The 'Magic' of Tin

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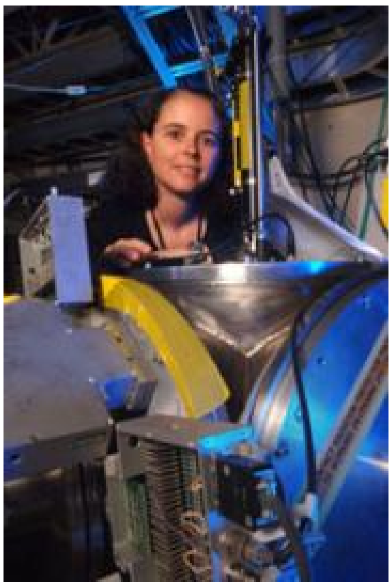

Credit: Oak Ridge Associated Universities Kate Jones, former Rutgers postdoctoral researcher, now assistant professor at the University of Tennessee

(PhysOrg.com) -- The metal tin lacks the value and prestige of gold, silver, and platinum -- but to nuclear physicists, tin is magic.

In the journal *Nature*, Rutgers physicists recently reported studies on tin that add knowledge to a concept known as magic numbers while perhaps helping scientists to explain how heavy elements are made in exploding stars.

Their research methods could also help other scientists and engineers develop next-generation nuclear reactors and gather forensic evidence in case rogue states or terrorists ever deploy nuclear weapons.

Physicists who study the nuclei of atoms - the dense cluster of protons and neutrons at the atom's center - apply the "magic" moniker to elements with a certain number of protons or combination of protons and neutrons. At these numbers - 2, 8, 20, 28, 50, 82, and 126 - the protons and neutrons are tightly bound together, giving many "magic" elements a high degree of stability in their nuclei.

Articulated by Maria Goeppert-Mayer and J. Hans D. Jensen during the 1940s, the concept was part of their nuclear shell model that earned them the Nobel Prize in physics in 1963. The concept is akin to noble gases such as helium and neon, which are stable and don't react with other elements because their numbers of electrons fill orbital shells.

Professor Jolie Cizewski and postdoctoral researcher Kate Jones, now an assistant professor at the University of Tennessee in Knoxville, wanted to boost the scientific community's knowledge of magic numbers by studying an isotope of tin that is, in fact, doubly magic - with 50 protons and 82 neutrons. Isotopes are different atomic forms of the same element, with the same number of protons but different numbers of neutrons.

Unlike other magic nuclei that are stable, however, this isotope of tin is fleeting. Its half-life, or the time it takes for half the material to radioactively decay, is 40 seconds. That's far too brief to conduct many direct studies of its nuclear properties.

Working at the Oak Ridge National Laboratory's Holifield Radioactive Ion Beam Facility, Jones and Cizewski created this short-lived but magic isotope of tin and immediately modified it by adding a single neutron - converting it from tin-132 (the isotope with 82 neutrons) to tin-133 (the isotope with 83 neutrons). By examining properties of an ejected particle in the course of producing tin-133, they could deduce properties of the doubly-magic isotope of tin that couldn't be studied directly.

Using funding from a 2003 Department of Energy National Nuclear Security Administration grant, Cizewski and her collaborators developed the technique that Jones applied to this study.

"The properties we're studying in our experiment have parallels to the formation of elements heavier than iron in stars," Cizewski said. "This form of tin may be formed in supernova explosions or collisions of neutron stars, and lies along the path to forming heavier elements."

The knowledge gained using this neutron transfer process for research could also help investigators if rogue states or terrorists ever fabricate and detonate a nuclear weapon. It could help scientists read a bomb's nuclear fission products like a fingerprint that could lead investigators to the suspected bomb builder.

Provided by Rutgers, The State University of New Jersey

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