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NATIONAL INSTITUTE FOR COMPUTATIONAL SCIENCES
NICS

Nuclear Density Functional Theory for Excitations
Vibrations in deformed nuclei

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in collaboration with

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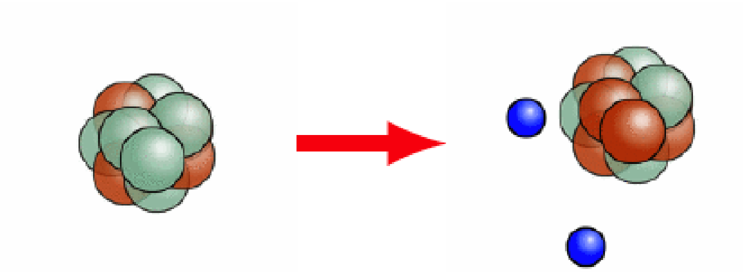
Challenges

- **Can we understand the shape vibrations of deformed nuclei ?**
  - **Calculated vibrational energies in 27 heavy deformed rare-earth nuclei**
  - **Compared the data**
- **Can we generalize the concept of vibration to processes in which neutrons oscillate into protons ?**
  - **It is essential if we want to learn about the masses of neutrinos from expensive and difficult experiments currently looking for "neutrinoless double-beta decay", in which two neutrons change into two protons (producing two electrons)**

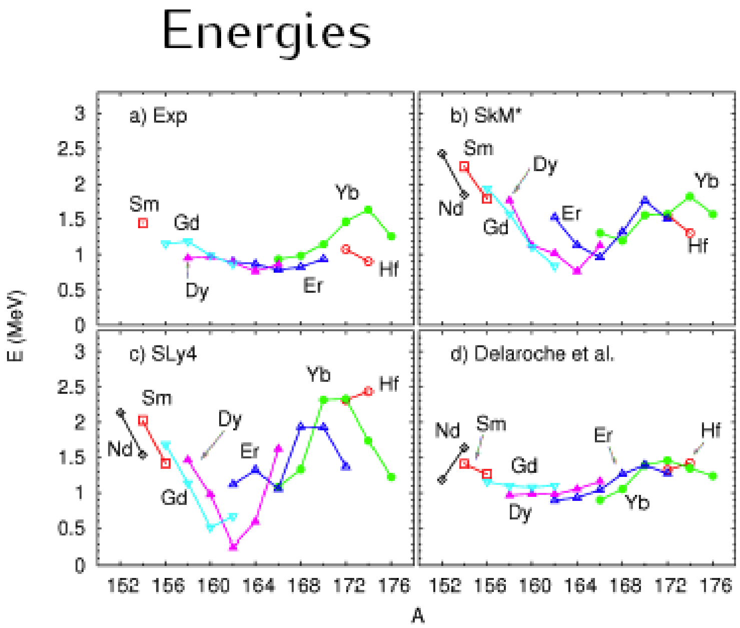


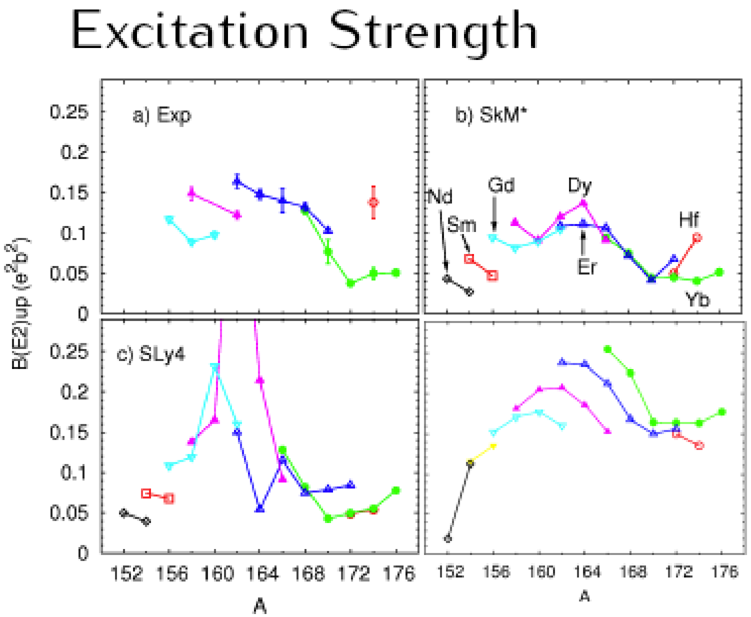
Calculations of decay rate are in progress

Computing

- Shape vibrations
  - Compute 10^{10} matrix elements in each K^{π} and nucleus
  - Each matrix element a sum of many two-dimensional integrals over the nuclear volume
- Double-beta decay
  - Need all excited states in the nucleus between the initial and final nuclei in the decay (all those figure in)
- Calculations done on Kraken
  - Total for each project: 10M SU
  - Typical job size: 10,800 cores x 2.25 hour
    - Run 8 – 10 jobs for shape vibrations
    - Run 20 for double-beta decay calculation

Results

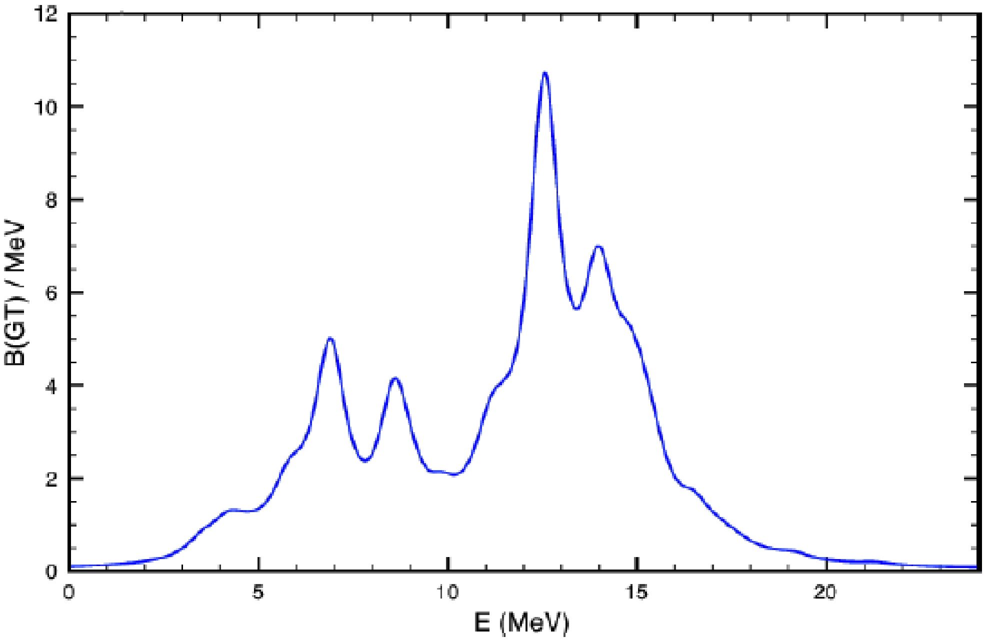




- **Vibrational results b and c agree qualitatively with data (a) but not as well with model (d)**
  - **Model d assumes states are not completely vibrational**
- **Results demonstrate that shape vibrations are in anharmonic**

Double-beta decay

- Preliminary calculation of single beta decay strength from ground state of 122Te to all excited states of nucleus with one more proton and one less neutron. This kind of calculation in other nuclei, folded with second single beta distribution, will yield double-beta decay rate.



- Upcoming calculations will reduce the current factor-of-two uncertainty in the rate, with a big payoff for experiments and neutrino science.

Contact

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