Cosmic 'dust factory' reveals clues to how stars are born

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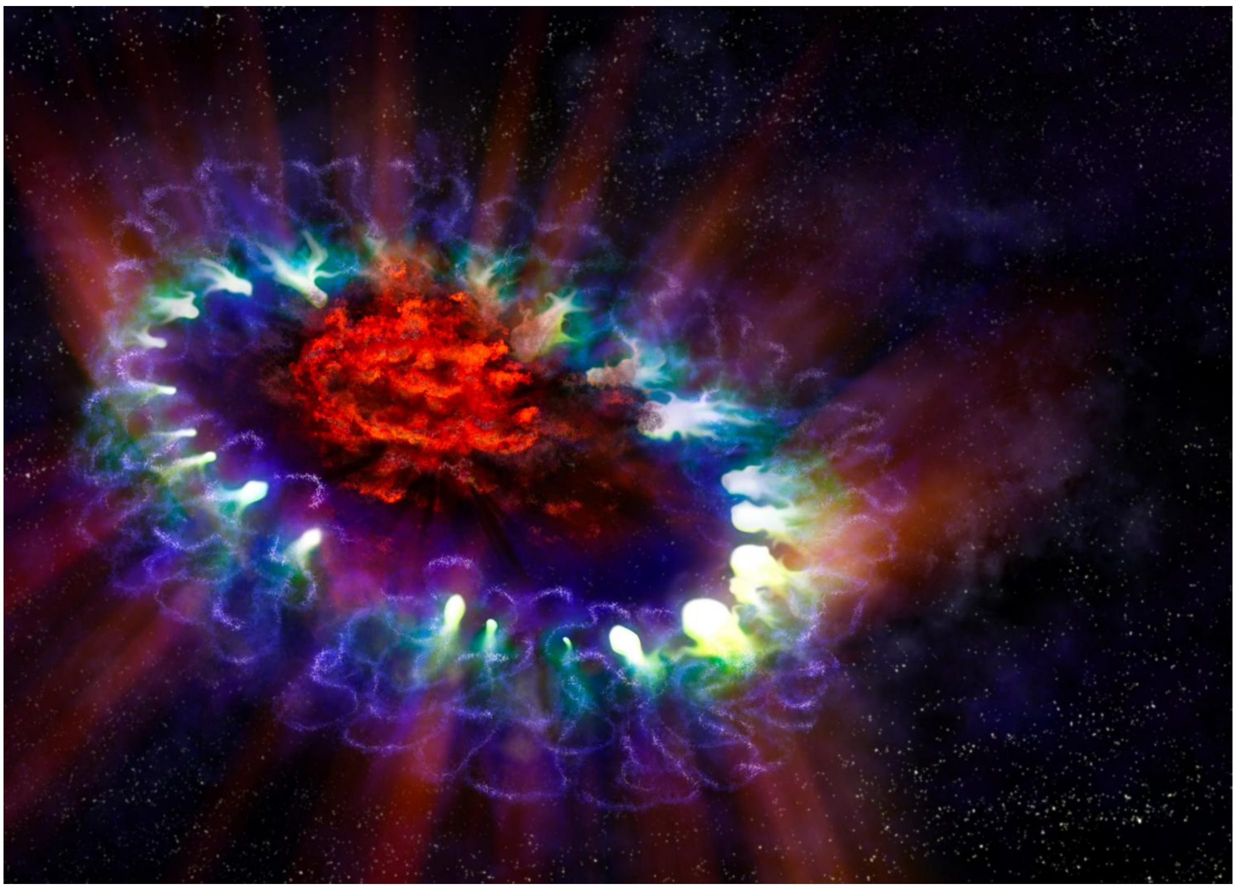

This artist's illustration of Supernova 1987A reveals the cold, inner regions of the exploded star's remnants (red) where tremendous amounts of dust were detected and imaged by ALMA. This inner region is contrasted with the outer shell (blue), where the energy from the supernova is colliding (green) with the envelope of gas ejected from the star prior to its powerful detonation. Credit: A. Angelich; NRAO/AUI/NSF

A group of scientists led by researchers at Cardiff University have discovered a rich inventory of molecules at the centre of an exploded star for the very first time.

Two previously undetected molecules, formylium (HCO+) and sulphur monoxide (SO), were found in the cooling aftermath of Supernova 1987A, located 163,000 light years away in a nearby neighbour of our own Milky Way galaxy. The explosion was originally witnessed in February 1987, hence its name.

These newly identified molecules were accompanied by previously detected compounds such as carbon monoxide (CO) and silicon oxide (SiO). The researchers estimate that about 1 in 1000 silicon atoms from the exploded star can be found in SiO molecules and only a few out of every million carbon atoms are in HCO+ molecules.

It was previously thought that the massive explosions of supernovae would completely destroy any molecules and dust that may have been already present.

However, the detection of these unexpected molecules suggests that the explosive death of stars could lead to clouds of molecules and dust at extremely cold temperatures, which are similar conditions to those seen in a stellar nursery where stars are born.

Lead author of the study Dr Mikako Matsuura, from Cardiff University's School of Physics and Astronomy, said: "This is the first time that we've found these species of molecules within supernovae, which questions our long held assumptions that these explosions destroy all molecules and dust that are present within a star.

"Our results have shown that as the leftover gas from a supernova begins to cool down to below 200°C, the many heavy elements that are synthesised can begin to harbour rich molecules, creating a dust factory.

"What is most surprising is that this factory of rich molecules is usually found in conditions where stars are born. The deaths of massive stars may therefore lead to the birth of a new generation."

The team arrived at their findings using the Atacama Large Millimeter/submillimeter Array (ALMA) to probe the heart of Supernova 1987A in remarkably fine detail.

The findings have been published in the journal *Monthly Notices of the Royal Astronomical Society*.

Astronomers have been studying Supernova 1987A since it was first discovered over 30 years ago, but have found it difficult to analyse the supernova's innermost core. ALMA's ability to observe at millimetre wavelengths - a region of the electromagnetic spectrum between infrared and radio light - made it possible to see through the intervening dust and gas and study the abundance and location of the newly formed molecules.

In an accompanying paper, a second research team have used ALMA's data to create the first 3D model of Supernova 1987A, revealing important insights into the original star itself and the way supernovae create the basic building blocks of planets.

It is well understood that massive stars, those more than 10 times the mass of our Sun, end their lives in spectacular fashion. When such a star runs out of fuel, there is no longer enough heat and energy to fight back against the force of their own gravity. The outer reaches of the star, once held up by the power of nuclear fusion, then come crashing down on the core with tremendous force. The rebound from this collapse triggers an explosion that blasts material into space.

Building on their current findings, the team hope to use ALMA to find out exactly how abundant the molecules of HCO+ and SO are, and to see if there are there any other molecules within the supernova that have yet to be detected.

Provided by Cardiff University

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