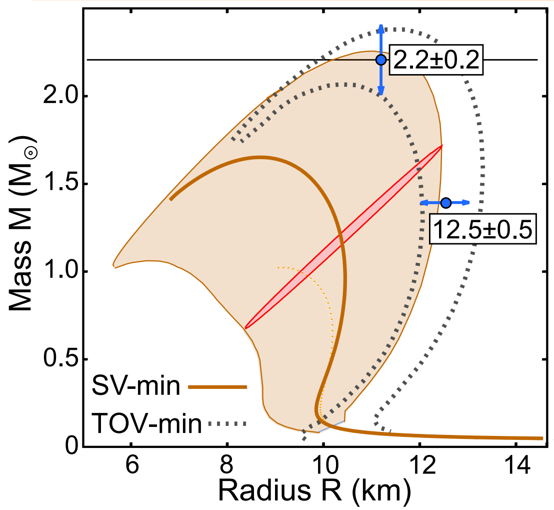
Energy density functional for nuclei and neutron stars

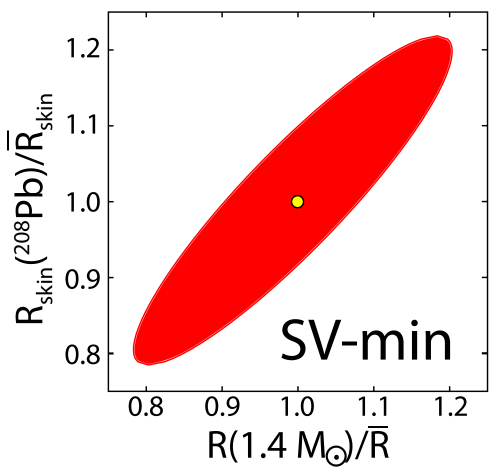
Objectives

- Recent observational data on neutron star masses and radii provide stringent constraints on the equation of state of neutron rich matter. We use the state-of-the-art nuclear density functional theory, coupled with state-of-the-art computational tools, to develop a nuclear energy density functional that can be simultaneously applied to finite nuclei and neutron stars
- By employing the covariance analysis, we assess correlations between observables for finite nuclei and neutron stars

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





Left: The mass-radius relation for neutron stars obtained with the nuclear functional SV-min (with the uncertainty band) and the uncertainty limits for the new functional TOV-min constrained to neutron star data indicated by blue arrows . Right: The covariance ellipsoid for the neutron skin R_{skin} in ^{208}Pb and the radius of a $1.4M_\odot$ neutron star calculated using SV-min. The mean values are: R ($1.4M_\odot$)=10.18 km and R_{skin}= 0.17 fm.

Accomplishments

1. We developed the new functional TOV-min, informed by neutron star data to better constrain isovector interactions. TOV-min yields results for nuclear bulk properties of the same quality as those obtained with the established functionals.
2. We demonstrate that standard energy density functionals optimized to nuclear data do not carry information on the expected maximum neutron star mass.
3. The new functional is expected to yield more reliable predictions in the region of very neutron-rich heavy nuclei.

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NUCLEI Nuclear Computational Low-Energy Initiative

Reference: J. Erler et al., Phys. Rev. C (2013)

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