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Experiments with the High Resolution gamma-ray Array at RIBF

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Understanding the nuclear structure and dynamics in terms of the underlying fundamental interactions between protons and neutrons is one of the overarching goals of the nuclear science community. To this end, nuclear theory is currently developing nuclear interactions and Hamiltonians derived from chiral Effective Field Theory (EFT) employing 2- (NN) and 3-body (3N) forces. This new approach provides an exciting link to the theory of the strong interaction, Quantum Chromodynamics, and hence a unique opportunity to understand the nuclear structure and its evolution from first principles.

The neutron-rich C and O isotopes lie at the limit of accessibility of many ab initio techniques, while first calculations indicate a significant sensitivity of their electromagnetic (EM) structure to the underlying nuclear interaction and in particular to the inclusion of 3N forces. Therefore, experimental studies of these nuclei provide a critical testing ground for newly-developed chiral interactions, as well as new many-body techniques. I will propose to:
• re-measure the lifetime of the 2+ state of 20C with increased precision and accuracy,
• perform a Coulomb excitation of 22O (this potentially will benefit from the use of DALI instead).

Ab initio theory is working towards extending its calculations of transition rates to heavier medium mass and open-shell nuclei. These calculations are under development by e.g. applying the in medium similarity renormalization group (IM-SRG) for valence-shell Hamiltonians and extending it to new multi-reference formulations. I will propose experiments in two regions of the nuclear chart that will play a critical role in testing the newly developed ab initio calculations, the so-called "Island of Inversion"at N=20 and the neutron-rich Ca isotopic chain. In particular, I will propose to:
• study the transitional nucleus 30Na using neutron knockout reactions and study in detail its excitation spectrum, from lifetimes to gamma-ray polarization measurements,
• extract lifetimes of excited states in neutron-rich Ca isotopes (both odd and even), namely 48-54Ca using nucleon-removal reactions to study at the same time their single-particle structure.

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