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QCD: Our Weight on Its Shoulders

QCD is the first theory to demand that science fully resolve the conflicts generated by joining relativity and quantum mechanics. In attempting to match QCD with Nature, it is necessary to confront the innumerable complexities of strong, nonlinear dynamics in relativistic quantum field theory, e.g. the loss of particle number conservation, the frame and scale dependence of the explanations and interpretations of observable processes, and the evolving character of the relevant degrees-of-freedom. The peculiarities of QCD ensure that it is also the only known fundamental theory with the capacity to sustain massless elementary degrees-of-freedom, gluons and quarks; and yet gluons and quarks are predicted to acquire mass dynamically so that the only massless systems in QCD are its composite Nambu-Goldstone bosons. All other everyday bound states possess nuclear-size masses, far in excess of anything that can directly be tied to the Higgs boson. These points identify and highlight the most important unsolved questions within the Standard Model, namely: what is the source of the mass for the vast bulk of visible matter in the Universe, how is its appearance connected with confinement; how is this mass distributed within hadrons and does the distribution differ from one hadron to another? This presentation will provide a contemporary sketch of the strong-QCD landscape, highlighting features of its running coupling and masses, and parton distribution amplitudes and functions, which together reveal aspects of the answers to these critical questions.

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