Department of Physics & Astronomy

PHYSICS NEWS FLASH

UT Physicist Gets Down with the White Dwarf

Astronomers Identify the Source for Earth's Iron and the Universe's "Standard Candles"

Research Assistant Professor Raphael Hix is co-author of a paper reporting that astronomers have made a major step forward in identifying the type of star that will become a white dwarf supernova. Dr. Hix works with the Theoretical Astrophysics Group at Oak Ridge National Laboratory.

White dwarf supernovas have given us most of the iron that the Earth is largely made of and helped us measure the size and age of the universe, but exactly what kind of star causes these explosions has remained a matter of debate. Now, astronomers are reporting that they have made a major step forward in identifying objects known as "Super Soft X-Ray Sources" as the type of star that will become a white dwarf supernova.

The report was presented January 6 to the American Astronomical Society meeting in Atlanta, Georgia. The authors are Sumner Starrfield and Steve Dwyer (Arizona State University), Dr. Hix, Frank Timmes and Warren Sparks (Los Alamos National Laboratory), and Edward Sion (Villanova University).

More information on the AAS meeting is available from the meeting Web site (http://www.aas.org/meetings/aas203/). The site includes an abstract of the paper as well. *Sky and Telescope Magazine* has already reported on this work.

The result is of extreme interest because white dwarf supernovas are important events in the universe and have produced most of the iron on our Earth. They are also extremely similar in their energy output and are used by astronomers as "standard candles" to measure distance, time and the evolution of the Universe. There are two major types of supernovas, one that occurs during the death of a massive star and the other which has been proposed to occur on a white dwarf star which is a member of a binary star system. Observations of the supernovas that occur as a result of the explosion of a white dwarf show that they eject mostly elements like iron but no hydrogen or helium. Since hydrogen and helium are the most abundant elements in the universe and provide the nuclear fuel for the lives of the stars that we see in the sky, these explosions must occur on evolved stars that have earlier consumed all their hydrogen and helium fuel. Although there are a number of types of binary star systems that contain a white dwarf, these systems show evidence for large amounts of hydrogen and helium that would be seen if the white dwarf exploded.

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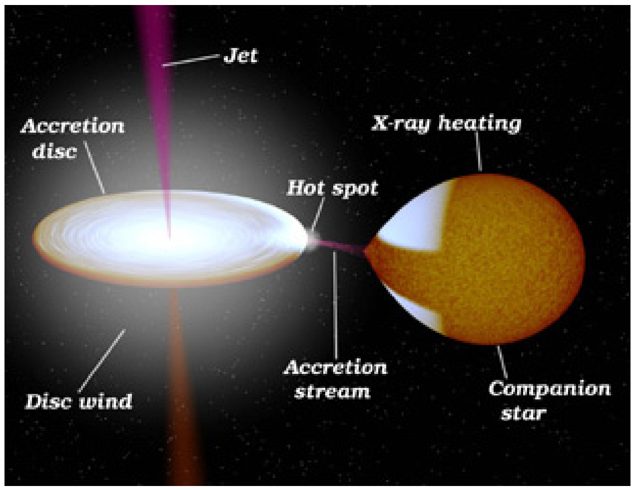

There has been a great deal of speculation about the kind of binary systems that produce white dwarf supernovas, but the models now computed by our group fit the observations of the Super Soft X-ray sources and suggest that they are good candidates.

Super Soft X-ray Sources were recently discovered by a German X-ray satellite, ROSAT, as a class of binary systems where the white dwarf was extremely hot and bright. Since they emit a lot of light in low energy (soft) X-rays, astronomers named them Super Soft X-ray Sources. The other star in a Super Soft X-ray source is thought to be much like our own Sun. Gas is lost by the Sun-like star and this gas falls onto the white dwarf.

"Our calculations show that an Earth mass of material must be falling onto the white dwarf every few years," says Starrfield. "At these high rates we find that hydrogen fuses to helium at the very surface of the white dwarf." Our calculations also fit the observed properties of the Super Soft Sources and predict that as the gas falls onto the surface, the layer of helium under the surface gradually grows in mass and gets hotter and more dense so that the helium fuses to carbon and oxygen and maybe even heavier elements.

Because the gas is accumulating on the surface of the white dwarf and not being blown into space in smaller explosions, the total mass of the white dwarf grows. After many years of evolution, the core of the white dwarf becomes so dense that an explosion occurs and is observed as a white dwarf supernova.

"Since our calculations show that all the hydrogen and helium have already undergone nuclear fusion to heavier elements, we have now explained why these elements are not seen in observations of white dwarf supernovas" Says Timmes.

"The observable properties of our models agree with the observations of Super Soft X-ray Sources, so we strongly support the prediction that these systems are the ones that will evolve to white dwarf supernovae." Says Dwyer.

"The two most famous of the Super soft X-ray sources, CAL 83 and CAL 87, were discovered with the NASA Einstein satellite in 1981." says Sion. "Both CAL 83 and

CAL 87 are found in the Large Magellanic Cloud, a close galaxy to our own Milky Way Galaxy although other Super Soft Sources are now known in our Galaxy."

The two stars in CAL 83 orbit each other every 24 hours while those in CAL 87 orbit every 10 hours. After the studies by ROSAT, it was predicted in 1992 by Ed van den Heuvel in Amsterdam, and his collaborators, that nuclear fusion of hydrogen to helium in the accreted layers of the white dwarf would lead to the explosion of the white dwarf as a supernova but no one did the necessary calculations until now.

The new calculations of Starrfield and collaborators not only confirm this prediction, but explain why hydrogen and helium are not present in observations of white dwarf supernovas - they have already been fused to carbon and oxygen. Their results predict that white dwarf supernovas are also related to a less violent explosion called a Classical Nova because it is possible for a system undergoing Classical Nova explosions to evolve to a configuration where it resembles the Super Soft X-ray Sources.

The findings may be significant because "Until now there hasn't been a firm connection between these two types of explosions. CAL 83 and 87, are likely to become white dwarf supernovas in the future." says Sparks. Like all new findings, this work requires confirmation by other scientists. In particular, Dr. Hix says "The outer layers of this type of supernova is thought to be unprocessed by the explosion, and there could be important support or refutation for these models in the comparison with the observed spectrum of real white dwarf supernovas".

This work was supported by the National Science Foundation, NASA, and the Department of Energy.