Nonuniform-temperature effects on the phase transition in an Ising-like model

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[PhysRevD.104.016031]

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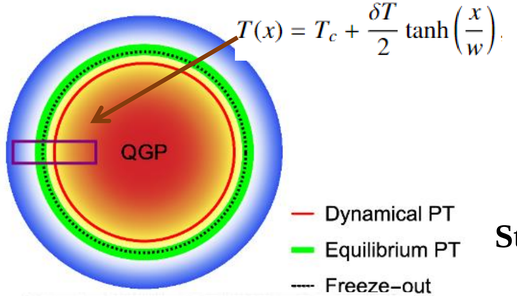
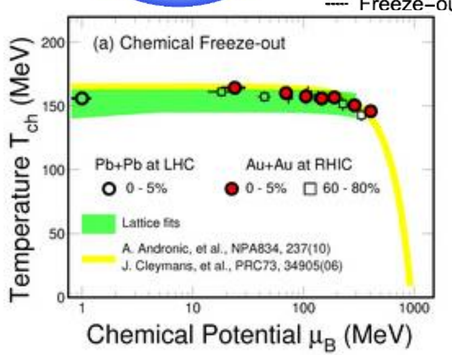
We present the spatially-nonuniform-temperature effects on the phase transition temperature, the fluctuations, and the correlation length via a simplified Ising-like model. Different from the dynamical effects, which delay the phase transition, we reveal that the nonuniform-temperature effects lead to higher phase transition (PT) temperature. Besides, the suppression of the critical fluctuation can be as stronger as the dynamical slowing down effects, and the nonzero-momentum modes of fluctuations play a crucial role. Our study presents a different perspective to understand the recent STAR data and lattice results, and can be further generalized to other temperature-nonuniform systems like the compact stars.

Nonuniform T in a QGP fire ball

$$T(x) = T_c + \frac{\delta T}{2}\tanh\left(\frac{x}{w}\right)$$





Probability distribution function of sigma field in T(x) field

$$P[\sigma(r)] \propto \exp\left\{-\int dr \frac{(\nabla\sigma)^2/2 + V[\sigma(r)]}{T(x)}\right\}$$

Ising-like effective potential

$$V[\sigma] = a(T-T_c)(\sigma-\sigma_0)+b(\mu-\mu_c)(\sigma-\sigma_0)^2+c(\sigma-\sigma_0)^4,$$

Stationary solution to σ_c (variational extremum of P[σ]

$$\nabla^2\sigma = \frac{1}{T}\nabla T\cdot\nabla\sigma + \frac{\partial V}{\partial\sigma}.$$

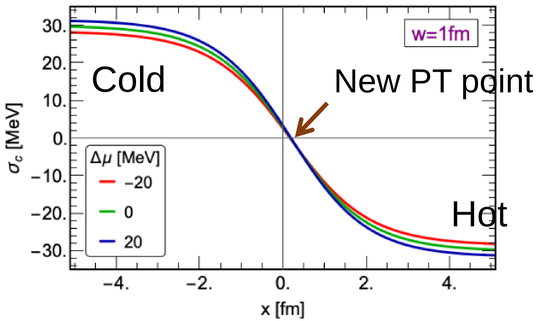
Probability function of fluctuations,

$$P[\sigma] \propto \exp\left[-\int dr \frac{(\nabla\delta\sigma)^2/2 + m^2\delta\sigma^2/2 + 4c\sigma_c\delta\sigma^3 + c\delta\sigma^4}{T(x)}\right],$$

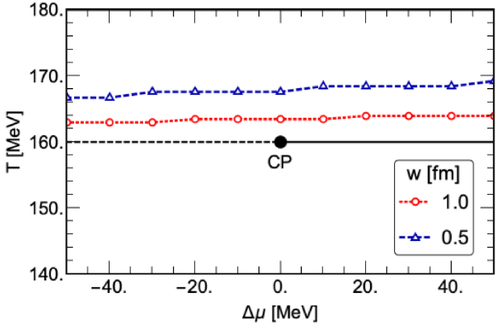
Approx.: 1-dimension, uniform chemical potential, local equilibrium, Markov process

Results:

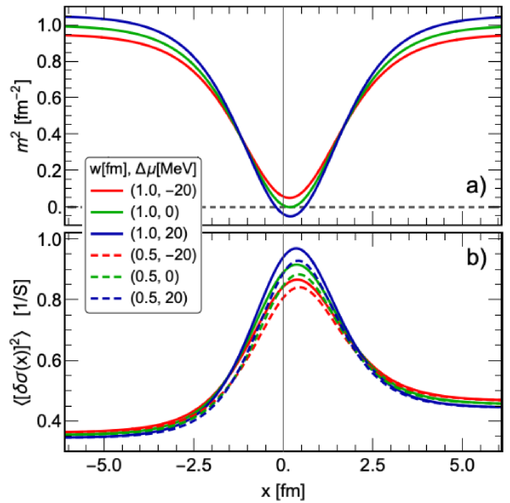
Stationary solution σ_c



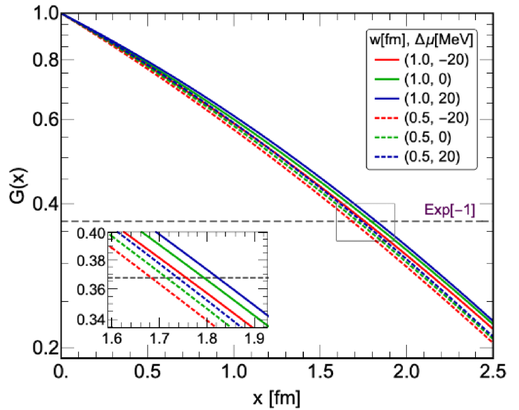
Lifted PT temperature



m^2 and variance of $\delta\sigma^2$



Nonlocal correlation length



$$G(x) = \frac{\langle\delta\sigma(x_p + x/2)\delta\sigma(x_p - x/2)\rangle}{\langle\delta\sigma(x_p)\delta\sigma(x_p)\rangle}$$