TOPIC OF THE WEEK

• Are these the ways
• our world will end?

By Randall Hyman | Published: March 1, 2024 | Last updated on July 24, 2024

Stardust to stardust

Ancient trees — like the one at right, found in the eroded banks of the Drouzet River, near the town of Gap in the southern French Alps — hold the keys to dating the most powerful solar storms. These storms, known as Miyake events, cause radiocarbon spikes to appear in the trees' rings.

Perhaps nothing symbolises the cosmic cycle of life and death like a supernova. These events are either the explosive final act of a massive star or of a white dwarf triggered by runaway nuclear fusion. Just like asteroids and superflares, there is ample evidence that supernovae have bombarded Earth and even shaped life throughout our planet's history.

"We are the children of supernovae," says Brian Fields, an astronomer at the University of Illinois Urbana-Champaign. "Life would not be possible without them. The iron in your blood, the oxygen you're breathing, the silicon in your computer, all are from supernovae that blew up long before the solar system was formed."

While supernovae provide the building blocks of life, they can also destroy it. Being too close can mean instant incineration or lethal irradiation. Although the gamma rays produced by supernovae cannot penetrate the upper reaches of our atmosphere, they can destroy our protective ozone layer through a chain of chemical reactions.

There are several types of supernovae, but it is the death throes of high-mass stars — weighing at least eight times our Sun — that spark the colossal core-collapse or type II supernovae. These supernovae produce nearly all atomic elements besides hydrogen and helium. Within our Milky Way Galaxy, two or three supernovae occur every century.

When shrouded in gas, type II supernovae become particularly potent. Months or years after the initial burst of gamma rays, superheated shock waves reverberate within the gas bubble and generate copious amounts of X-rays. Millennia later, as the blast barrels through space, it interacts with dust and radiation, producing high-energy particles called cosmic rays.

To understand the reach and frequency of these multistage killer events, scientists need more than Miyake dating. Tree-ring records go back only 15,000 years, and carbon-14 dating isn't reliable after 60,000 years (too much of the sample has decayed away), so uncovering traces of nearby supernovae in the geological record requires different techniques.

In 2015, a team of scientists perfected the use of an isotope called iron-60, a byproduct of supernovae, as a powerful chronometer with a half-life of 2.6 million years, providing reliable dates up to 10 million years in the past.

"It's basically like tree rings," says Fields. "We know there were recent nearby supernovae explosions because there is a wealth of iron-60 in two specific layers on the ocean floor, as well as on the Moon and in Antarctic snow. Something brought it here 3 million years ago, and another pulse 7 million years ago."

While iron-60 does an excellent job of detecting past supernovae, it can also help determine how far away they were. "The farther away you stand, the less iron-60 you intercept," says Fields. "By seeing how much there is, we can work out the distance."

Until a recent paper that Fields co-authored with principal investigator Ian Brunton, scientists deemed 10 parsecs — about 33 light-years — to be a safe enough distance for surviving supernovae. Their new research significantly expands the kill zone for gaseous type II supernovae to about 160 light-years, multiplying the affected volume of space about 125 times over.

The explosive death of a massive star 325 years ago created the Cassiopeia A supernova remnant. This composite image includes infrared data from the Spitzer Space Telescope (red), visible imagery from the Hubble Space Telescope (yellow), and X-ray data from the Chandra X-ray Observatory (green and blue). The X-rays — which pose a threat to the atmospheres of nearby planets — are emitted by gases that are caught in the expanding shock wave and heated to temperatures of up to 18 million F (10 million C). Credit: NASA/JPL-Caltech/O. Krause (Steward Observatory)

“That’s why we wrote the paper,” says Fields. “We realised that this kind of supernova can be dangerous to a much larger region than ordinary supernovae.”

Fields notes that the supernova 3 million years ago coincided with a notable megafauna die-off in the Pliocene.

According to one theory, muons may be the reason. These subatomic particles, about 200 times heavier than electrons, are produced by gamma rays. Large megafauna even half a mile (0.8 km) underwater would have been especially subject to their lethal effects. Based on iron-60 traces in seafloor sediments, astrobiologists have linked the die-off of whale-sized megalodon sharks with at least one supernova 2.6 million years ago in the Local Bubble, some 160 light-years away, at that very time.

The good news is that because supernova candidates are supermassive stars, they are also hard to miss, pumping out 100,000 times more light than the Sun. When they’re nearby, we know it, and even those shrouded in gas are brilliant in infrared wavelengths.

When this next occurs, it won’t likely be from any star we know by name today. Spica in Virgo is the nearest supermassive star likely to go supernova, and it lies some 250 light-years away — well outside the supernova danger zone.

But as our star system orbits the centre of the Milky Way, it passes through our galaxy’s spiral arms every 100 million years or so. By some estimates, each passage is likely to bring Earth within 33 light-years of a supernova, leaving it potentially exposed to its devastating effects.