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Global properties of nuclei and drip lines at finite temperature

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In stellar environments nuclei appear at finite temperatures, becoming extremely hot in core-collapse supernovae and neutron star mergers. However, due to theoretical and computational complexity, most model calculations of nuclear properties are performed at zero temperature, while those existing at finite temperatures are limited only to selected regions of the nuclide chart. Recently a theoretical framework has been established for the description of properties of hot nuclei, based on the relativistic nuclear energy density functional (RNEDF) and finite temperature relativistic Hartree-Bogoliubov model supplemented by the continuum subtraction procedure. A variety of nuclear properties have been investigated, including nuclear binding energies, neutron emission lifetimes, quadrupole deformations, neutron skin thickness, proton and neutron pairing gaps, entropy and excitation energy. At lower temperatures the nuclear landscape is influenced only moderately by the finite-temperature effects, mainly by reducing the pairing correlations. As the temperature increases, the effects on nuclear structure become more pronounced, reducing both the deformations and the shell effects. It is also important to understand where are the limits of nuclear binding in hot stellar environments. Recently the nuclear drip lines have been mapped at temperatures up to around 20 billion kelvins in the RNEDF framework including treatment of thermal scattering of nucleons in the continuum. With extensive computational effort, the drip lines have been determined using several RNEDFs with different underlying interactions, demonstrating considerable alterations of the neutron drip line with temperature increase, especially near the magic numbers. At temperatures less than around 12 billion kelvins, the interplay between the properties of nuclear effective interaction, pairing, and temperature effects determines the nuclear binding. At higher temperatures, surprizingly the total number of bound nuclei increases with temperature due to thermal shell quenching effect. The nuclear drip lines for hot nuclei appearing in stellar environments should be viewed as limits that change dynamically with temperature. Nuclear excitations and weak interaction processes also display sensitivity on the finite temperature effects.

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Primary author(s) : Prof. PAAR, Nils (Department of Physics, Faculty of Science, University of Zagreb, Bijenička c. 32, 10000 Zagreb, Croatia)

Presenter(s) : Prof. PAAR, Nils (Department of Physics, Faculty of Science, University of Zagreb, Bijenička c. 32, 10000 Zagreb, Croatia)

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