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GRAVITATIONAL WAVES

Ten Years of Gravitational-Wave Astronomy

THE LASER INTERFEROMETER GRAVITATIONAL-WAVE OBSERVATORY (LIGO) has detected the clearest signal yet from colliding black holes, confirming key predictions of general relativity. Released to coincide with the 10th anniversary of the first LIGO signal, the measurement is part of the observatory's latest data release.

Gravitational waves are ripples in spacetime predicted by Einstein in 1916. Since the first discovery of gravitational waves from two colliding black holes a century later, the floodgates have opened — LIGO now observes a black hole merger roughly every three days.

The increase in detections comes thanks to a fourfold improvement in sensitivity, which has now for the first time enabled researchers to precisely measure the *ringdown* of a merger-made black hole settling down after the crash. By analyzing the final vibrations of the event known as GW250114, the collaboration found that the mass and spin of the new black hole are consistent with the solutions to Einstein's equations that physicist Roy Kerr found more than 60 years ago. The size of the black holes' event horizons before and after the merger likewise match predictions that Stephen Hawking made 55 years ago. The results appear in the September *Physical Review Letters*.

That event and others in the first part of LIGO's fourth observing run were released on August 25th as part of the updated catalog put together by the LIGO-Virgo-KAGRA Collaboration. The latest round of detections now reaches out to when the universe was 8 billion years old, just over half its current age.

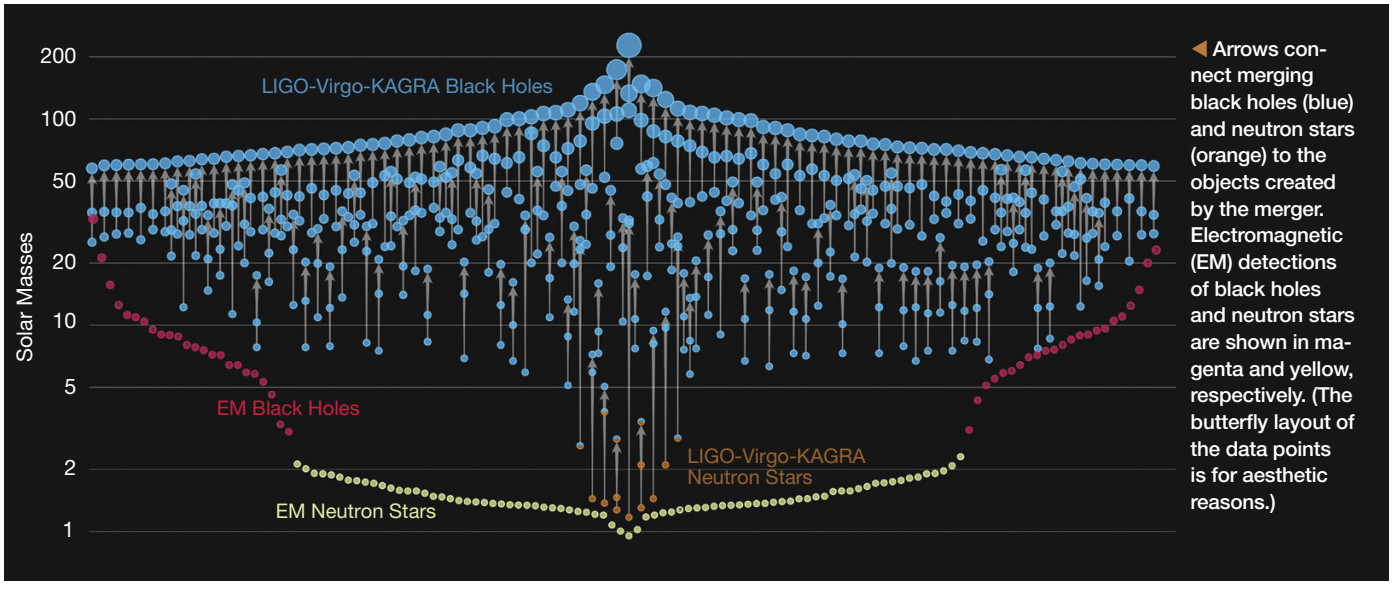
◀ This artwork imagines the view of GW250114, a collision of two black holes.

The new results include 128 confidently detected mergers, all but two of which were smashups of binary black holes. These events bring the tally of events over all observing runs so far to 218, more than doubling the previous count. The mergers have implications across a range of topics, from cosmology to gravity itself, discussed in a slew of companion papers. The researchers are in the process of submitting these to the *Astrophysical Journal Letters* for an upcoming special issue.

Two of the 128 mergers appear to have involved a black hole and a neutron star, based on the objects' masses. (None of the mergers in this run involved two neutron stars.) But while astronomers expect that black holes could shred neutron stars before swallowing them, researchers detected no sign of shredding for these two mergers.

The other 126 events were mergers of two black holes, spanning a wide range of masses from 4 solar masses to more than 100. For an overview of the findings, visit **skyandtelescope.org/O4a**.

■ COLIN STUART & CAMILLE M. CARLISLE



◀ Arrows connect merging black holes (blue) and neutron stars (orange) to the objects created by the merger. Electromagnetic (EM) detections of black holes and neutron stars are shown in magenta and yellow, respectively. (The butterfly layout of the data points is for aesthetic reasons.)

BLACK HOLE ART: AURORE SIMONNET (SSU / EDEON) / LVK / URI; MERGER CATALOG VISUALIZATION: LIGO-VIRGO-KAGRA / AARON GELLER / NORTHWESTERN UNIV.