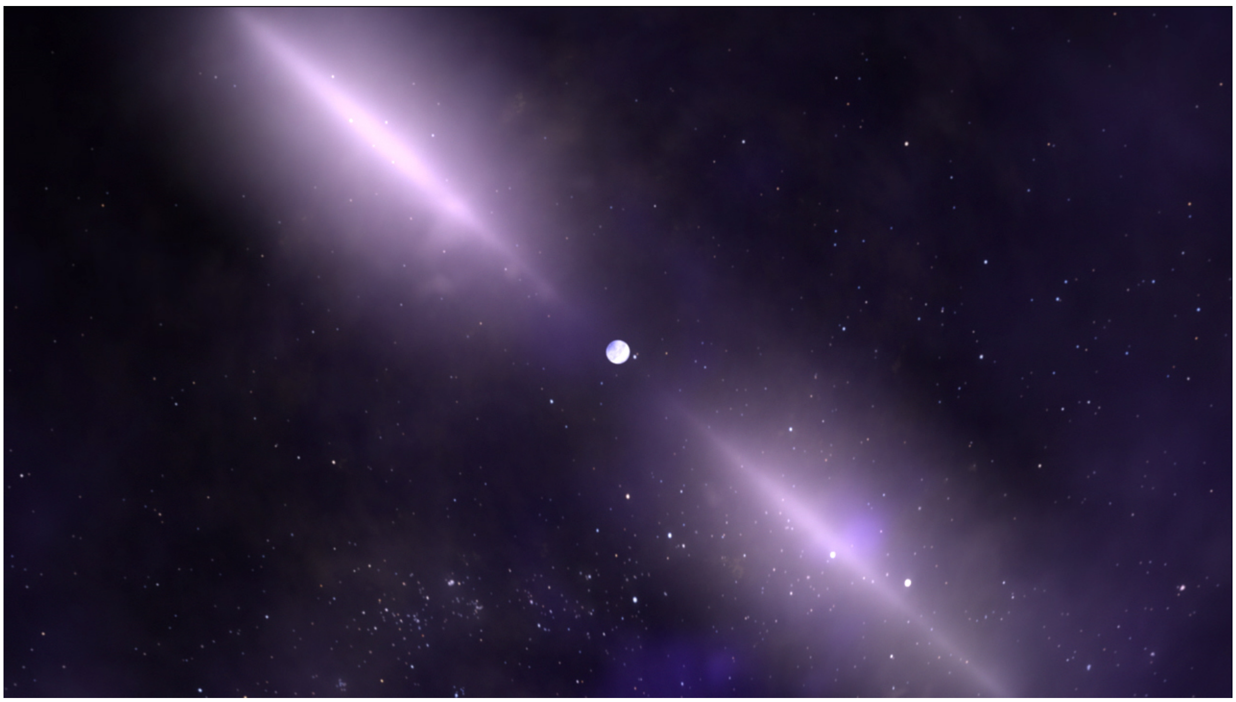
NASA continues to study pulsars, 50 years after their chance discovery

August 1 2017, by Clare Skelly



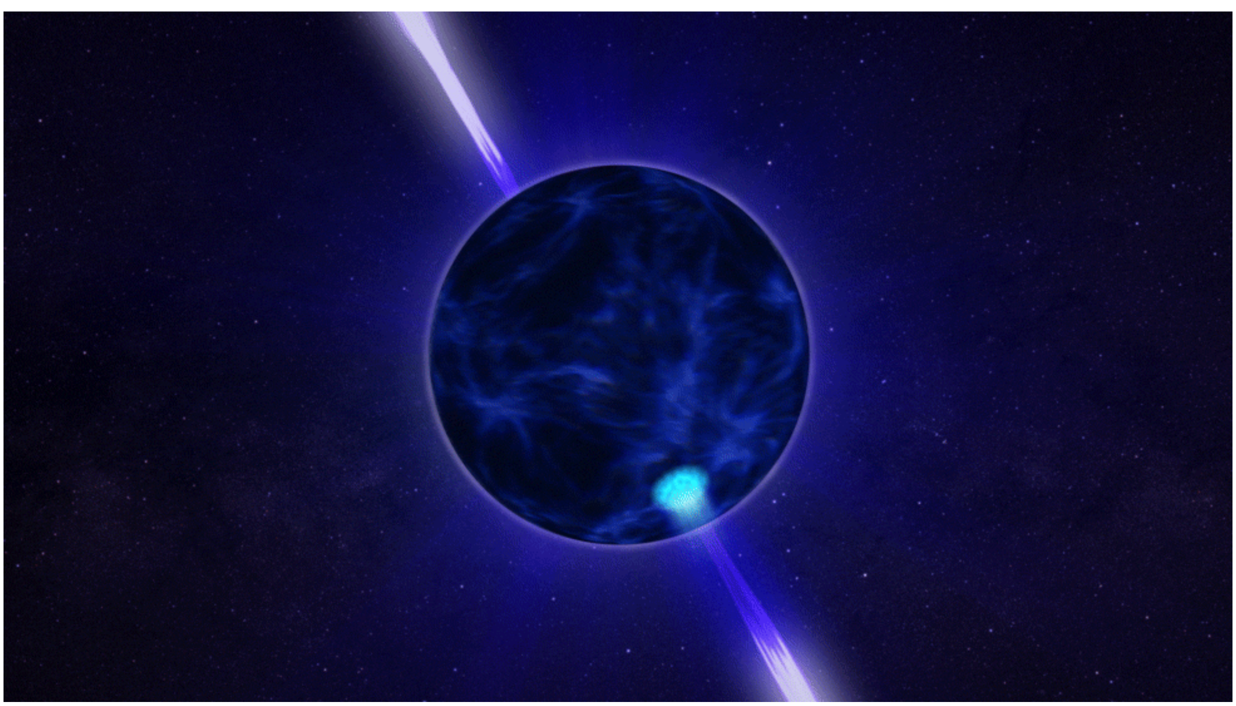
This artists concept shows the two jets from a pulsar. Credit: NASA's Goddard Space Flight Center

A little bit of "scruff" in scientific data 50 years ago led to the discovery of pulsars—rapidly spinning dense stellar corpses that appear to pulse at Earth.

Astronomer Jocelyn Bell made the chance discovery using a vast radio telescope in Cambridge, England. Although it was built to measure the random brightness flickers of a different category of celestial objects called quasars, the 4.5 acre telescope produced unexpected markings on Bell's paper data recorder every 1.33730 seconds. The pen traces representing radio brightness revealed an unusual phenomenon.

"The pulses were so regular, so much like a ticking clock, that Bell and her supervisor Anthony Hewish couldn't believe it was a natural phenomenon," said Zaven Arzoumanian of NASA's Goddard Space Flight Center in Greenbelt, Maryland. "Once they found a second, third and fourth they started to think differently."

The unusual stellar objects had been previously predicted but never observed. Today, scientists know of over 2,000 pulsars. These rotating "lighthouse" neutron stars begin their lives as stars between about seven and 20 times the mass of our sun. Some are found to spin hundreds of times per second, faster than the blades of a household blender, and they possess enormously strong magnetic fields.



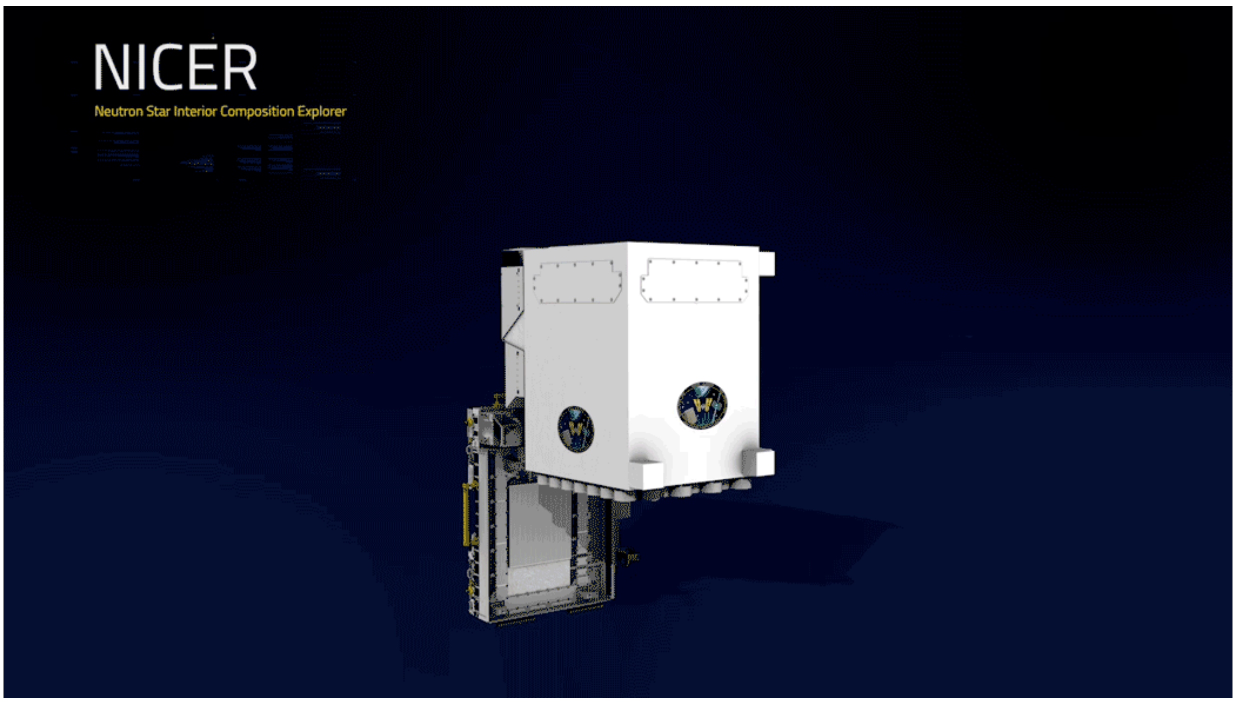
Most known neutron stars are observed as pulsars, emitting narrow, sweeping beams of radiation. They squeeze up to two solar masses into a city-size volume, crushing matter to the highest possible stable densities. To explore these exotic states of matter, NICER measures X-ray emissions across the surfaces of neutron stars as they spin, ultimately confronting the predictions of nuclear physics theory. Credit: NASA's Goddard Space Flight Center

Technology advances in the past half-century allowed scientists to study these compact stellar objects from space using different wavelengths of light, especially those much more energetic than the radio waves received by the Cambridge telescope. Several current NASA missions continue to study these natural beacons.

The Neutron star Interior Composition Explorer, or NICER, is the first NASA mission dedicated to studying pulsars. In a nod to the anniversary of Bell's discovery, NICER observed the famous first pulsar, known today as PSR B1919+21.

NICER launched to the International Space Station in early June and started science operations last month. Its X-ray observations - the part of the electromagnetic spectrum in which these stars radiate both from their million-degree solid surfaces and from their strong magnetic fields - will reveal how nature's fundamental forces behave within the cores of these objects, an environment that doesn't exist and can't be reproduced anywhere else. "What's inside a pulsar?" is one of many long-standing astrophysics questions about these ultra-dense, fast-spinning, powerfully magnetic objects.

The "stuff" of pulsars is a collection of particles familiar to scientists from over a century of laboratory studies on Earth—neutrons, protons, electrons, and perhaps even their own constituents, called quarks. However, under such extreme conditions of pressure and density, their behavior and interactions aren't well understood. New, precise measurements, especially of the sizes and masses of pulsars are needed to pin down theories.



NICER is currently installed on the International Space Station. This turntable animation of the payload calls out the locations of NICER's star tracker camera, electronics, space station attachment mechanism, 56 sunshields, pointing actuators and stow/deploy actuator. Credit: NASA's Goddard Space Flight Center

"Many nuclear-physics models have been developed to explain how the make-up of neutron stars, based on available data and the constraints they provide," said Goddard's Keith Gendreau, the principal investigator for NICER. "NICER's sensitivity, X-ray energy resolution and time resolution will improve these by more precisely measuring their radii, to an order of magnitude improvement over the state of the art today."

The mission will also pave the way for future space exploration by helping to develop a Global Positioning System-like capability for the galaxy. The embedded Station Explorer for X-ray Timing and Navigation Technology, or SEXTANT, demonstration will use NICER's X-ray observations of pulsar signals to determine NICER's exact position in orbit.

"You can time the pulsations of pulsars distributed in many directions around a spacecraft to figure out where the vehicle is and navigate it anywhere," said Arzoumanian, who is also the NICER science lead. "That's exactly how the GPS system on Earth works, with precise clocks flown on satellites in orbit."

Scientists have tested this method using computer and lab simulations. SEXTANT will demonstrate pulsar-based navigation for the first time in space.

NICER-SEXTANT is the first astrophysics mission dedicated to studying pulsars, 50 years after their discovery. "I think it is going to yield many more scientific discoveries than we can anticipate now," said Gendreau.

Provided by NASA's Goddard Space Flight Center