Contribution ID: **316** Type: **Plenary talk (30 min + 10 min questions)**

Nuclear Structure across the energy scales from microscopic effective theories

Monday, 11 July 2022 17:15 (35 minutes)

The microscopic theory of atomic nuclei now spans energy scales from kilo-electron-volts to giga-electron-volts. The leading degrees of freedom for prominent experimental phenomena range from clusters or collective modes of nucleons to quarks and gluons. Many profound questions can be raised. Is there harmony across scales? Are there emergent phenomena at one scale that trace their origins to a higher energy scale? Are there theoretical tools that are useful at more than one scale? Can one establish that theory retains predictive power?

At the highest energy scales accessible to current and planned laboratory experiments, there is widespread agreement that atomic nuclei should be well-described by the Standard Model of Elementary Particles. How can we achieve this? I will present Basis Light Front Quantization1 as a relativistic Hamiltonian approach for quarks and gluons that is complementary to Lattice QCD and capable of describing nuclear phenomena using supercomputer simulations. The first goal of successfully describing mesons and nucleons is progressing rapidly and phenomena such as chiral symmetry breaking are becoming better understood2. Near-term goals include the properties of exotic baryonic systems and properties of the pion-nucleon and nucleon-nucleon interactions.

At the lower energy scales, Chiral Effective Field Theory (χEFT)3,4 has emerged as the systematic and controllable embodiment of QCD below the chiral symmetry breaking scale. Can we discover collective nuclear phenomena emerging from treating all nucleons on an equal footing? I will present recent results from the ab initio No-Core Shell Model (NCSM)5 with χEFT interactions showing promising agreement between theory and experiment6 within well-quantified theoretical uncertainties. Exotic phenomena such as alpha clustering7 and predictions of a tetraneutron resonance8 serve as example highlights.

1. J.P. Vary, et al., "Hamiltonian light-front field theory in a basis function approach", Phys. Rev. C 81, 035205 (2010)
2. Y. Li and J.P. Vary, "Light-front holography with chiral symmetry breaking," Phys. Letts. B 825, 136860 (2022)
3. R. Machleidt and D.R. Entem, "Chiral effective field theory and nuclear forces," Phys. Rep. 503, 1 (2011)
4. E. Epelbaum, H.-W. Hammer and Ulf.-G. Meißner, "Modern theory of nuclear forces," Rev. Mod. Phys. 81, 1773 (2009).
5. B.R. Barrett, et al., "Ab Initio No Core Shell Model," Prog. Part. Nucl. Phys. 69, 131 (2013)
6. P. Maris, et al., "Light nuclei with semilocal momentum-space regularized chiral interactions up to third order," Phys. Rev. C 103, 054001 (2021)
7. T. Otsuka, et al., "Alpha-Clustering in Atomic Nuclei from First Principles with Statistical Learning and the Hoyle State Character," Nature Communications 13:2234 (2022)
8. A.M. Shirokov, et al., "Prediction for a four-neutron resonance," Phys. Rev. Letts. 117, 182502 (2016)

The speaker is a student or young scientist

No

Section

1. Nuclear structure: theory and experiment

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