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Bulk Properties and Collective Flow of Quark Gluon Plasma[1]

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Quantum Chromodynamics predicts a transition from a hadronic phase at temperatures less than 150-200 MeV to a quark gluon plasma phase at higher temperatures. Lattice calculations show a big increase in the entropy density in this vicinity. Whether the transition is first or second order or a smooth rapid crossover depends upon the values of the up, down and strange quark masses. The goal of the heavy ion experimental program at RHIC is to observe this transition and to study the nature of the quark gluon plasma quantitatively. Two big surprises arose from these experiments: Substantial collective flow has been observed, as evidenced by single-particle transverse momentum distributions and by azimuthal correlations among the produced particles, and the degree to which high energy jets are attenuated in the produced matter. A variety of theoretical models of these collisions require initial energy densities more than a factor of 10 greater than in neutron star cores and more than a factor of 100 greater than within atomic nuclei. Taken together this body of work implies a strongly interacting phase of quarks and gluons beyond the capabilities of perturbation theory. This has motivated approaches based on gauge theories with gravity duals where physical observables may be calculated in a strong coupling limit. This in turn has stimulated interest from members of the string theory community who are currently bringing their expertise to bear on the problem.

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