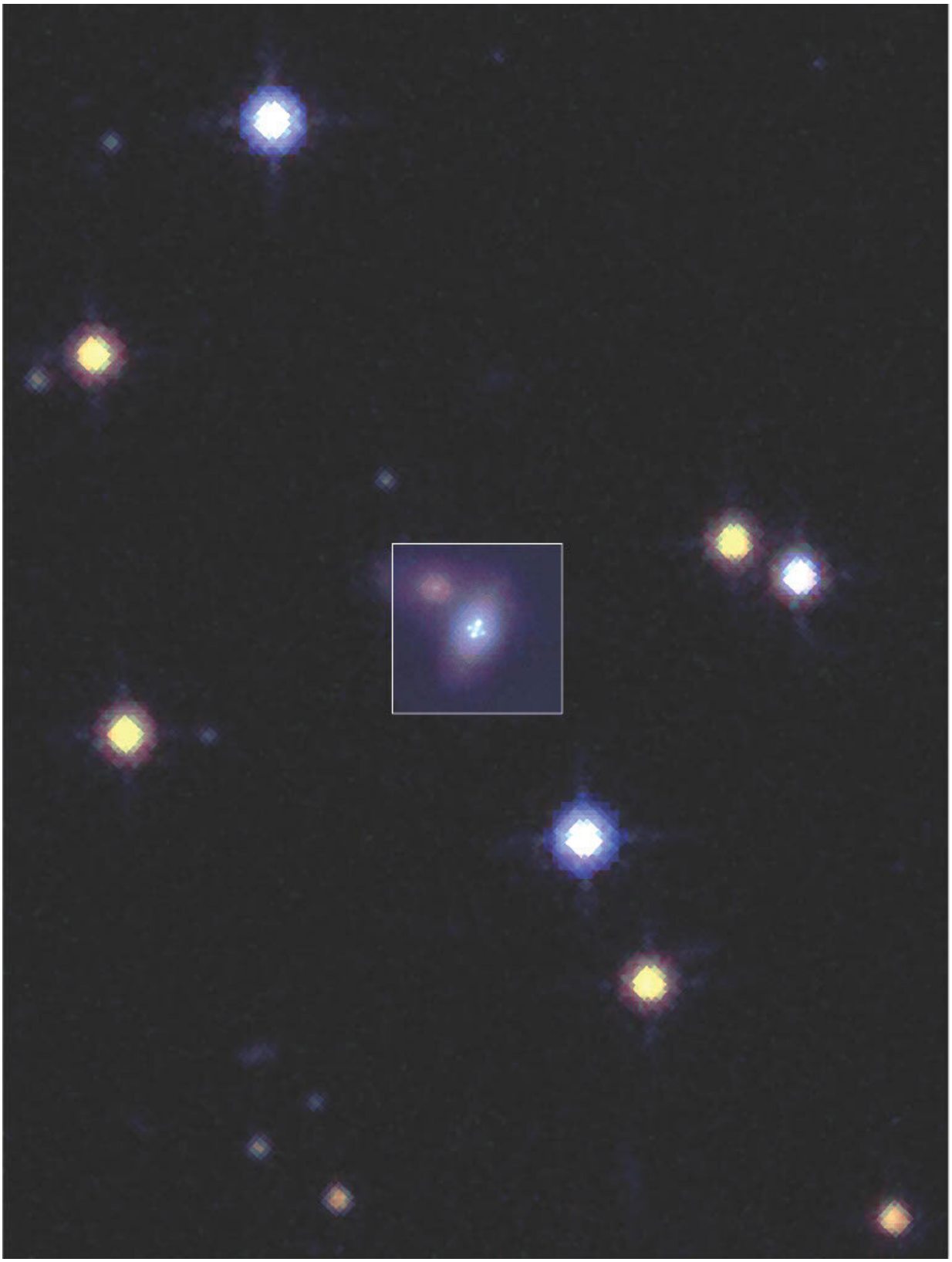
Astronomers discover supernova explosion through rare 'cosmic magnifying glasses'

June 12 2023, by Georgia Jiang



SN Zwicky. Credit: Joel Johansson, Stockholm University.

According to Einstein's general theory of relativity, time and space are fused together in a quantity known as spacetime. The theory suggests that massive objects, like a galaxy or galaxy clusters, can cause spacetime to curve.

Gravitational lensing is a rare yet observable example of Einstein's theory in action; the mass of a large celestial body can significantly bend light as it travels through spacetime, much like a magnifying lens. When light from a more distant light source passes by this lens, scientists can use the resulting visual distortions to view objects that would otherwise be too far away and too faint to be seen.

An international team of scientists, including University of Maryland astronomer Igor Andreoni, recently discovered an exceptionally rare gravitationally lensed supernova, which the team named "SN Zwicky." Located more than 4 billion light years away, the supernova was magnified nearly 25 times by a foreground galaxy acting as a lens.

The discovery presents a unique opportunity for astronomers to learn more about the inner cores of galaxies, dark matter and the mechanics behind universe expansion. The researchers published their findings—including a comprehensive analysis, spectroscopic data and imaging of SN Zwicky—in the journal *Nature Astronomy* on June 12, 2023.

"The discovery of SN Zwicky not only showcases the remarkable capabilities of modern astronomical instruments but also represents a significant step forward in our quest to understand the fundamental forces shaping our universe," said the paper's lead author Ariel Goobar,

who is also the director of the Oskar Klein Center at Stockholm University.

Initially detected at the Zwicky Transient Facility (ZTF), SN Zwicky was quickly flagged as an object of interest due to its unusual brightness. Then, using adaptive optics instruments on the W.M. Keck Observatory, the Very Large Telescopes and NASA's Hubble Space Telescope, the team observed four images of SN Zwicky taken from different positions in the sky and confirmed that gravitational lensing was behind the supernova's extraordinary radiance.

According to Andreoni, who is a postdoctoral associate in UMD's Department of Astronomy and NASA's Goddard Space Flight Center, supernovae like SN Zwicky play a crucial role in helping scientists measure cosmic distances.

"SN Zwicky not only is magnified by the gravitational lense, but it also belongs to a class of supernovae that we call 'standard candles' because we can use their well-known luminosities to determine distance in space," Andreoni explained. "When a source of light is farther away, the light is dimmer—just like seeing candles in a dark room. We can compare two light sources in this way and gain an independent measure of distance without having to actually study the galaxy itself."

In addition to being useful as a metric for cosmic distance, SN Zwicky also opens new avenues of research for scientists exploring the properties of galaxies, including dark matter (which is matter that does not absorb, reflect or emit light but make up the majority of matter in the universe).

Researchers also believe that lensed supernovae like SN Zwicky could prove to be very promising tools for examining dark energy (a mysterious force counteracting gravity and drives the accelerated

expansion of the universe) and refining current models describing the universe's expansion, including the calculation of the Hubble constant—a value that describes how fast the universe is expanding.

For Andreoni, who is preparing for the opening of the Vera Rubin Observatory in Chile, the team's success in identifying and analyzing SN Zwicky is only the beginning. Now still in its construction phase, the new observatory is expected to begin full operations in 2024 and build upon the team's findings as it takes multiple images of the entire visible sky to search for other supernovae and asteroids.

Andreoni believes that the "big picture" tactic used to find SN Zwicky will continue to help scientists gather large volumes of data about celestial events in the sky.

"This discovery paves the way to find more of such rare lensed supernovae in future big surveys that will help us study transient astronomical events like supernovae and gamma ray bursts," Andreoni said. "We look forward to more unexpected discoveries using broad, untargeted optical surveys of the sky like the one that helped us identify SN Zwicky. With this approach, we'll be able to probe the transient sky with an unprecedented depth."

More information: Ariel Goobar et al, Uncovering a population of gravitational lens galaxies with magnified standard candle SN Zwicky, *Nature Astronomy* (2023). DOI: 10.1038/s41550-023-01981-3. www.nature.com/articles/s41550-023-01981-3

Provided by University of Maryland