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Neutron-rich nuclei and neutron-rich stars: a trapped ion's perspective of the two infinities

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Now famous as quantum computers, ion traps were already recognized (with the 1989 Nobel Prize) as superior instruments for precision measurements, made possible by long-term observation of their stored quarry.

The use of ion traps for measuring nuclear binding energies at on-line radioactive beam facilities (first CERN-ISOLDE, later TRIUMF-ISAC) has now brought improved topographical knowledge of the nuclear chart, revealing a richness of emergent nuclear structure - yet to be explained by the quarks and gluons of quantum chromodynamics.

Defining the energy available for reactions, the nuclear binding energy plays a key role in the stellar process of rapid neutron-capture nucleosynthesis that created the heavy elements, forming the basis of ourselves and our daily life. This *r* process was recently observed thanks to a "heads up"detection of gravitational waves from neutron-star merger GW170817 that has ushered in the present era of multi-messenger astronomy.

Understanding neutron stars and their associated gravitational wave signal requires deriving a nuclear equation of state –which can also be achieved from the same binding-energy data. Using an equation of state, with the help of the Tolman-Oppenheimer-Volkoff equations derived from General Relativity, we can perform the interesting thought experiment of drilling into the crust of a neutron star to mine these same heavy elements!

Optional reading:
"The origin of the elements and other implications of gravitational wave detection for nuclear physics,"4Open Science 3, 14 (2020)
https://doi.org/10.1051/fopen/2020014

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