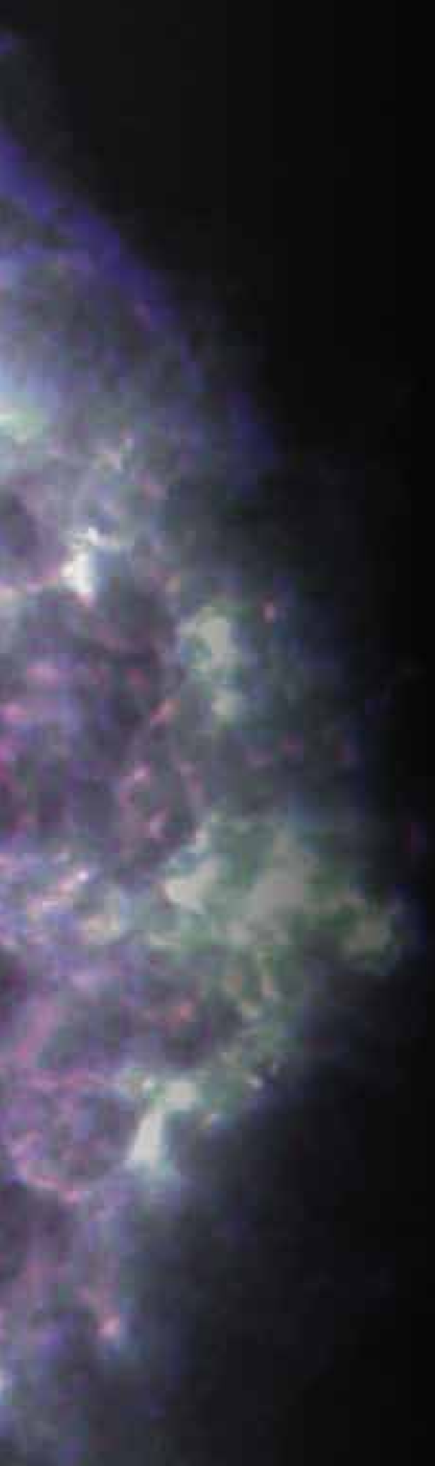


STARSTRUCK

By Nicole Sweeney Etter

Dr. Christopher Stockdale's fascination with supernovae could help us better understand the origins of the universe.

The famous astronomer Carl Sagan once said, “We are all star stuff.” Perhaps that’s why Dr. Christopher Stockdale, a Marquette assistant professor of physics, is fascinated with supernovae, the explosions of massive stars that are key to life on earth.

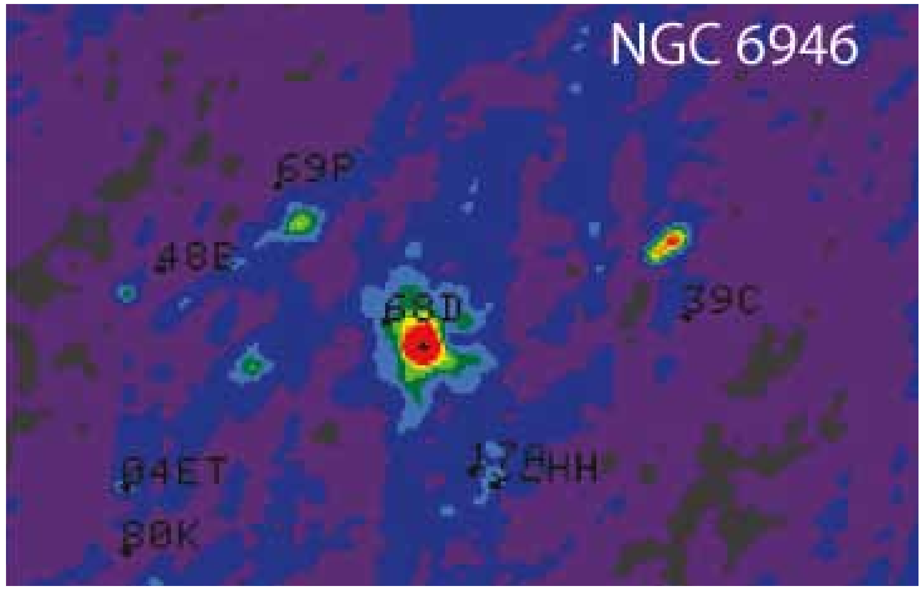
“If we want to understand on a fundamental level where we come from, we need to understand these huge massive stars and how they evolve,” Stockdale says.

Stockdale is part of an international collaboration that monitors X-ray, ultraviolet, infrared and radio emissions from extragalactic supernovae, and he leads the U.S. radio group. His work is funded by the National Aeronautics and Space Administration, and he frequently publishes in *Astrophysical Journal*, *Astronomy & Astrophysics*, and the *Monthly Notices of the Royal Astronomical Society*.

His team recently made an important discovery about the nature of a small subset of supernovae called Type IIb. This type of supernova has significantly less hydrogen (the key component of ordinary stars) in its composition than an ordinary supernova. This group may represent an important evolutionary transition in the life story of massive stars.

When a massive star dies, the force of the explosion forges new elements and scatters a multitude of other elements throughout the universe. Stars give birth to oxygen, carbon, nitrogen, iron and other elements essential to life. “It leads to a constant chemical enrichment of our galaxy,” Stockdale explains.

But there is a lot about supernovae that scientists don’t understand. “We quite frankly don’t understand how they happen,” Stockdale says. “When a star dies, the star falls in on itself, and the collapse causes an expansion, and we know the expansion happens because we’ve seen it. But the actual physics of how it goes from a collapse to an explosion, we don’t get yet.”

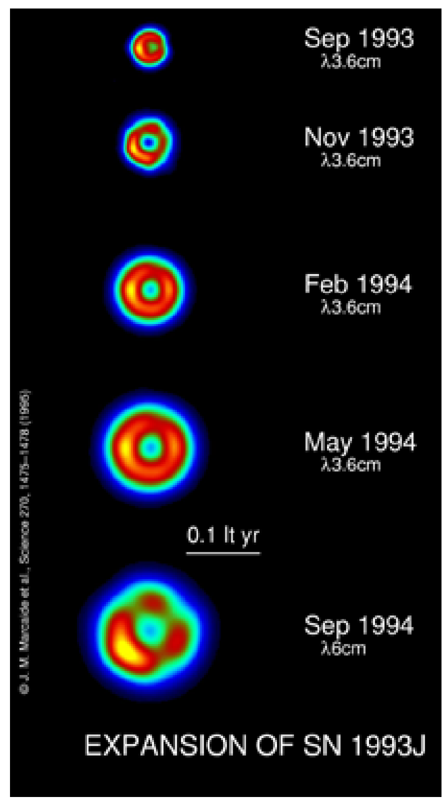


NGC 6946 is a nearby galaxy — about 20 to 25 million light years away — that is known as a starburst galaxy because of its frequent supernovae. It has had at least eight in the past 100 years. Image courtesy of Matt Kelley and Christopher Stockdale.

Supernovae are relatively rare. These massive stars have eight or 10 times the mass of our sun, and probably 1/100th of a percent of the stars in our galaxy are big enough to cause these kinds of explosions, Stockdale says. That’s one reason why his team typically focuses on galaxies at least 3 to 4 million light years away.

“In terms of our galaxy, we’re kind of out here in the sticks as opposed to being downtown in the city,” Stockdale says. “We’re not in a place where there’s a lot of violent activity going on, which is a good thing.”

So how does Stockdale’s team know when and where to look? Exploding stars briefly become the brightest objects in their galaxy, and astronomers around the world send announcements as soon as they notice something new. Stockdale gets an e-mail alert, quickly puts in a request for data collection from the National Radio Astronomy Observatory in



Supernovae 1993J is one the closest supernovae to be observed in the past 20 years. From this high-resolution study, astronomers can measure the speed of the supernova shockwave and strongly constrain the physical conditions in the region responsible for the radio and X-ray emissions. Image courtesy of J.M. Marcaide.

New Mexico and then analyzes the results.

"It's exciting stuff. Sometimes we're in the lab at 3 a.m.," he says.

Before stars die, they shed material in a slow-moving wind. Stars might shed 1/10,000th of a percent of their mass in a year, which over 10,000 years could be an entire sun's worth of material. When the star blows up, it sends out a shock wave that moves 10,000 times faster than the wind. Electrons in the gas get excited and swept up in the blast wave, and that leads to radio or X-ray waves that can be detected with a variety of telescopes. The X-ray and radio emissions from the shock wave could last 75 years after the initial blast or even longer.

"If you look at the radio emissions, you can actually piece together the density of the wind, and that can tell us what happened with the star before it died," Stockdale says. "It's an astrophysical forensic study, like *CSI* shows you on television."

Last year, Stockdale's team noticed a peculiar supernova belonging to the small subset of supernovae known as Type IIb. "The radio emissions rose and fell and were gone in about a month instead of taking years," he says. "So we're thinking that there are perhaps two types of objects. They look the same when you look through an optical telescope but inside are very different." Stockdale and others speculate that a companion star might have stolen some of its hydrogen and played a role in the star's death.

With so much unknown, it's an exciting field. "There's an element of discovery," Stockdale says. "We're always learning something new about how the universe works."

Image courtesy of NRAO/AUI

TOOLS OF THE TRADE

Stockdale primarily collects data from the National Radio Astronomy Observatory's Very Large Array, a collection of 27 dish antennae that are each as wide as a quarter of a football field. Together, the antennae work to form the most sensitive radio telescope available. However, scientists are working to upgrade the observatory into a new, stronger instrument called the Expanded Very Large Array, scheduled to be completed in 2011.

The EVLA will increase the telescope's sensitivity by a factor of 10, allowing scientists to see 250 million light years away. "It'll be like removing blinders and sunglasses," Stockdale says. That will allow Stockdale's team to study nearby supernovae for longer and also increase the sample size of the newest class of supernovae. Up until this point, scientists have only been able to study a handful of the Type IIb supernovae.

Stockdale also uses a technique called Very Long Baseline Interferometry, which allows him to use data from telescopes around the world. "You can get a view that's essentially the size of the earth," he explains. That technique allowed scientists to see the shock wave of one supernovae expanding and accelerating. "That is remarkable to be able to do," he says. "Most supernovae are so far away that even with a telescope the size of the earth, you're never going to be able to see the shock wave."

In 2007, Dr. J.M. Marcaide at the University of Valencia, a member of Stockdale's team, published the results of the first comprehensive VLBI study of a Type IIb supernova that was first seen on Earth in 1993.