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New advances in the hydrodynamic description of the QCD critical point in heavy-ion collisions

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Hydrodynamics has been very successful in explaining a variety of data from heavy-ion collision experiments. An essential ingredient is the equation of state, which allows for the study of the impact of different descriptions of the QCD medium and of the phase transition on the evolution of the bulk matter. At the critical point the correlation length of fluctuations of the order parameter diverges in thermodynamic systems. At the same time the relaxation times become infinite at the critical point, which in dynamic systems weakens critical phenomena. In order to provide solid predictions for event-by-event fluctuations of observables extensions of previous studies to dynamic systems are crucial to guide the search for the discovery of the critical point in heavy-ion collision experiments, like the beam energy scan at RHIC, BNL. A hydrodynamic description of the expanding matter, which takes further restrictions of the system like its inhomogeneity and finite size into account, is especially suitable because the order parameter oscillates slowly at the critical point and can thus be described as a collective variable within a hydrodynamic setup. First models, which propagate the fluctuations of the order parameter explicitly by a coupling to a hydrodynamically expanding heat bath, are able to see dynamic effects like critical slowing down at the critical point and supercooling at the first order phase transition. Latest results show that for the first order phase transition this leads to the phenomenon of domain formation. At the critical point the enhancement of event-by-event fluctuations can be observed. These explicitly dynamic models are thus a promising approach to a realistic description of the QCD critical point in heavy-ion collisions. In this talk I will review recent advances in our understanding of the phase transition obtained within hydrodynamic models and outline possible approaches to future contributions to the search for the QCD critical point.