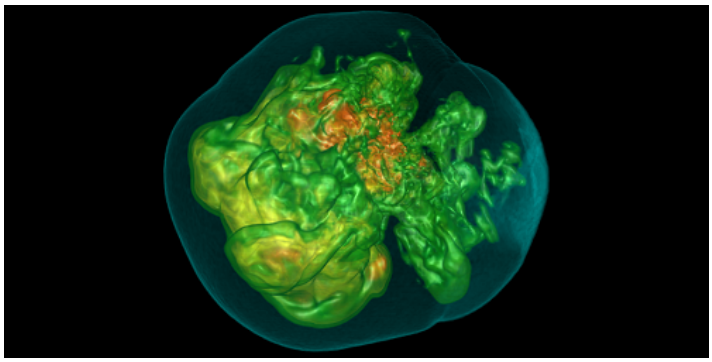
Spotting the Scars of Spacetime

Scientists have devised a way to use current gravitational-wave detectors to observe permanent deformations of spacetime caused by certain supernovae.

By **Ryan Wilkinson**

Gravitational waves stretch and squeeze spacetime as they pass. But they are also expected to leave a lasting imprint on the Universe, forever altering the relative positions of points in space. This phenomenon, dubbed gravitational-wave memory, is predicted to be extremely subtle, and its observation is often assumed to require a sensitivity that will only be achieved by future generations of gravitational-wave detectors. Now Colter Richardson at the University of Tennessee, Knoxville, and his colleagues present a strategy that could allow this elusive effect to be uncovered using existing detectors [**1**].

The researchers considered the gravitational waves produced by a so-called core-collapse supernova, the dramatic explosion of a massive dying star. Such a supernova is thought to generate gravitational-wave memory through the asymmetric emission of neutrinos during the explosion and through the nonspherical expansion of the supernova's shock wave. The team investigated these processes using sophisticated simulations of three core-collapse supernovae, which differed in the masses of their exploding stars.



Credit: M. Sandoval/Oak Ridge National Laboratory

On the basis of their findings from these simulations, Richardson and his colleagues then explored whether the current gravitational-wave detectors of the LIGO-Virgo-KAGRA Collaboration could spot the memory effect generated by a core-collapse supernova in the Milky Way. The team found that these detectors could succeed if their data were analyzed using a previously unconsidered combination of two techniques for isolating the subtle memory signal from the otherwise overwhelming transient gravitational-wave signals. Implementing this approach might offer insights into the nature of gravitational waves and could also improve our understanding of core-collapse supernovae, the researchers say.

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REFERENCES

1. C. J. Richardson *et al.*, "Detecting gravitational wave memory in the next Galactic core-collapse supernova," **Phys. Rev. Lett. 133, 231401 (2024).**