

A101 Slide Set: Shockingly Bright Pulsar

- Developed by the *NuSTAR* EPO Group
 - at
- Sonoma State University

Topic: Pulsars, X-rays, black holes

Concepts: multi-wavelength observations, galactic and stellar evolution

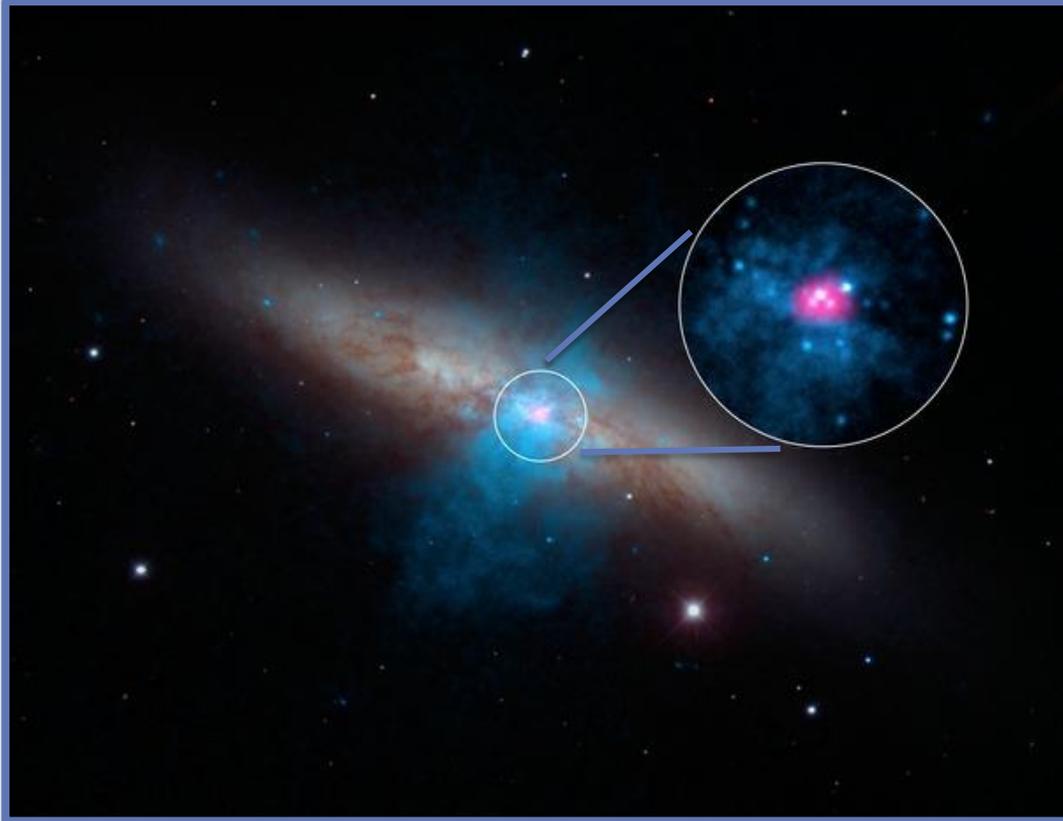
Missions: NuSTAR, Chandra, Swift

Coordinated by
the NASA Astrophysics Forum

An Instructor's Guide for using the slide sets is available at the ASP website

<https://www.astrosociety.org/education/resources-for-the-higher-education-audience/>

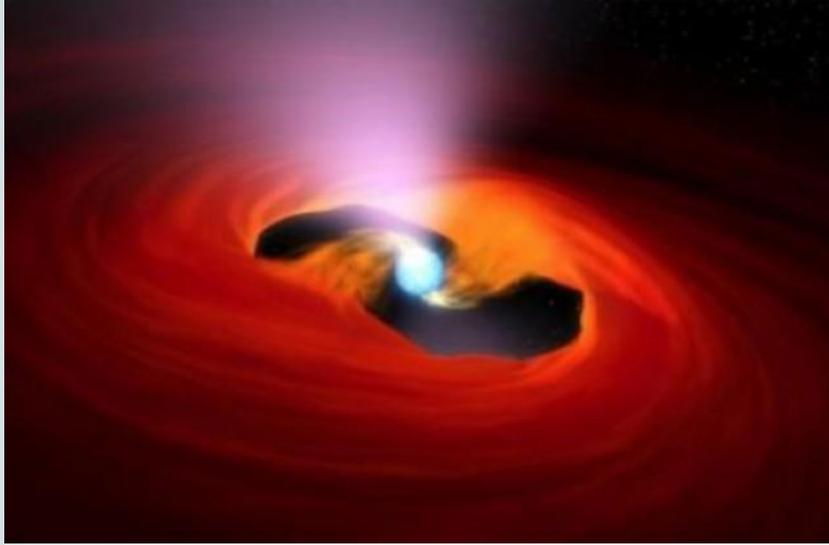
The Discovery



High-energy X-rays (pink), streaming from the brightest pulsar found to date, can be seen in this image combining multi-wavelength data from three telescopes: NOAO's 2.1m telescope at Kitt Peak provides the visible light image of the galaxy M82, Chandra adds low-energy X-ray emissions (blue), and NuSTAR adds the high-energy X-ray emissions coming from the pulsar. Credit: NASA/JPL-Caltech/SAO/NOAO.

- Astronomers have found the brightest pulsar ever recorded in the galaxy Messier 82 (M82), “beaming” with the energy of about 10 million suns.
- This neutron star—the collapsed core of a massive star, spins once every 1.37 seconds; as its emitted beams of X-rays sweep past our line of sight, the star appears to “pulse.”
- The object was previously thought to have been an intermediate-mass black hole, so astronomers now have to figure out how a single spinning, pulsing neutron star can emit so much energy.

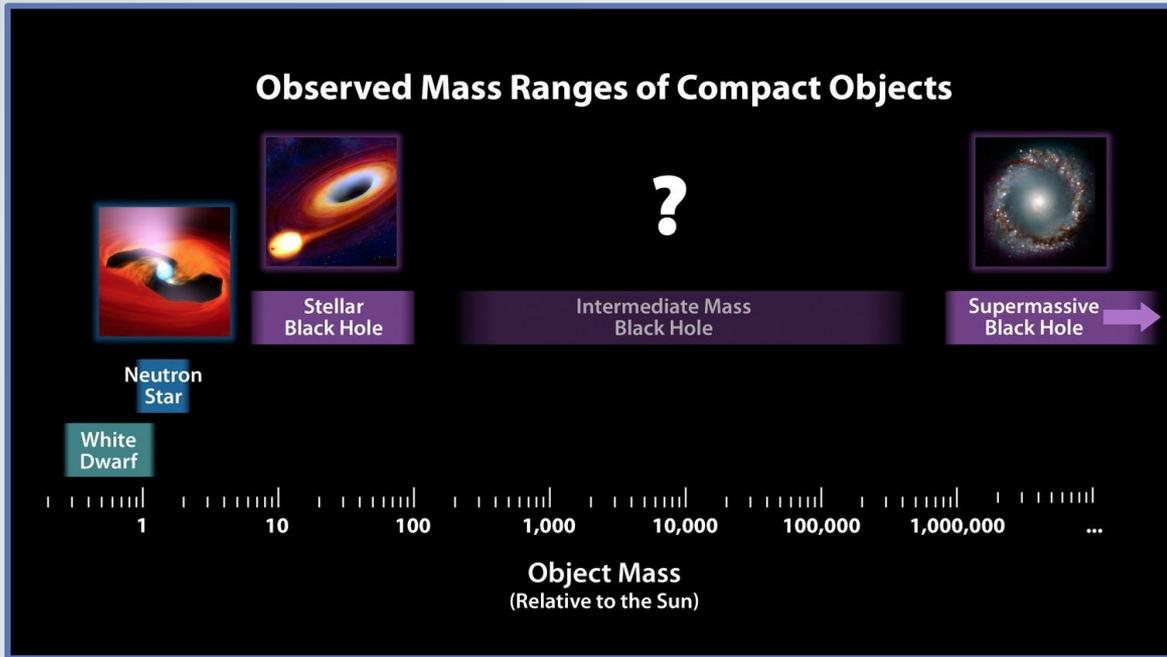
How was the Discovery Made?



Artist's conception of the pulsar sweeping up surrounding material and beaming X-rays. Credit: Optical: DSS; Illustration: NASA/CXC/M. Weiss.

- The *NuSTAR* (Nuclear Spectroscopic Telescopes Array) high energy X-ray mission observed M82 seven times in early 2014.
- NuSTAR's sensitivity to high energy X-rays and its capability to precisely measure the timing of energy signals made it possible for the mission to serendipitously discover that one of the galaxy's "ultraluminous X-ray sources" was pulsing every 1.37 seconds.
- The Chandra and Swift X-ray missions observed the region and confirmed that the X-rays were coming from a pulsar.

The Big Picture

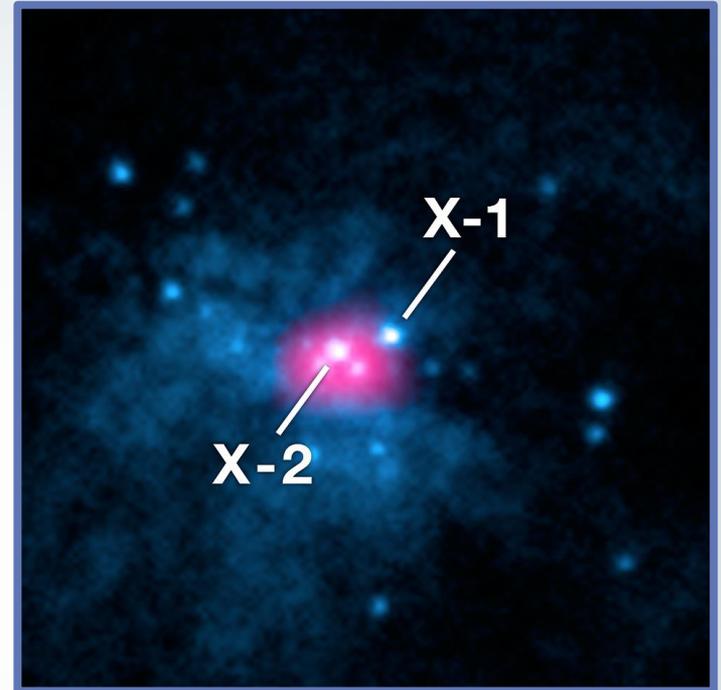


The chart illustrates the relative masses of super-dense cosmic objects, from white dwarf stars to supermassive black holes inhabiting the cores of most galaxies. Credit: NASA/JPL-Caltech/SAO.

- The newly identified pulsar is one of a class of objects called “ultraluminous X-ray sources,” or ULXs—which are extremely bright in X-ray emissions.
- ULXs were previously all suspected to be “intermediate mass” black holes—black holes up to a few hundred solar masses--accreting matter that heated and emitted X-rays in large quantities.
- Now, astronomers have to explain how a stellar-mass pulsar can act as extremely.

How Does this Change our View?

- Ultraluminous X-ray sources now appear to be more than one kind of object.
- Scientists will want to determine if the newly identified ULX pulsar is unusual or if others can be identified.
- Scientists will also need to figure out how a pulsar can accrete material and emit X-rays at the level of a black hole many times the pulsar's own mass.
- Sometimes new discoveries initially raise more questions than they answer; it is part of the process of science!



M82's ULX designated "X-1" appears to be a typical black hole, while the nearby newly-identified pulsar—designated "X-2"—is not. Scientists must explain how both can be ULXs. Credit: NASA/JPL-Caltech/SAO.

Resources

Press Release:

<http://www.nasa.gov/press/2014/october/nasa-s-nustar-telescope-discovers-shockingly-bright-dead-star>

Peer-Reviewed Paper:

<http://www.nature.com/nature/journal/v514/n7521/full/nature13791.html>

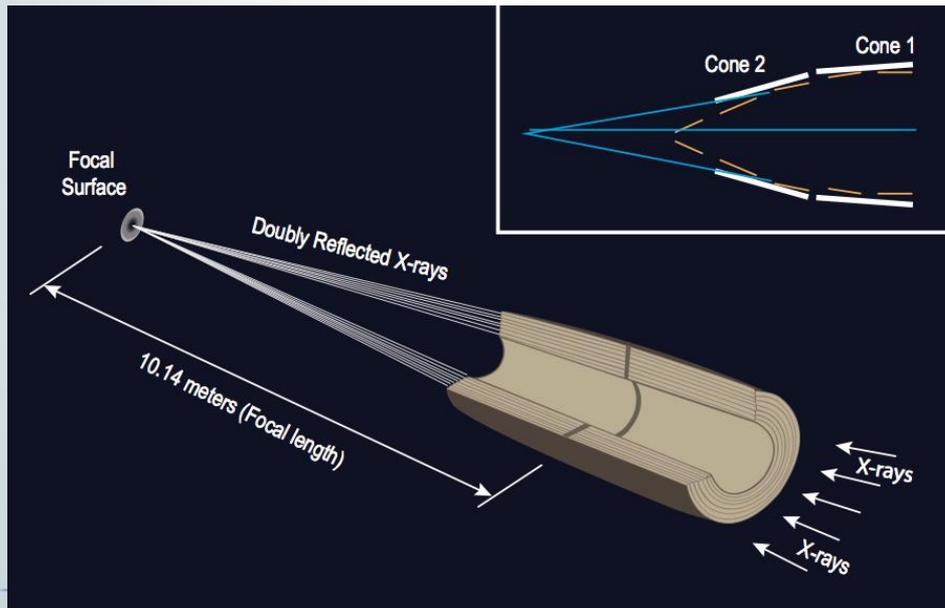
Shockingly Bright Pulsar

BONUS CONTENT

NuSTAR

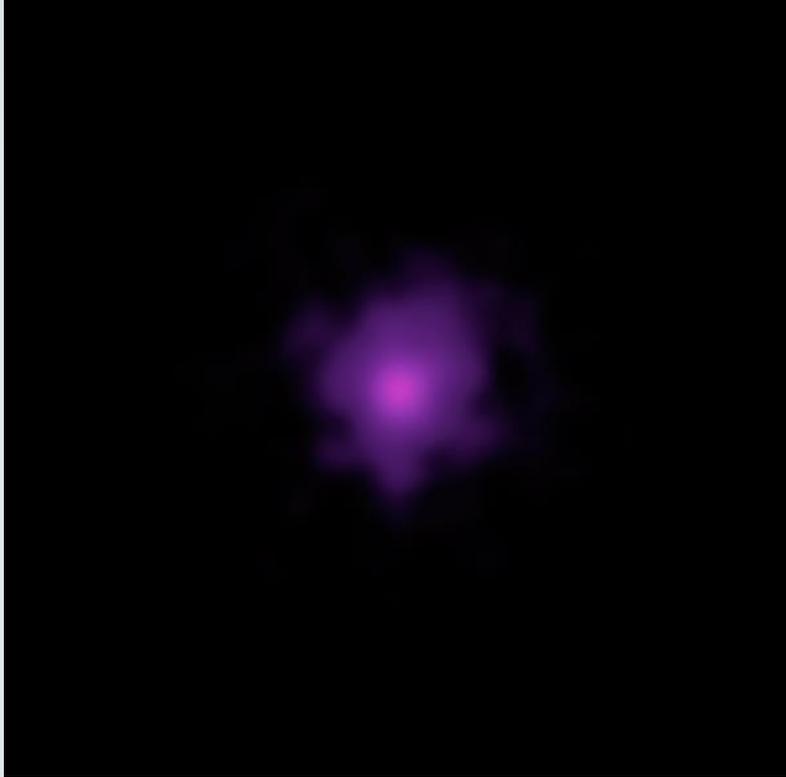
NASA's Nuclear Spectroscopic Telescope Array (NuSTAR) is the first satellite to focus high-energy X-rays into sharp images. It includes two focusing X-ray telescopes which capture images, and also measure the energy of each incoming X-ray.

Essential to the NuSTAR design is a deployable mast which extended to 10 meters after launch. This mast separates the X-ray optics from the detectors, a necessity to achieve the long focal length required by the optics design.



High energy X-rays will pass directly through most mirrors. Specialized Wolter-I mirrors reflect X-rays at grazing angles twice, once off an upper mirror section and again off a lower mirror section. Since the angles are so shallow, consecutive shells of mirrors, 133 in total, are nested tightly together to increase the collecting area. NuSTAR has two of these Wolter-I optical units.

Pulsar Animation



This animation flips back and forth between images captured by NuSTAR. The pulsar pictured here sends out X-ray beams that pass Earth every 1.37 seconds.

The animation was created by stacking images taken both while the pulsar was “on” and “off”, meaning its beams were either pointed toward Earth or away from us and not visible.