Conformal Theories with IR cutoff

Y. Iwasaki[1]

[1] *Center for Computational Sciences, University of Tsukuba,Tsukuba, Ibaraki 305-8577, Japan*

We give a new perspective on the dynamics of conformal theories realized in the SU(N) gauge theory, when the number of flavors N_f is within the conformal window. Motivated by the RG argument on conformal theories with a finite IR cutoff $\Lambda_{\rm IR}$, we conjecture that the propagator of a meson $G_H(t)$ on a lattice behaves at large t as a power-law corrected Yukawa-type decaying form $G_H(t) = c_H \exp(-m_H t)/t^{\alpha_H}$ instead of the exponentially decaying form $c_H \exp(-m_H t)$, in the small quark mass region where $m_H \leq c\,\Lambda_{\rm IR}$: m_H is the mass of the ground state hadron in the channel H and c is a constant of order 1. The transition between the "conformal region" and the "confining region" is a first order transition. Our numerical results verify the predictions for the $N_f = 7$ case and the $N_f = 16$ case in the SU(3) gauge theory with the fundamental representation.

Secondly, we discuss small number of flavors ($N_f = 2 \sim 6$) QCD at finite temperatures. We point out theoretically and verify numerically that the correlation functions at $T/T_c > 1$ exhibit the characteristics of the conformal theories with IR cutoff, a Yukawa-type decaying form of the propagators.

Further, we observe our data are consistent with the picture that the $N_f = 7$ case and the $N_f = 2$ at $T \sim 2\,T_c$ case are close to the meson unparticle model. On the other hand, the $N_f = 16$ case and the $N_f = 2$ at $T = 10^2 \sim 10^5\,Tc$ cases are close to the fermion unparticle model. All results are consistent with naive physical intuition and solve long standing issues at high temperatures such as why the free energy at high temperatures does not reach the Stefan-Boltzmann ideal gas limit even at $T = 100\,T_c$.