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Study of the QGP Initial State and its Evolution to QGP

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I give a summary of recent theoretical developments in our understanding of the early-time dynamics of the strongly interacting quarks and gluons right after the relativistic heavy-ion collision. The theory tells us that the soft components of the high energetic reaction can accommodate abundant gluons enough to justify a semi-classical approximation or a description in terms of coherent fields. The question is then how such coherent fields can be decohered and eventually be turned in a hydrodynamical regime. I will put my emphasis on the fact that such a theoretical question is not only challenging in high-energy QCD but also relevant for many other fields; quantum fluctuations and particle productions on a non-trivial metric associated with the expansion, classical and quantum turbulence, scaling behavior and attractors, etc. There are already promising results from numerical simulations, but at the same time, there is no established theoretical framework that can be used for the real-time investigation including full quantum fluctuations. In this talk I will briefly introduce the idea of the semi-classical gluon fields at high energy first, and then proceed into advantages and disadvantages of respective analytical and numerical approaches, and finally comment on the remaining problems and future prospects.