Astronomers pin down origins of 'mile markers' for expansion of universe

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Pinwheel Galaxy and SN2011fe. Credit: Lawrence Berkeley National Laboratory

(Phys.org)—A study using a unique new instrument on the world's largest optical telescope has revealed the likely origins of especially bright supernovae that astronomers use as easy-to-spot "mile markers" to measure the expansion and acceleration of the universe.

In a paper to appear in the Astrophysical Journal, researchers describe observations of recent supernova 2011fe that they captured with the Large Binocular Telescope (LBT) using a tool created at Ohio State University: the Multi-Object Double Spectrograph (MODS).

MODS measures the frequencies and intensities of light shining from a star. Stars shine at different frequencies depending on the chemical elements they are made of; a star like the sun, which is made mostly of hydrogen, shines at different frequencies than a star that is made mostly of helium. So astronomers can use spectra to determine what a particular star is made of.

Based on the frequencies of light emanating from supernova 2011fe, this type of supernova – known as Type Ia – is most likely caused by the interaction between a pair of dead stars known as white dwarfs, the astronomers concluded. One white dwarf orbits the other and sheds material onto it, until the other white dwarf becomes unstable and explodes, shining billions of times brighter than the sun.

Astronomers worldwide have tried to confirm the origin of Type Ia supernovae for decades. Groups have proposed several different hypotheses, including exotic scenarios involving white dwarfs paired with still-"living" giant stars, or even stars like the sun.

Kris Stanek, professor of astronomy at Ohio State and a co-author of the study, explained why settling this issue is important.

"We really want to know more about these supernovae, given their importance in our understanding of how the universe is expanding," he said. "Many observations have been done over the years, and I think many astronomers are starting to accept one explanation – that two white dwarfs are probably responsible."

Still, the alternative theories keep re-emerging, he said: "like zombies that won't die."

"With this study, we were looking for a zombie 'kill shot,' and we think we found it."

Rick Pogge, professor of astronomy and lead designer of MODS, said that the spectrograph is the ideal tool for settling the debate.

"MODS is one of the most sensitive optical spectrometers in operation today, and being used on what is currently the world's largest optical telescope. If we couldn't kill this debate with MODS and the LBT, something would be dreadfully wrong," he added.

Type Ia supernovae make good mile markers for the universe because their extreme brightness – 5 billion times brighter than the sun – makes them easy to see, and their distinctive pattern of brightening and dimming in the weeks after they appear makes them easily identifiable.

Astronomers use that information to calculate the distance from Earth to the supernova, and in turn, calculate how fast the universe is expanding. Knowing more about the composition of the stars that create the supernovae could open up new ideas in the understanding of that expansion.

Here's what nearly all astronomers agree on: Type Ia supernovae originate in binary systems, where one star or star-like object is orbiting another. The main object – the one that initiates the explosion – is a white dwarf, the massive remnants of a dead star. Over time, the white dwarf's gravity peels off gas and dust from the companion and absorbs that material. Eventually, the white dwarf becomes unstable, and explodes in a supernova.

At issue, explained lead study author and doctoral student Ben Shappee, is the identity of the white dwarf's companion – is it another white dwarf, or a giant star, or even a star like our sun?

The Ohio State astronomers found their answer in the light spectrum emanating from the supernova. If the companion were a star like ours, or even a giant star, a sizeable portion of the debris blown away from the supernova would contain atoms of the element hydrogen.

Supernova 2011fe provided a good chance for the researchers to test for the presence of hydrogen. Located in the Pinwheel Galaxy some 21 million light-years away, it was the closest near-Earth Type Ia supernova to occur in the last 20 years.

"If the companion were a star such as ours or even a red giant, we would expect to see a lot of hydrogen in the signal – maybe even half a solar mass' worth, as the companion was blown away. But instead, we saw at most only one tenth of one percent of a solar mass' worth of hydrogen. That suggests that the white dwarf's companion had very little if any hydrogen in it, and is likely another white dwarf," Shappee said.

Pogge called the study "a beautiful demonstration of the kind of data we are able to get on a routine basis with the LBT and MODS. Our entire instrument team is very proud of how well MODS is working."

In fact, this study was done with only one half of the MODS system – MODS1 – which is currently installed on one mirror of the LBT. It's twin, MODS2, is currently under construction in Columbus and scheduled to be installed on the second mirror in early 2013.

More information: arxiv.org/abs/1210.3027

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