New half-life measurements could improve understanding of heavy elements

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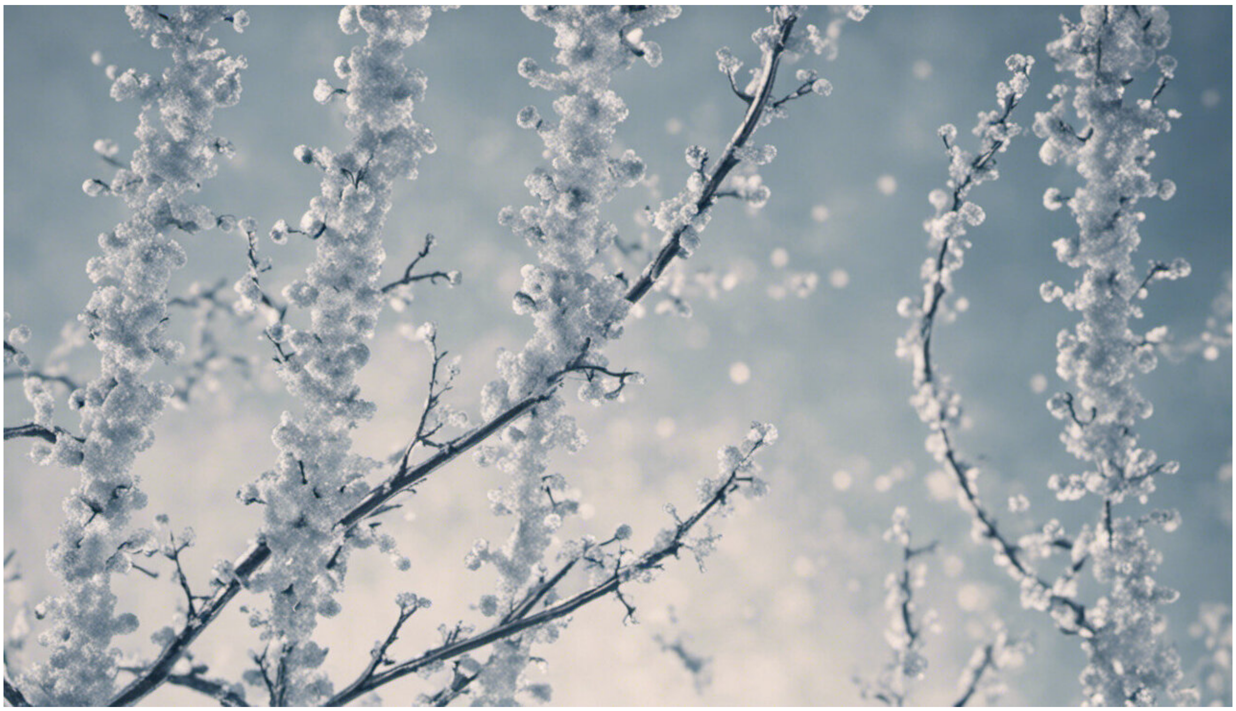

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Giuseppe Lorusso, of the National Physical Laboratory (NPL), has furthered understanding of the creation of heavy elements as part of an international collaboration to measure the beta-decay half-lives of 110 isotopes. The new and updated values are important for determining the abundance of heavy elements, and allow for a more reliable discussion of the processes by which they are made.

How elements heavier than iron are created is a question scientists have yet to fully answer. The astrophysical s-process is known to produce approximately half of the heavy elements in the universe. The s-process is a nucleosynthesis whereby heavier nuclei are created by slow neutron capture. A new element is formed when the captured neutron transforms into a proton, emitting an electron in the process - this is known as radioactive beta (minus) decay.

The more rapid r-process occurs in very neutron rich and extremely high temperature environments. However, the exact astrophysical site of the r-process cannot fully be explained by current observations and models, although supernovae explosions and neutron star mergers are the most likely candidates. Also, the mechanism of the r-process still remains unclear.

Researchers rely on clues from direct measurements of the beta-decay timescales of radioactive isotopes to help understand the r-process. The new measurements of the beta-decay half-lives of 110 neutron-rich isotopes provide vital input into theoretical models that attempt to explain the production of the heavy elements found on earth.

Isotopes of elements from rubidium (atomic number 37) to tin (atomic number 50) were produced as products of uranium-238 nuclear fission, a process whereby a nucleus splits into smaller nuclei. The measurements were carried out at the Radioactive Isotope Beam Factory (RIBF) at RIKEN, Japan, using a silicon strip detector array (WAS3ABi) in conjunction with a germanium detector array, EURICA.

The results were recently published in the journal *Physical Review Letters*, with Giuseppe Lorusso from NPL's Radioactivity team named as the lead author. The paper provides the first measurement of beta-decay half-lives for over 40 isotopes and provides updated measurements for around 70 others.

Many of the re-measured half-life values indicated that those currently available in the literature were overestimates - for example, cadmium-130 was found to be 20 % smaller than previous estimates.

The new measurements have led to a recalibration of the nuclear shell-model, a model that is used to predict the half-lives of nuclei for which there is no measurement data; the half-lives calculated with the recalibrated shell-model now fit the existing data within the expected uncertainty. The new measurements further the understanding of the energy released during neutron-induced fission of uranium, which is vital to the design of the next generation nuclear reactors.

More information: "β-Decay Half-Lives of 110 Neutron-Rich Nuclei across the N=82 Shell Gap: Implications for the Mechanism and Universality of the Astrophysical r Process." *Phys. Rev. Lett.* 114, 192501 – Published 11 May 2015.
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