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From the Age of Discovery to the Age of Exploration: Determining the Properties of the Quark-Gluon-Plasma

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In one of the most surprising discoveries of the past few years, experiments at the Relativistic Heavy Ion Collider (RHIC) have identified a new form of matter formed in nucleus-nucleus collisions at energy densities more than 100 times that of a cold atomic nucleus. Measurements and comparisons with relativistic hydrodynamic models indicate that the matter thermalizes in an unexpectedly short time, has an energy density at least 15 times larger than needed for color deconfinement, has a temperature about twice the critical temperature predicted by lattice QCD, and appears to exhibit collective motion with ideal hydrodynamic properties - a "perfect liquid." The matter appears to flow with a near-zero viscosity-to-entropy ratio, lower than any previously observed fluid and close to a universal lower bound recently derived from string theory. All evidence so far indicates that the quark-gluon plasma formed in the collisions at RHIC is a strongly coupled plasma and not a dilute gaseous plasma as originally expected. However, a fundamental understanding of the medium seen in heavy-ion collisions at RHIC does not yet exist. The most important scientific challenge for the field in the next decade is the quantitative exploration of the new state of matter, *i.e.*, to quantify its properties and to understand precisely how they emerge from the fundamental properties of QCD. This will include the search for the critical endpoint in the QCD phase diagram, the discovery of which is a distinct possibility in a series of low energy runs at RHIC. The next steps at RHIC will require new data that will, in turn, require enhanced capabilities of the RHIC detectors and accelerator. I will report on recent measurements and their implications for our current understanding of the hot and dense matter created at RHIC, as well as the scientific opportunities for an upgraded RHIC (RHIC II) in conjunction with upgrades to the large experiments, PHENIX and STAR.