Argonne's pioneering user facility to add magic number factory

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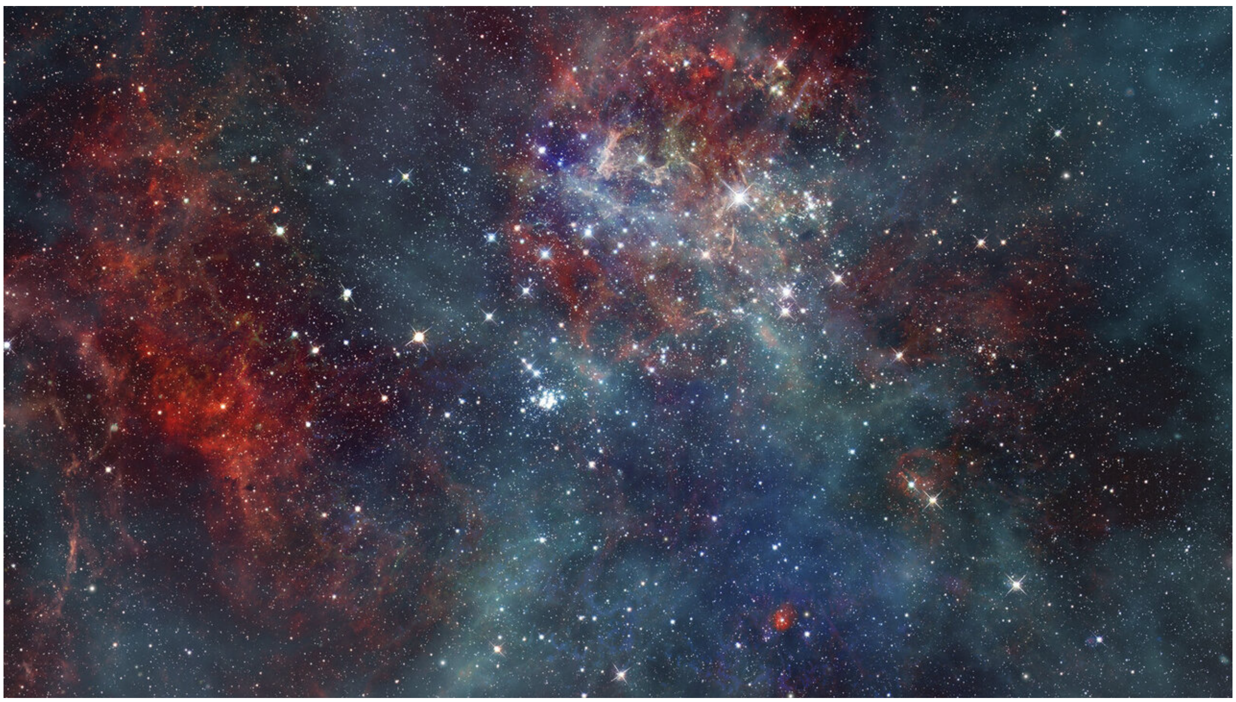

Credit: NASA images

One of the big questions in physics and chemistry is, how were the heavy elements from iron to uranium created? The Argonne Tandem Linac Accelerator System (ATLAS) at the U.S. Department of Energy's (DOE) Argonne National Laboratory is being upgraded with new capabilities to help find the answer to that question and many others.

Of five DOE Office of Science user facilities at Argonne, ATLAS is the longest lived. "Inaugurated in 1978, ATLAS is ever changing and developing new technological advances and responding to emerging research opportunities," says ATLAS director Guy Savard. It is now being outfitted with an "N = 126 factory," scheduled to go online later this year. This new capability will soon be producing beams of heavy atomic nuclei consisting of 126 neutrons. This is made possible, in part, by the addition of a cooler-buncher that cools the beam and converts it from continuous to bunched.

For many decades, ATLAS has been a leading U.S. facility for nuclear structure research and is the world-leading facility in the provision of stable beams for nuclear structure and astrophysics research. ATLAS can accelerate beams ranging across the elements, from hydrogen to uranium, to high energies, then it smashes them into targets for studies of various nuclear structures.

Since its inception, ATLAS has brought together the world's leading scientists and engineers to solve some of the most complex scientific problems in nuclear physics and astrophysics. In particular, it has been instrumental in determining properties of atomic nuclei, the core of matter and the fuel of stars.

The forthcoming N = 126 factory will be generating beams of atomic nuclei with a "magic number" of neutrons, 126. As Savard explains, "Physics has seven magic numbers: 2, 8, 20, 28, 50, 82 and 126. Atomic nuclei with these numbers of neutrons or protons are exceptionally stable. This stability makes them ideal for research purposes in general."

Scientists at ATLAS will be generating N = 126 nuclei to test a reigning theory of astrophysics—that the rapid capture of neutrons during the explosion and collapse of massive stars and the collision of neutron stars is responsible for the formation of about half the heavy elements from iron through uranium.

The N = 126 factory will be accelerating a beam composed of a xenon isotope with 82 neutrons into a target composed of a platinum isotope with 120 neutrons. The resulting collisions will transfer neutrons from the xenon beam into a platinum target, yielding isotopes with 126 neutrons and close to that amount. The very heavy neutron-rich isotopes are directed to experimental stations for study.

"The planned studies at ATLAS will provide the first data on neutron-rich isotopes with around 126 neutrons and should play a critical role in understanding the formation of heavy elements, the last stage in the evolution of stars," said Savard. "These and other studies will keep ATLAS at the frontier of science."

The architects of the "N = 126 factory" include Savard, as well as Maxime Brodeur (University of Notre Dame), Adrian Valverde (joint appointment with University of Manitoba), Jason Clark (joint appointment with University of Manitoba), Daniel Lascar (Northwestern University) and Russell Knaack (Argonne's Physics division).

The authors recently published two papers on the subject in Nuclear Instruments and Methods in Physics Research B, "The N = 126 Factory: A New Facility to Produce Very Heavy Neutron-Rich Isotopes" and "A Cooler-Buncher for the N = 126 Factory at Argonne National Laboratory."

More information: G. Savard et al, The N = 126 factory: A new facility to produce very heavy neutron-rich isotopes, *Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms* (2019). DOI: 10.1016/j.nimb.2019.05.024

A.A. Valverde et al. A cooler-buncher for the N=126 factory at Argonne

National Laboratory, *Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms* (2019).
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