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Resurgent QCD

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QCD is a highly successful theory that underlies most of collider physics and describes a wide range of phenomena. Despite this success, a few foundational issues remain open. These issues include first principle computation of such properties of bound states as masses and parton distributions. Mathematically it is the next logical step compared to TQFT as it is explicitly sensitive to metric. We will discuss the first principle approach to QCD and the mathematical concepts involved. First principle definition of QCD requires connections to a few branches of mathematics. We will start by stating the problem in the context of doing analysis of PDEs on Banach and other related infinite dimensional manifolds. Then we will discuss certain algebraic and categorical structures suggested by perturbation theory. These structures include the relation to flat bundles with logarithmic singularities, certain generalizations of quantum groups and Grothendieck-Teichmuller spaces. Then we will discuss resurgent phenomena in QCD. The emergence of Riemann surfaces of infinite genus is inherent in any known formulations of QCD. We will discuss the current status of the theory of these surfaces and the circle of math ideas needed for successful applications to physics, emphasising connections to transcendental number theory and holomorphic dynamics. Then we discuss applications of this formalism to the theory of bound states, such as the proton, and possible ways to test this experimentally. If time permits, we will mention possible ways of resolution of the resurgence conjecture of Kontsevich and Soibelman, as well as its multiparameter generalizations, in the context of mixed Riemann Hilbert problems.

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