ADVENTURE:
A Mason-Dixon Venus Transit
PAGE 28

OBSERVING:
Herschel Highlights
PAGE 22

ASTROIMAGING:
Break Bad Photoshop Habits
PAGE 58

SKY & TELESCOPE

THE ESSENTIAL GUIDE TO ASTRONOMY

MARCH 2022

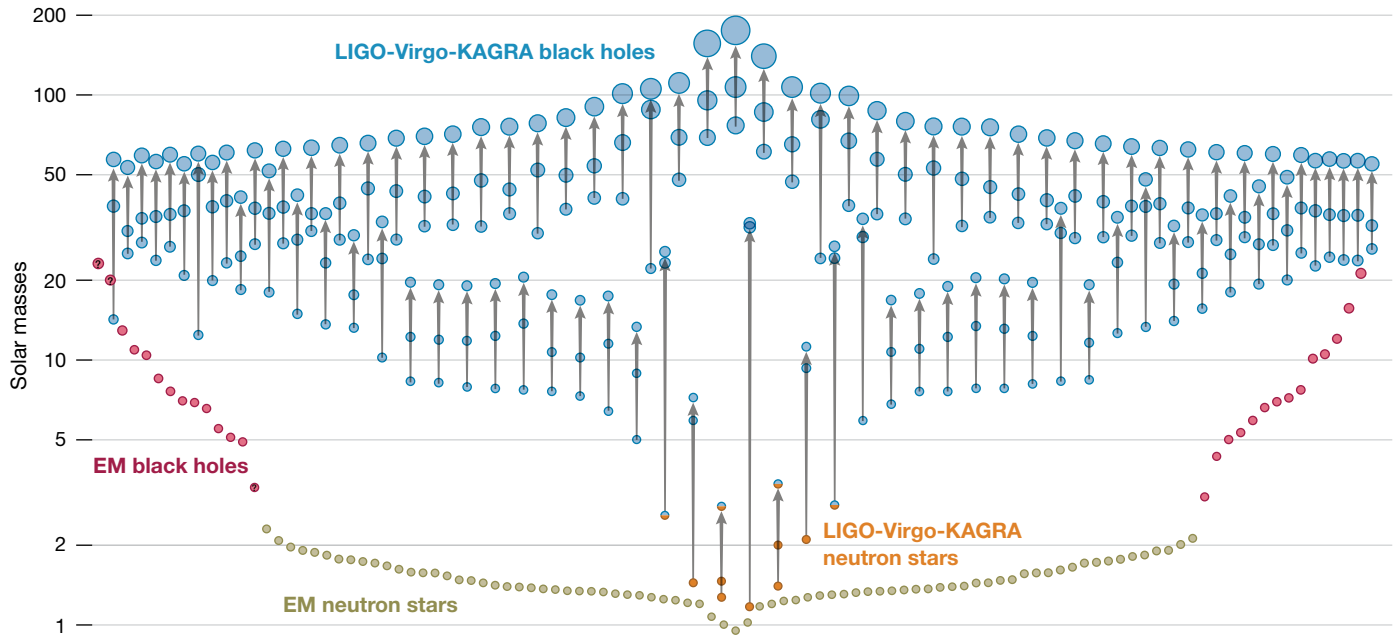
Scientists GRAPPLE with the Expanding Universe

Page 14

BROWN DWARFS:
Failed Stars or Giant Planets?
Page 34

The Venusian Polar Caps That Weren't
Page 52

skyandtelescope.org



BLACK HOLES

Third Gravitational-wave Catalog Released

THE INTERNATIONAL TEAM associated with three gravitational-wave projects has unveiled results from their latest observing run, adding 35 new events and raising the total number to 90.

The catalog includes compact objects caught colliding between November 2019 and March 2020. This run included both Europe's Virgo and the U.S.-based LIGO detectors. The Japanese KAGRA project joined the fun for the campaign's last two weeks.

Of the 35 pairs in the newest catalog, 32 were black hole mergers. There were also two neutron star–black hole collisions and one event of indeterminate type: It might have been a black hole gnashing a neutron star, but chances are the smaller object was a tiny black hole 2.8 times the Sun's mass.

▲ Scientists have now detected 90 gravitational-wave events. The dots indicate the masses of the objects that merged and of the object they created. (Pink and yellow dots are detections from electromagnetic observations.)

In a separate publication, the LVK Collaboration analyzed 76 of the most reliable events, upending some expectations about black holes as a population.

Astronomers had predicted that they wouldn't see objects between roughly 3 and 5 solar masses, and there *is* a drop in the number of objects just above 2 solar masses. But the gravitational-wave data don't show a hard upper edge, nor does this putative gap appear to be totally empty.

Astronomers had also thought that stars large enough to make black holes between 50 and 120 solar masses should tear themselves apart, leaving no remnant when they die. But the observations reveal black holes in this region, too: Although the latest gravitational-wave data do show a drop-off above 40 Suns or so, it's not precipitous.

The detectors will return for a fourth observing run in late 2022, when further upgrades may increase the number of detections by a factor of three.

■ CAMILLE M. CARLISLE

GRAVITATIONAL-WAVE EVENTS: LIGO-VIRGO / AARON GELLER / NORTHWESTERN UNIVERSITY; JUPITER: NASA / JPL-CALTECH / SWRI / MSSS; IMAGE PROCESSING: NAVANEETH KRISHNAN S / CC BY

JUPITER

The Roots of the Great Red Spot Run Deep

NASA'S JUNO MISSION has obtained measurements that finally say just how far down the Great Red Spot goes. The deep roots of the centuries-long storm could be a clue to its longevity.

Previous work using the microwave radiometer aboard NASA's Juno spacecraft demonstrated the storm was still going strong 240 kilometers (150 miles) below the cloudtops. Now, a study in the October 28th *Science* puts a bottom limit to its depth. Juno scientist Marzia Parisi (JPL-Caltech) led an effort utilizing two passes that had the spacecraft zipping right over the Great Red Spot. The team also analyzed data from another 10 passes.

The spacecraft's path changed ever so slightly over the cyclone because of the uneven distribution of mass in the clouds below. By measuring deviations to Juno's expected path to within 0.01 millimeter per second, Parisi and colleagues showed that the Great Red Spot

JunoCam captured this image of Jupiter's south temperate belt and Great Red Spot on Dec. 30, 2020.