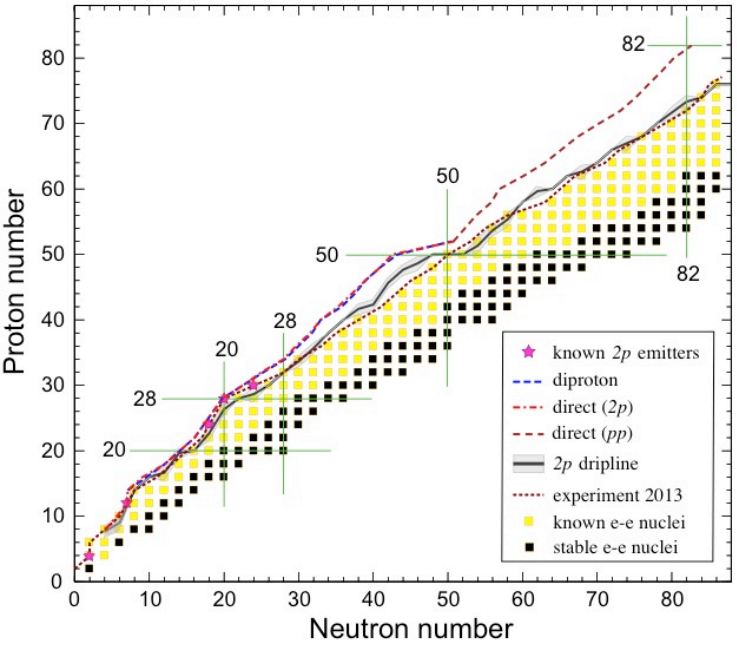
Landscape of Two-Proton Radioactivity

Objectives

- Ground-state two-proton (2*p*) radioactivity, the simultaneous emission of two protons by a nucleus, is a rare decay mode found in isotopes of elements with even atomic numbers located beyond the proton-rich border of the nuclear landscape. So far, this exotic process has been experimentally observed in a few light and medium-mass nuclides with atomic number Z < 32.
- Using state-of-the-art nuclear density functional theory, we globally analyze *2p* radioactivity and for the first time identify the candidates for this exotic decay in elements heavier than strontium.

Impact

- Enable rigorous data-driven predictive modeling in complex physical systems, supported by:
  - inference and calibration from experimental data and observations
  - model selection and learning of model structure
  - validation and verification of model-based extrapolations
- Guidance for the radioactive beam facilities worldwide
- Provide benchmark for future model developments



The landscape of ground-state 2p emitters. The mean two-proton drip line (thick black line) and its uncertainty (gray) were obtained in by averaging the results of six interaction models. The known proton-rich even-even nuclei are marked by yellow squares, stable even-even nuclei by black squares, and known 2p emitters by stars. The current experimental reach for even-Z nuclei (including odd-A systems) is marked by a dotted line. The average lines of 2p emission for the diproton model and direct-decay model (simultaneous 2p and sequential pp) are shown.

Accomplishments

1. We quantified the landscape of ground-state 2p radioactivity.
2. We predict that almost all elements between argon and lead have 2*p*-decaying isotopes. The upper end of the 2*p*-decay territory is determined by alpha decay.
3. We predict a few cases where the competition between 2*p* emission and alpha decay may be observed. The observation of these two distinct decay modes in the same nucleus would provide an excellent test of nuclear structure models and a deeper understanding of charged particle emission from atomic nuclei.

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