Excited Sodium-32 with a Spherical Wave Function

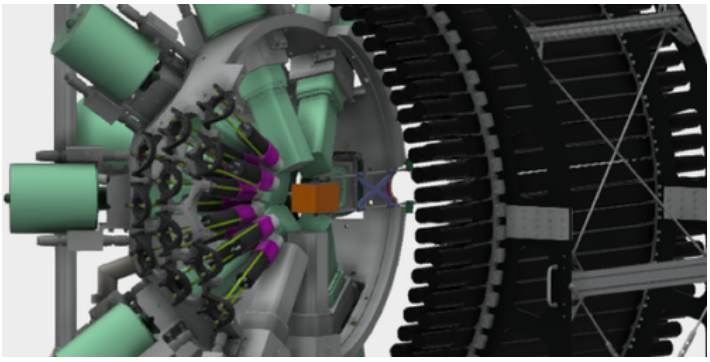
Researchers may have found an unstable sodium nucleus that has an excited state with a spherical wave function—an elusive prospect for the study of nuclear shapes.

By **Martin Rodriguez-Vega**

The wave functions of a nucleus are either spherical or deformed. Typically, for a nucleus with a long-lived (more than 5 nanoseconds) excited state known as an isomer, either the ground state's wave function is spherical and the isomer's wave function is deformed, or the ground state's and the isomer's wave functions are both deformed. A nucleus with a deformed ground-state wave function and a spherical isomer wave function has yet to be definitively observed. That observation may now be on the horizon. In data collected during the first experiment at the Facility for Rare Isotope Beams (FRIB) in Michigan, Timothy Gray of Oak Ridge National Laboratory in Tennessee and collaborators have found a previously unseen isomer of sodium-32 (^{32}Na) that has a wave function that calculations indicate could be spherical or deformed [**1**]. The finding leaves open the possibility that they have observed the elusive excited spherical system.

The FRIB experiment involved aiming at a detector a beam of excited ^{32}Na nuclei, about 1.8% of which were later found to be the new isomer. The detector "stopped" the nuclei, causing them to decay to their ground states via the emission of two gamma rays. By measuring the time delay between the arrival of the nuclei at the detector and the emission of the gamma rays, the team deduced that the new ^{32}Na isomer has a lifetime of 24 microseconds. This lifetime is the longest for an isomer with approximately 20 to 28 neutrons that decays by emitting gamma rays.

Numerical calculations performed by the team offer two possible explanations for the wave-function shape of such a nucleus: it is either spherical with six units of angular momentum or deformed with none. Measurements of the spatial angular correlations between the two emitted gamma rays could help determine the correct explanation. Such measurements may be possible after upcoming upgrades to the FRIB facility.



Credit: G. Hollenhead/ORNL

Martin Rodriguez-Vega is an Associate Editor for *Physical Review Letters*.

REFERENCES

1. T. J. Gray *et al.*, "Microsecond isomer at the $N = 20$ island of shape inversion observed at FRIB," **Phys. Rev. Lett. 130, 242501 (2023).**