Neutron star crash: 'The gift that will keep on giving'

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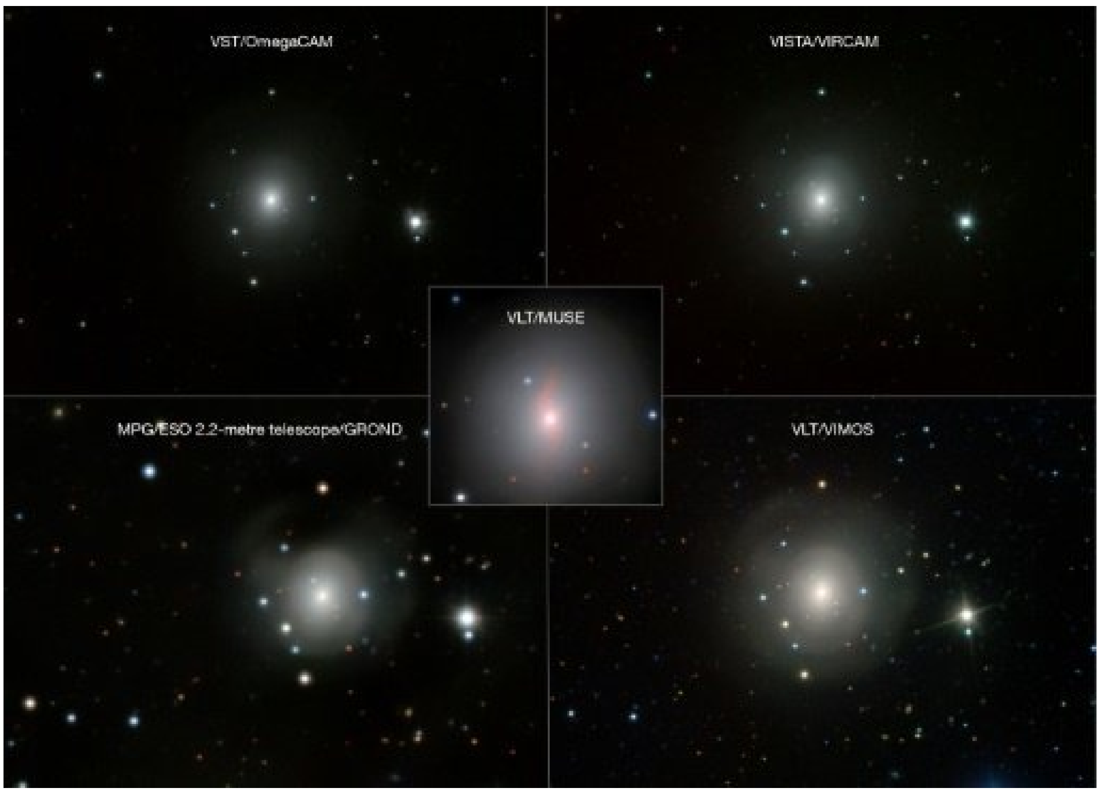

Neutron stars are the condensed, burnt-out cores that remain when massive stars run out of fuel, blow up, and die

The astrophysics world is abuzz after the first-ever observation of two neutron stars merging in a cataclysmic crash that left a rich trail of debris for scientists to comb through.

Here are three things the event has told us about the Universe we inhabit:

Cosmic gold mine

At last, scientists are now able to pinpoint the source of at least half the gold, platinum, lead and other heavy elements in the cosmos.

"The gold in your wedding ring probably came from a neutron star merger in our part of the galaxy that happened five billion years ago or so before our Sun was born. And the mercury in your fillings," said co-discoverer Patrick Sutton of Cardiff University.

When the Universe emerged from the "Big Bang", it consisted mainly of hydrogen and helium, the lightest elements on the Periodic Table.

Heavier elements—everything from the carbon in our bodies to the oxygen we breathe—were formed later by nuclear reactions in the cores of stars fusing atoms together.

But the heaviest element a star can make, scientists say, is iron—number 26 on the Periodic Table of 100+ entries.

One theoretical source for heavier elements is supernova explosions that happen when massive stars run out of fuel and die.

But there are not enough such explosions, and insufficient material produced by them, to explain more than about half the heavy elements in the Universe.

Another theorised source was neutron star mergers.

Now, telescopes have spotted evidence for newly-synthesised heavy elements in the light bursts from one such cataclysmic crash.

"For the very first time, we see unequivocal evidence of a cosmic mine that is forging about 10,000 Earth-masses of heavy elements," said Mansi Kasliwal from the California Institute of Technology, another member of the global team.

Radiation

Another mystery solved: neutron star smashups are now known to be one source for the bright flashes of high-energy radiation known as short gamma ray bursts.

First detected by American satellites in the 1960s, they were suspected at first of being Russian nuclear bomb explosions in space.

When that theory collapsed, neutron star mergers were seen as another potential source.

On August 17 this year, telescopes picked up a rather unspectacular gamma ray burst—brief and dimmer than usual.

The flash could easily have been ignored if not for the fact that it came a mere 1.7 seconds after gravitational wave instruments happened upon the death spiral of two neutron stars in exactly the same spot.

"This is, if you will, a smoking gun," said Sutton.

"It's now clear that binary neutron stars are a source of the short gamma ray bursts," though there may be other origins too.

Expanding Universe

Scientists know that the cosmos is expanding, but figuring out just how fast has been a challenge.

If we can pinpoint the rate, we can determine the Universe's age, and how much matter it contains.

By measuring the size of gravitational waves emitted from a monster event such as a merger of black holes or neutron stars, scientists can theoretically deduce how far away it happened.

Similarly, examining a gamma ray flash should reveal the "redshift" of the source, and thus the speed at which it is moving. Redshift is a measure of the changing wavelength of light travelling away from an observer.

In the August 17 breakthrough, scientists observed both gamma rays and gravitational waves from the same source for the first time—enabling them to make a fresh, though preliminary, estimate of how fast the Universe is expanding.

For now, the number remains subject to large "statistical uncertainties", and needs to be refined by observing more neutron star crashes, the teams said.

To infinity, and beyond

Scientists hope to use neutron star merger data to learn more about the laws of Nature, and how matter behaves in such extreme environments.

"From informing detailed models of the inner workings of neutron stars and the emissions they produce, to more fundamental physics such as general relativity, this event is just so rich," said David Shoemaker, head of the LIGO collaboration that helped detect the celestial smashup.

"It is a gift that will keep on giving."

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