compared with the difference in energy density between the perturbative partonic and the non-perturbative hadronic vacua. When this condition is no longer satisfied, a bubble of hadronic vacuum may be formed with a probability determined by statistical-mechanical considerations.

This paper is organized in two main parts. The first part, consisting of Secs. 2 and 3, is intended as a comprehensive presentation of the general field-theoretical framework and necessary elements of quantum transport theory. In Sec. 2 we construct on the basis of the dual vacuum picture of coexisting perturbative and non-perturbative domains an effective theory that embodies the correct scale and symmetry properties of QCD and that has the desired features outlined above. We also discuss the relation to the phenomenology of the QCD phase transition, where the role of the critical temperature is analogous to the critical confinement length scale in our approach. Sec. 3 outlines the method of real-time Green functions that we use to derive from the field equations of motion the corresponding coupled equations for the particle distribution functions. We also indicate how macroscopic quantities related to observables can be extracted from the microscopic particle dynamics within the kinetic theory of (non-equilibrium) many-particle systems. The second part of the paper, Secs. 4-6, is devoted to the application of this effective QCD field theory to the dynamics of parton-hadron conversion for the prototype process of fragmenting jet systems initiated by e^+e^- annihilation. In Sec. 4 we derive transport equations that, in the case of the partons, are generalized QCD evolution equations in full phase space, and similar equations for the excitations of the χ and U fields. In Sec. 5 we present results of simulating this real-time evolution of partons through the perturbative shower stage, via subsequent formation of color-singlet clusters, and finally hadronic cluster decay to give the final hadron yield. We investigate phenomenological implications for particle production and the Bose-Einstein effect, which we find to be a particularly sensitive probe to measure and test the confinement dynamics. Finally, Sec. 6 is reserved for a summary and a brief discussion of future perspectives of the approach, in particular its applicability to the QCD phase transition, and to high-density QCD.