ENTERING *a* NEW AGE *of* DISCOVERY

• FACT SHEET •

What are neutron stars?

Neutron stars are the smallest and densest stars in existence. Size is relative, however, and a typical neutron star has a diameter of about 12.5 miles, an expanse about the size of Manhattan. A single teaspoon of neutron star matter would weigh about a billion tons. These incredibly dense orbs are formed from stars about 10 times heavier than the sun that explode when they reach the end of their lives—an event called a supernova. Neutron stars are the collapsed core of these exploded stars.

Why was this detection so revolutionary?

This discovery marks the first time scientists have detected the collision of neutron stars. As the stars collide, they give off gravitational waves. Just after they collide, they emit a powerful burst of gamma rays. The gravitational waves were "heard" by the Advanced LIGO detectors, and the flash of gamma rays was seen by a NASA satellite. With the combined data from the LIGO and Virgo detectors, scientists were able to pinpoint the likely spot in the sky from which the gravitational waves came. This in turn enabled powerful telescopes—such as NASA's Hubble Space Telescope and the U.S. Gemini Observatory—to quickly locate and actually observe the radioactive fireworks and afterglow emanating from the cosmic smash-up. This discovery marks the dawn of a new era of "multi-messenger" astronomy that promises to expand even further our understanding of the universe.

What does all this have to do with gold?

Scientists have long wondered about the origins of the periodic table's heaviest elements, such as gold and platinum—elements whose creation would have required an incredibly rapid infusion of neutrons. While they once believed these metals originated in a supernova, more recent evidence has pointed to colliding neutron stars as the likely source. Observational data from the radioactive afterglow of the Aug. 17 collision now confirms this. This means the gold that now veins Earth—the same stuff that finds its way into our jewelry—is the byproduct of a cataclysmic collision of neutron stars some billions of years ago.

So how did the gold that we find on Earth get here?

The gold that is strewn into the universe from the collision of two neutron stars eventually gets recycled as atomic dust into the formation of new planets. These atoms of gold get absorbed into the planet's crust, and over time, they compress into nuggets and veins, such as those that enrich the Earth today.

What are LIGO and Virgo?

LIGO is an acronym for the Laser Interferometer Gravitational-Wave Observatory. Funded by the National Science Foundation, LIGO is a joint project involving scientists at MIT, Caltech, Syracuse, and many other institutions around the world dedicated to the detection of gravitational waves. LIGO has two advanced detectors, one in Livingston, Louisiana, and the other in Hanford, Washington. The Virgo detector is located near Pisa, Italy, and is operated by a consortium of 20 European research groups. The August discovery was made during the first simultaneous run of the LIGO and Virgo detectors since all three had undergone upgrades.

What role does Syracuse University play in LIGO?

All three of the Syracuse LIGO team leaders have played a significant role in LIGO's gravitational-wave research. Stefan Ballmer was a key member of the team that designed and built the Advanced LIGO detectors—an upgrade that helped make the recent breakthroughs possible. Duncan Brown works to detect and study the signals from colliding black holes and neutron stars, and is a member of the Dark Energy Camera team—one of the three independent groups to locate the optical afterglow. Peter Saulson is a co-founder of the LIGO Scientific Collaboration—the global team of researchers who analyze LIGO data—and was among the first physicists in that group to propose neutron stars as a dominant source of gravitational waves for LIGO.

What direct role did Syracuse physicists play in this discovery?

The Syracuse LIGO team was among the first wave of scientists alerted to the possible detection of a neutron star collision and connected via teleconference call to determine how to proceed. When a glitch in data from one of the LIGO detectors prevented the localization of the source and threatened to slow the alert to observing partners, a team of current and former Syracuse students and scientists fixed the glitch. Brown and Alex Nitz G'15 then rapidly reprocessed the data to generate the precise sky localization—information that was then relayed to telescopes that could zoom deeply into the point in space where the collision had occurred.