String Theory for Strongly Interacting Systems

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Youngman Kim *obtained his Ph. D at Hanyang University in 1999 and was a postdoctoral research fellow at Seoul National University, University of South Carolina, and Korea Institute for Advanced Study.*

The junior research group entitled String Theory for Strongly Interacting Systems (SSIS) consists of a leader (myself); two postdoctoral research fellows, Dr. Takuya Tsukioka and Dr. Ik Jae Shin; and one PhD student, Mr. Deokhyun Yi. In addition, both visitors to SSIS and APCTP postdoctoral research fellows (who are part of the Young Scientists Training Program (YST)) are also an essential part of SSIS.

Below I will introduce a basic theoretical tool of our group, describe some research goals, and finally will briefly discuss the future of SSIS.

The approaches based on the Anti de Sitter/conformal field theory (AdS/CFT) correspondence show many interesting possibilities to explore strongly interacting systems, such as dense baryonic matter, stable/unstable nuclei, and strongly interacting quark-gluon plasma. The objective is to introduce an additional space, which roughly corresponds to the energy scale of 4D boundary field theory, and to try to construct a 5D holographic dual model that captures certain non-perturbative aspects of strongly coupled field theory. They are highly non-trivial to analyze in conventional quantum field theory based on perturbative techniques.

There are generally two different routes to modeling a holographic dual of quantum chromodynamics (QCD). One way is a top-down approach based on stringy D-brane configurations. The other way is a so-called bottom-up approach to a holographic, in which a 5D holographic dual is constructed from QCD. A cautionary remark is that a usual, simple, tree-level analysis in the holographic dual model, both top-down and bottom-up, is capturing the leading Nc contributions, and we are bound to suffer from sub-leading corrections.

(1) Quark number susceptibility with finite chemical potential in holographic QCD:

We calculate the quark number susceptibility in holographic QCD by considering a finite chemical potential at finite temperature. We observe that approaching the critical temperature from high temperature regime the quark number susceptibility develops a peak as we increase the chemical potential. We discuss this behavior in connection with the existence of the critical end point in the QCD phase diagram.

(2) Self-bound dense objects in holographic QCD, a new doorway to nuclei:

We study a self-bound dense object in the hard wall model, a simple bottom-up holographic QCD model. We consider a spherically symmetric dense object which is characterized by its radial density distribution and non-uniform but spherically symmetric chiral condensate. For this we analytically solve the partial differential equations in the hard wall model

and read off the radial coordinate dependence of the density and chiral condensate according to the AdS/CFT correspondence. We then attempt to describe nucleon density profiles of a few nuclei within our framework and observe that the confinement scale changes from a free nucleon to a nucleus.

(3) Symmetry energy of dense matter in holographic QCD:

We study the nuclear symmetry energy of dense matter using a holographic QCD model.

To this end, we consider two flavor branes with the same quark masses in a D4/D6/D6 model in confined phase. We find that the symmetry energy increases monotonically with the density, and it shows power law behavior near zero density.

SSIS is continuing the effort to understand the QCD phase diagram at finite density, the QCD vacuum, nuclear physics, hadron physics, and dense objects like nuclei or neutron stars in the framework of the holographic QCD.

For more on SSIS, please visit:

http://apctp.org/jrg/blogindex.php?JrgId=4