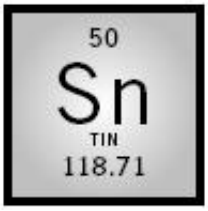
# Radioactive isotope of tin confirmed to have doubly magic nucleus

May 28 2010, by Lin Edwards




(PhysOrg.com) -- Scientists in the U.S. and U.K. have demonstrated that the short-lived radioactive and neutron-rich isotope tin-132 has a doubly magic nucleus.

Protons and neutrons in nuclei occupy orbital shells in a similar way to electrons in atoms. Nuclear magic numbers were first identified in 1948 by Maria Goeppert-Mayer, who shared in the 1963 Nobel prize for physics for her work on developing the nuclear shell model. Nuclear magic numbers are the numbers of nucleons (protons or neutrons) that form full (closed) outer shells in an atomic nucleus, like the magic numbers of electrons in helium, neon and other noble (super-stable) gases. The magic numbers for nuclei are 2, 8, 20, 28, 50, 82, and 126, while for electrons the magic numbers are 2, 8, 18, 32, and 50.

Magic proton or neutron numbers give the nucleus greater stability and stronger binding, and are therefore usually more common than nuclei

with unfilled orbital shells. In doubly magic nuclei both proton and neutron shells are filled, leading to even stronger binding and stability. The outer shells of doubly magic nuclei are rigidly spherical.

Other confirmed doubly magic nuclei include helium-4, oxygen-16, lead-208, calcium-49, and nickel-48, which are abundant and stable, and nickel-56, which was discovered in 1998 and is less stable than the others, having a half-life of just 5.9 days. Tin-132 is even more unstable with a half-life of only four seconds, which has made confirmation of its doubly magic nature difficult. It has 50 protons and 82 neutrons, and is the first confirmed doubly magic isotope that is both neutron-rich and radioactive.

Kate Jones, from the Department of Physics and Astronomy at the University of Tennessee in Knoxville, Tennessee, and her colleagues used a cyclotron reactor at the Oak Ridge National Laboratory dating from the 1950s to carry out the experiments. Jones said they were excited to have managed the feat, when most people thought it would not be possible until newer facilities were available.

One method used to identify doubly magic nuclei has been to strip neutrons from the isotope and examine the properties of the stripped-off neutrons to infer the structure of the nucleus. To do this a film is made of the isotope in question, and this is then hit with a beam of deuterium (an isotope of hydrogen having one proton and one neutron).

Tin-132's extremely short half-life made this process impossible, so Jones and her team reversed it, using the isotope as the firing beam instead of as the film being hit. They accelerated a beam of tin-132 to about 10 percent of the speed of light and fired it at a target of deuterated polyethylene. As the tin-132 collides with the target some of the neutrons are stripped from the deuterium molecules to form tin-133, leaving the deuterium proton to fall back to the target.

The researchers then analyzed the energy and angular distribution of the particles and were able to confirm the stripped neutron fell into a separate orbital shell above the closed inner shells of tin-132, which means the nucleus must be robustly spherical as expected for a doubly magical nucleus.

The research findings will help physicists studying what is called the R-process, which is thought to be the process by which over half the elements heavier than iron are created through a series of neutron captures on seed nuclei such as nickel-56, probably in neutron star mergers or in collapsing supernovae.

The research paper is published in the journal *Nature*.

**More information:** The magic nature of 132Sn explored through the single-particle states of 133Sn, Nature 465, 454-457 (27 May 2010) doi:10.1038/nature09048