An even closer look at the 'doubly magic' tin-100 nucleus

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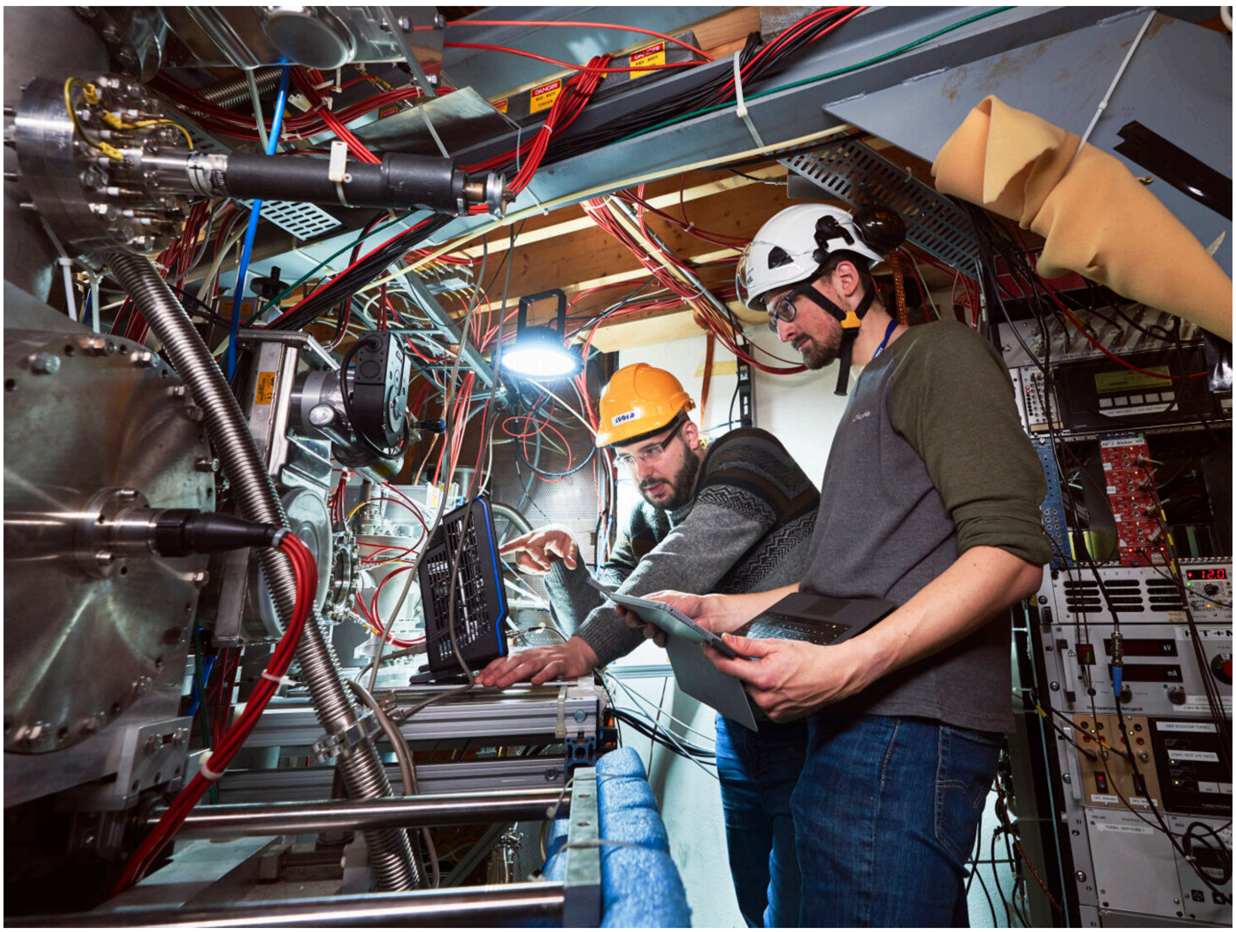

ISOLTRAPpers Lukas Nies (right) and Maxime Mougeot (left) setting up the ISOLTRAP experiment’s multireflection time-of-flight mass spectrometer. Credit: CERN

In a new paper published in *Physical Review Letters*, researchers working at CERN's ISOLDE facility describe how an upgrade to the ISOLTRAP experiment has allowed them to determine the energy necessary to bring the atomic nucleus of indium-99 from its ground state to a long-lived excited state called an isomer. The result follows an earlier ISOLTRAP measurement of indium-99 in the ground state, offering an even closer look at the nucleus of tin-100—a "doubly magic" nucleus that is a mere proton above indium-99.

Atomic nuclei in which the constituent protons and neutrons each completely fill the orbital shells to capacity are more strongly bound than their nuclear neighbors. Such "doubly magic" nuclei provide stringent tests of theoretical models of the nucleus.

This is the case of the tin-100 nucleus, which has 50 protons and 50 neutrons. But this special doubly magic nucleus—it is also the heaviest such nucleus comprising protons and neutrons in equal number—is particularly challenging to produce in the lab and is relatively short-lived. Researchers therefore turn to its more easily produced nuclear neighbors to try and reveal its secrets.

In their latest study, the ISOLTRAP team turned to indium-99, in particular to its isomer, which has a slightly different orbital occupation—and hence higher energy—than the ground state and results in a slightly larger nuclear mass. Using an upgraded version of the experiment's multireflection time-of-flight mass spectrometer, the researchers were able to measure the difference in the time-of-flight of confined indium-99 nuclei in their ground and isomeric states. This small difference, which is caused by the different mass of the nucleus in these two states, made it possible to determine the energy necessary to excite the isomer.

The team then compared the result with measurements of isomer excitation energies for other indium neighbors, including a new ISOLTRAP measurement of indium-101. This comparison showed that the excitation energies are essentially the same down to the magic neutron number 50. The result is in stark contrast with recent results on the magnetic moments of indium nuclei from ISOLDE's CRIS experiment, which saw their remarkably constant value undergoing a surprisingly abrupt change at magic neutron number 82.

The researchers also compared the results with several sophisticated types of theoretical calculations, including "ab initio" calculations that attempt to describe nuclei from first principles. They found that all of the calculations struggle to predict the isomer excitation energies and the magnetic moments simultaneously.

The results will guide researchers in their effort to develop a fully ab initio description of the nucleus, which continues to make promising progress.

More information: L. Nies et al, Isomeric Excitation Energy for In99m from Mass Spectrometry Reveals Constant Trend Next to Doubly Magic Sn100, *Physical Review Letters* (2023). DOI: 10.1103/PhysRevLett.131.022502

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