-zero baryon number density. Finding evidence for or against the existence of this QCD critical point is one of the most challenging problems in current theoretical and experimental studies of the QCD phase diagram.

The chiral phase transition at vanishing values of the light quark masses as well as the elusive critical point at non-zero net baryon number density can be studied in lattice QCD simulations through the analysis of net baryon number, electric charge and strangeness fluctuations as well as correlations among these conserved quantum numbers. We will present recent progress made in the calculation of these observables, compare these calculations with measurements of proton and electric charge fluctuations in heavy ion collision experiments and discuss consequences for the QCD phase diagram at vanishing and non-vanishing net baryon number densities.

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