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Advancing Nuclear Structure Theory: From the Shell Model to Clustering in Open Quantum Systems

Tuesday, July 23, 2024 1:30 PM (25 minutes)

This presentation explores both historical and modern advancements in nuclear structure theory, evolving from the nuclear shell model introduced 75 years ago. It will provide an overview of quantum many-body tools such as the shell model and the configuration interaction (CI) technique, alongside newer methods that incorporate and leverage quantum complexity, entanglement, and the openness of many-body systems. These methods are applied not only to atomic nuclei but also to many other quantum systems.

We will discuss challenges and recent advancements in employing CI techniques to study clustering in light nuclei. This research addresses complex questions about geometry, effective interactions, configuration space limitations, and continuum physics. Recent advances in CI methods, grounded in ab-initio principles, increasingly align theoretical predictions with experimental observations, particularly concerning clustering properties in light nuclei. I will highlight recent cluster asymptotic normalization coefficient (ANC) results for 16O and 20Ne, showcasing the high quality of predictions.

Additionally, significant progress includes studies of alpha clustering near decay thresholds. This presentation will also cover the dynamics of weakly bound or resonance states, discussing the emergence of broad superradiant states and the decoupling of narrow states from the reaction continuum. Considering the nuclear system as an open quantum system enhances our understanding of clustering dynamics and the emergence of collective degrees of freedom. Experimental validations of these phenomena will also be highlighted.

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Session Classification: Nuclear Structure Theory