AI helps scientists understand cosmic explosions

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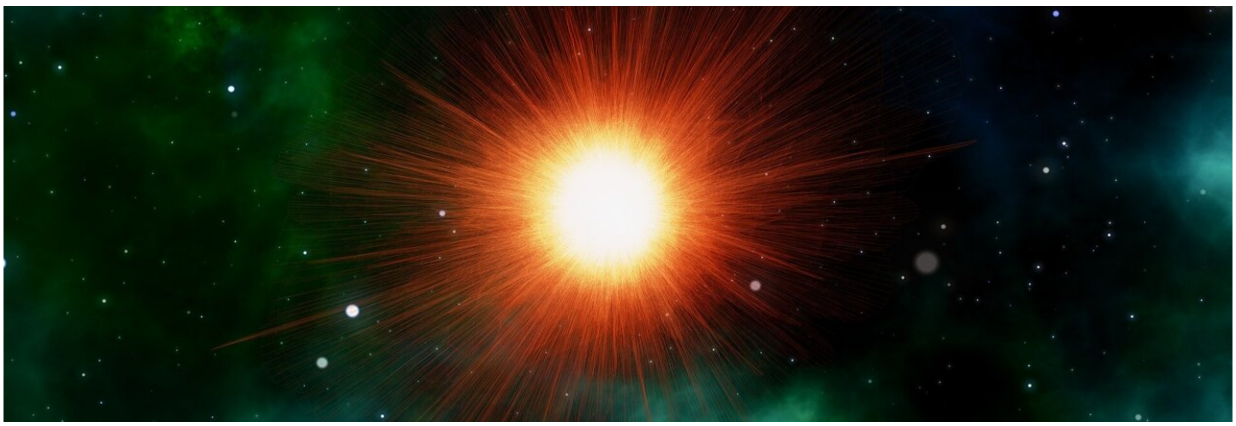

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Scientists at the University of Warwick are using artificial intelligence (AI) to analyze cosmic explosions known as supernovae. Their paper is published in *Monthly Notices of the Royal Astronomical Society*.

Many stars in the universe will end their lives as white dwarfs—compact stars containing about the mass of the sun in the size of the Earth. Some of these white dwarfs will eventually explode as supernovae. The process is highly energetic and results in the creation of heavy elements that are the building blocks of life, such as calcium and iron, being released back into the universe.

Despite their significance, astronomers still do not know exactly how or why these supernovae take place.

To help understand more, new research will make use of a type of AI known as machine learning to speed up experiments into supernovae—processes which are currently very computationally expensive and time consuming. This will help reveal how these cosmic explosions took place by comparing explosion models to real-life observations.

Lead Author Dr. Mark Magee, from the Department of Physics, University of Warwick, said, "When investigating supernovae, we analyze their spectra. Spectra show the intensity of light over different wavelengths, which is impacted by the elements created in the supernova. Each element interacts with light at unique wavelengths and therefore leaves a unique signature on the spectra.

"Analyzing these signatures can help to identify what elements are created in a supernova and provide further details on how the supernovae exploded.

"From this data, we prepare models, which are compared to real supernovae to establish what type of supernova it is and exactly how it exploded. Typically, one model might take 10–90 minutes to generate and we want to compare hundreds or thousands of models to fully understand the supernova. This isn't really feasible in many cases.

"Our new research will move away from this lengthy process. We will train machine learning algorithms on what different types of explosions look like and use these to generate models much more quickly. In a similar way to how we can use AI to generate new artwork or text, now we'll be able to generate simulations of supernovae. This means we'll be able to generate thousands of models in less than a second, which will be a huge boost to supernova research."

Alongside speeding up the process of supernova analysis, the use of AI will also enable better accuracy in research. This will help to establish what models match real-life explosions most closely and the range of their physical properties.

Dr. Magee added, "Exploring the elements released by supernovae is a crucial step in determining the type of explosion that occurred, as certain types of explosions produce more of some elements than others. We can then relate the properties of the explosion back to the properties of the supernova host galaxies and establish a direct link between how the explosion happened and the type of white dwarf that exploded."

The work now accepted is just the first step. Future research will expand to include an even greater variety of explosions and supernovae, and directly link the explosion and host galaxy properties. It is only through the advancements in machine learning that such research is now possible.

Dr. Thomas Killestein, University of Turku, who was also involved in the research, added, "With modern surveys, we finally have datasets of the size and quality to tackle some of the key remaining questions in supernova science: how exactly they explode. Machine learning approaches like this enable studies of larger numbers of supernovae, in greater detail, and with more consistency than previous approaches."

More information: M R Magee et al, Quantitative modelling of type Ia supernovae spectral time series: Constraining the explosion physics, *Monthly Notices of the Royal Astronomical Society* (2024). [DOI: 10.1093/mnras/stae1233](https://doi.org/10.1093/mnras/stae1233)

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