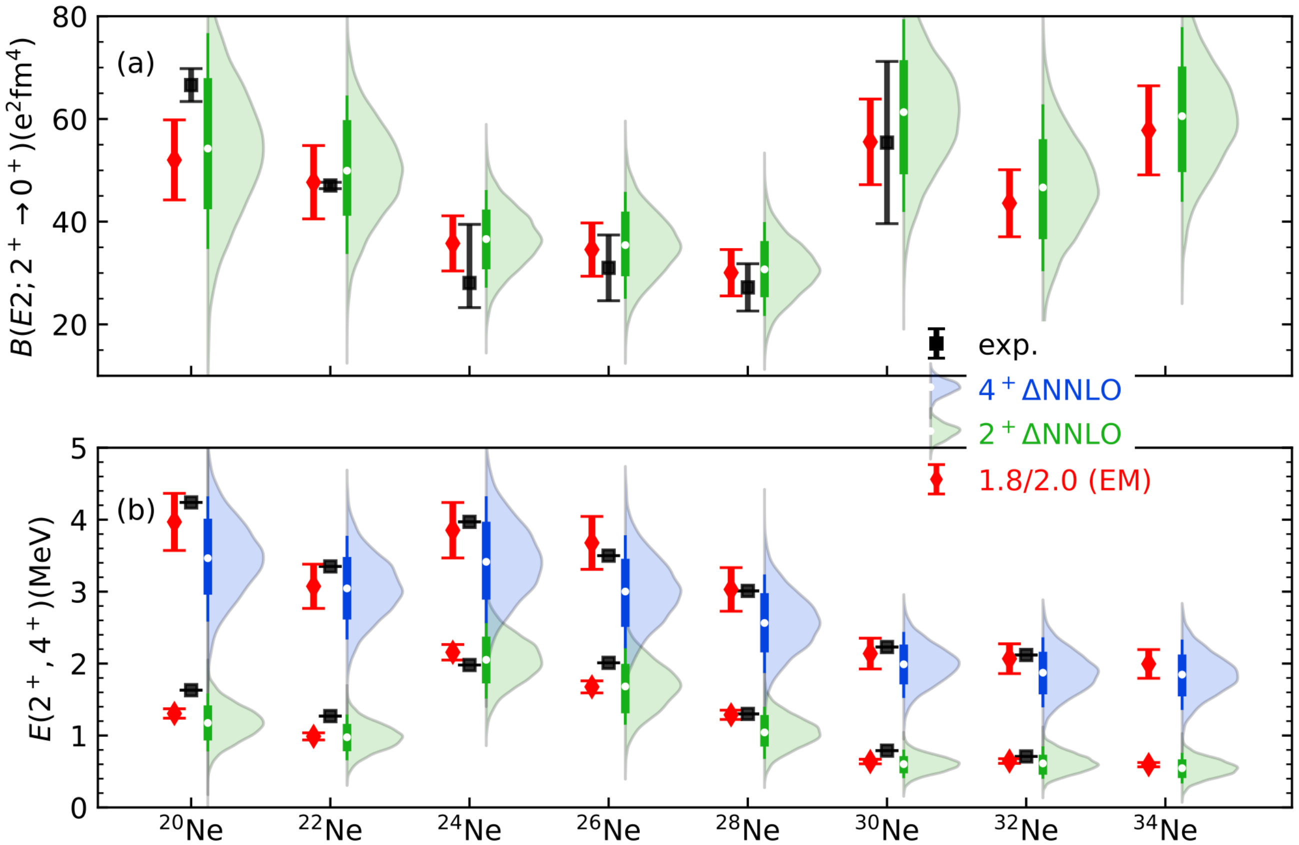
Multiscale physics from ab initio computations of nuclei

Objectives

- We want to accurately compute disparate energy scales in nuclei, which range from 100s of MeV in binding energy to just 100s of keV of rotational excitation energies in medium-mass nuclei. Capturing this multi-scale physics is a challenge when starting from nuclear forces that have roots in quantum chromodynamics, the fundamental theory of the strong nuclear force.



Electric quadrupole transition strengths (top) and energy levels of excited states with spin parity 2+ and 4+ for various isotopes of neon computed with a single interaction (red) and an ensemble of interactions (distributions).

Impact

- We accurately computed collective electro-magnetic transition strengths which are sensitive to small details in the nuclear wave functions.
- We predicted that the neutron-rich nucleus ^{30}Ne has spherical and deformed shapes that coexist and have very similar energies.
- Accurately capturing such small differences has been a challenge in ab initio computations
- We also made first steps in tying the occurrence of nuclear deformation to high-resolution forces from effective field theories of quantum chromodynamics.

Accomplishments

- Paper “Ab initio computations of strongly deformed nuclei around ^{80}Zr,” B. S. Hu, Z. H. Sun, G. Hagen, T. Papenbrock, arXiv:2405.05052, Physical Review C (Letters, in print).
- Paper ”Multiscale physics of atomic nuclei from first principles,” Z. H. Sun, A. Ekström, C. Forssén, G. Hagen, G. R. Jansen, T. Papenbrock, arXiv:2404.00058.