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Research Proposal

Job Number: **W22219**

Proposal Abstract In all generality, my goal is to improve hadronic models better fit hadron spectra and to improve theoretical predictions of multi nucleon objects. My proposed method of research is with holographic models. These models have the mysterious fifth dimension, but such a dimension is the geometric realization of the renormalization group (RG) flow of the theory from IR to the UV. The leading holographic model is holographic Sakai-Witten-Sugimoto model that is a bottom-up model with type IIA string theory. The strongly coupled hadron physics is said to be dual to weakly coupled supergravity theory. The model uses topological soliton in the bulk to model baryons (skymions) in the boundary with confinement and broken chiral symmetry. I propose to two topics of research: further understanding of the moduli space for the self-dual instatons/dual to skrymion. I propose two research topics. Extend the moduli analysis currently being done. The instatons in flat space represent the transitions of QCD vaccua. In the hologrpahic, negativly curved space case, the instatons are dual to skymions, so the moduli of such holographic solitons are dual to the baryons. Because the holographic solitons are topological, within the Sakai-Witten-Sugimoto number of baryons is a topological invariant. Further, analysis of the moduli spce can determine where it is a Riemannian manifold or not. Similar to the flat space case, such understanding of the moduli can help construct multi baryon solutions quantized degress of freedom. The other proposed line of research would involve modeling (high) spin hydronic spin states with a scalar theory. Within holographic theories, one can introduce two-component complex scalars such that they have a broken chiral symmetry. It is hypothesised that the broken chiral creates non-topological domains walls. It was novel to test the effectiveness of such a model to model confinement and it's effectiveness to model low mass hadron states.

I believe that my research topic and work would most closely aglign with Dr. Masaaki Kimura and his group at the Nucleon Many-body Theory laboratory. I also believe that is there is mutual befinit to our collaboration. The majority of my work it more along the lines of finding QCD adjacent theories. The main focus, not to compare with experimental data, but to expolore the strongly coupled field theory land-scape. I believe that Dr. Kimura, his group, and I could perform more phenomological approach to model building with there **ADD MORE HERE**

I would expect a year to find interestingly novel results. After model building, I would expect find analytically or numberical results after one or a few months.

Proposed Method of Research For research pertaining to hadron modeling, first it is important for the research is to construct the model in the terms of a holographic Lagrangian. That is a 5D hologrpahy. Immidiete candidates would be variations of the Sakai-Witten-Sugimoto. If the model has no known simple homogenous solutions of the equations of motion, I would first exploring finding such simple solutions. Such solutions are usually thermaldynamically the most favorable solution. Saying such thing, I would explore the thermalydyanmics of such a solution on the boundary. Further, analysis can be done by calculating meson spectra and couplings if admited by the model. Otherwise, for more non-trival, non-homogenous solutions, I would numberically solve such solutions as a boundary value problem (BVP). Calculating the spectra and couplings of meson similarly requires one to solve a BVP. **ADD MORE**

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For research involving moduli space of curved space instatons involves more mathematical techqiques involving algebraic topology. Essentially, the method of research here would be to concptually tackle the problem as a simple (but distinct problem first) or to exploit the symmetries of the problem. **ADD MORE HERE**

Expected Results **ADD MORE HERE**

Future Work For the moduli space reaserch, I would further develop methods to construct more generic solutions, similar to flat space case. Such solutions would be parametrized by the moduli. Such moduli can be quantized with the **TBD method quantization. ADD MORE HERE**