Spectacular ultraviolet flash may finally explain how white dwarfs explode[1]: Event also could give insight into dark energy and the creation of iron.

Summary by : Mehul Jangir
Date : August 2020
Professor : Dr. Jamie Lombardi

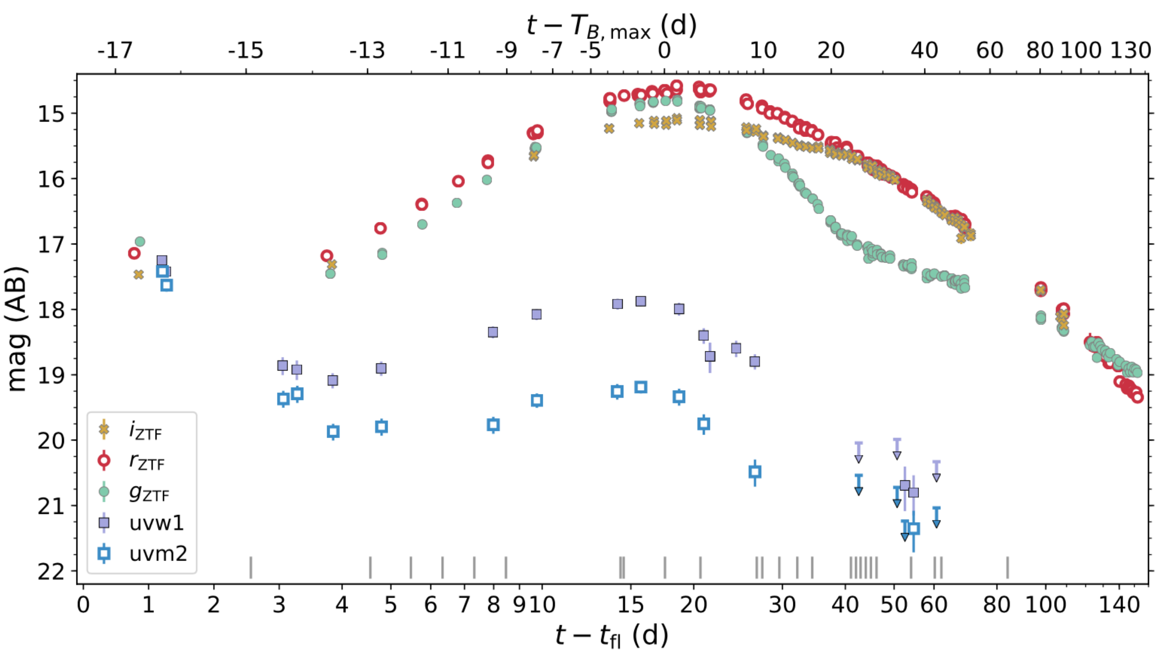
This summary was prepared by Mr. Mehul Jangir as a part of his undergraduate coursework for Principles of Astronomy under the guidance of Professor Jamie Lombardi at Allegheny College.

Original Research: https://iopscience.iop.org/article/10.3847/1538-4357/ab9e05
Credits: [1] Miller, A. A., et al. "The Spectacular Ultraviolet Flash from the Peculiar Type Ia Supernova 2019yvq." *The Astrophysical Journal*, vol. 898, no. 1, 2020, p. 56., doi:10.3847/1538-4357/ab9e05.
Source: Northwestern University

Summary:

White dwarfs are stars that have burnt up all of the hydrogen they once used as fuel. The inward push of gravity is balanced by electron degeneracy pressure. Fusion in a white dwarf's core produces outwards pressure, which is balanced by the inward push of gravity due to the star's mass. A type Ia supernova occurs when a white dwarf in a binary star system goes over the Chandrashekhar limit due to accreting mass from or a merger with its companion star. Ultraviolet radiation is produced by high temperature surfaces in space, such as the surfaces of blue supergiants.

The research article[1] details an astronomical event wherein a type Ia supernova explosion, a relatively common phenomenon, is accompanied by a UV flash, an incredibly rare phenomenon. This is pointed out as the second observed occurrence of such an event, making it innately important and intriguing. The supernova was first observed in December, 2019, using the Zwicky Transient-Facility in California. The event was dubbed as SN2019yvq, and it occurred in a nearby galaxy that lies 140 million light years from planet Earth in the Draco constellation.



Credit: Miller, A. A., et al. "The Spectacular Ultraviolet Flash from the Peculiar Type Ia Supernova 2019yvq." *The Astrophysical Journal*, vol. 898, no. 1, 2020, p. 56., doi:10.3847/1538-4357/ab9e05.

The given figure is a light curve for the observed type Ia supernova. A light curve plots the brightness of an object against time, as to showcase how its brightness/magnitude varies with time. This technique is used in other domains and applications like transit photometry. This light curve plots the absolute magnitude of 2019yvq, the event this paper looks at. The light curve of a supernova usually reaches a peak quickly, then gradually “cools off” with lowering intensity and brightness. This is demonstrated above.

What set this particular type Ia supernova apart was the aforementioned UV flash. What makes a UV flash important in this event is that it indicates very hot material in the white dwarf. This is presumably because of the explosion heating the material which was responsible for emitting light. The study offers four potential explanations behind the event: a consumed companion star that became so large that is exploded, leading to a UV flash; radioactive core materials reacting with the outer layer to make it very hot; an outer layer of helium igniting a carbon core; and two white dwarfs colliding and exploding. Understanding how type Ia supernovae work is key to our understanding of planetary formation as they produce iron, the most abundant element in the core of planets like the Earth. More importantly, type Ia supernovae can be used as ‘standard candles’ to measure extremely large cosmic distances. White dwarfs explode with the same brightness; hence their distance from planet Earth is inversely proportional to how brightly they seem to explode as observed from the Earth.. Further dividing type Ia supernovae on the basis of UV flashes would make the use of these cosmic yardsticks more accurate. Determining distances more accurately extends to working towards bigger challenges like how can we model the universe's expansion accurately, what is dark energy, and how much of 'stuff' is dark energy.

The implications of classifying type Ia supernovae further would lead to improved cosmic distance measurements, enabling insights into the nature of cosmic inflation and dark energy. Furthemore, the very act of attempting to classify type Ia supernovae with UV flashes could lead to the discovery of an entirely new astronomical event, which could catalyse a sub-domain of astronomical study. They add a more reliable and robust method of distance measurement to a gallery of techniques: radio astronomy, stellar parallax, cepheid variables, the Tully-Fisher relation etc. What type Ia supernovae add to this 'gallery' is the ability to measure incredibly large cosmic distances due to how bright their explosions are in absolute terms. This phenomenon offers improved accuracy over incredibly large distances.

Another pressing question is determining whether or not type Ia supernovae with UV flashes constitute a threat to us, if say, one occurs in our galactic neighbourhood. After observing a greater number of such events, a 'safe distance' could be determined below which such a supernova would have a sterilizing impact on life on Earth. According to the paper, the flash is of 19th magnitude as observed from planet

Earth. At a distance that is 10^6 times smaller, 140 light years, this would be 10^12 times brighter, or a magnitude of -11.

To conclude, discovering why these UV flashes occur and what they mean for cosmic distance measurement using type Ia supernovae can provide inroads into other pressing problems, like dark matter and dark energy.

Mehul Jangir

August 2020.