

Astrowatch

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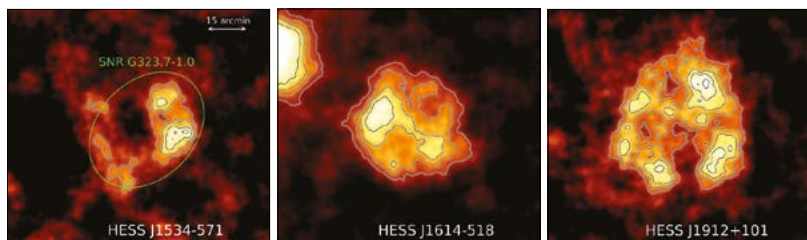
HESS proves the power of TeV astronomy

For hundreds of years, discoveries in astronomy were all made in the visible part of the electromagnetic spectrum. This changed in the past century when new objects started being discovered at both longer wavelengths, such as radio, and shorter wavelengths, up to gamma-ray wavelengths corresponding to GeV energies. The 21st century then saw another extension of the range of astronomical observations with the birth of TeV astronomy.

The High Energy Stereoscopic System (HESS) – an array of five telescopes located in Namibia in operation since 2002 – was the first large ground-based telescope capable of measuring TeV photons (followed shortly afterwards by the MAGIC observatory in the Canary Islands and, later, VERITAS in Arizona). To celebrate its 15th anniversary, the HESS collaboration has published its largest set of scientific results to date in a special edition of *Astronomy and Astrophysics*. Among them is the detection of three new candidates for supernova remnants that, despite being almost the size of the full Moon on the sky, had thus far escaped detection.

Supernova remnants are what's left after massive stars die. They are the prime suspect for producing the bulk of cosmic rays in the Milky Way and are the means by which chemical elements produced by supernovae are spread in the interstellar medium. They are therefore of great interest for different fields in astrophysics.

HESS observes the Milky Way in the energy range 0.03–100 TeV, but its telescopes do not directly detect TeV photons. Rather, they measure the Cherenkov radiation produced by showers of particles generated when these photons enter Earth's atmosphere. The energy and direction of the primary TeV photons



Surface-brightness maps of the three supernova-remnant candidates detected by HESS in our galactic plane. The green ellipse denotes the radio counterpart of HESS J1534-571.

can then be determined from the shape and direction of the Cherenkov radiation.

Using the characteristics of known TeV-emitting supernova remnants, such as their shell-like shape, the HESS search revealed three new objects at gamma-ray wavelengths, prompting the team to search for counterparts of these objects in other wavelengths. Only one, called HESS J1534-571 (figure, left), could be connected to a radio source and thus be classified as a supernova remnant. For the two other sources, HESS J1614-518 and HESS J1912+101, no clear counterparts were found. These objects thus remain candidates for supernova remnants.

The lack of an X-ray counterpart to these sources could have implications for cosmic-ray acceleration mechanisms. The cosmic rays thought to originate from supernova remnants should be directly connected to the production of high-energy photons. If the emission of TeV photons is a result of low-energy photons being scattered by high-energy cosmic-ray electrons originating from a supernova remnant (as described by leptonic emission models), soft

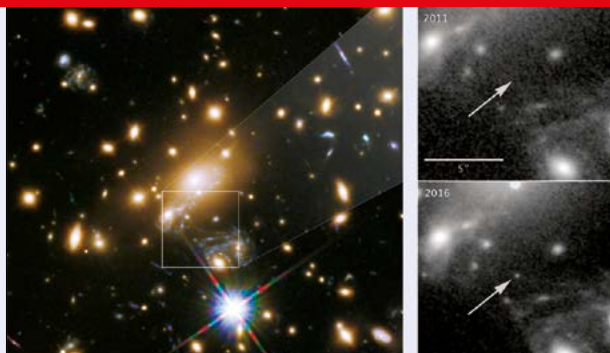
X-rays would also be produced while such electrons travelled through magnetic fields around the remnant. The lack of detection of such X-rays could therefore indicate that the TeV photons are not linked to such scattering but are instead associated with the decay of high-energy cosmic-ray pions produced around the remnant, as described by hadronic emission models. Searches in the X-ray band with more sensitive instruments than those available today are required to confirm this possibility and bring deeper insight into the link between supernova remnants and cosmic rays.

The new supernova-remnant detections by HESS demonstrate the power of TeV astronomy to identify new objects. The latest findings increase the anticipation for a range of discoveries from the future Cherenkov Telescope Array (CTA). With more than 100 telescopes, CTA will be more sensitive to TeV photons than HESS, and it is expected to substantially increase the number of detected supernova remnants in the Milky Way.

● **Further reading**
HESS Collaboration 2018 *Astron. Astrophys.* **612**A8.

Picture of the month

Although barely noticeable in this image of a massive galaxy cluster (left), which was taken with the Hubble Space Telescope, the small blue dot in the centre of the inset could be the farthest star ever observed. The source appeared to come out of nowhere: it was visible in 2016 (bottom right) but not in 2011 (top right). Such transients are typically associated with supernovae, but the spectrum and variability of the source seem to agree much more with those of a distant blue supergiant star magnified 2000 times by the gravitational lensing of the foreground galaxy cluster. If this interpretation is correct, the star, now called Icarus, would be the farthest star ever seen, with a light-travel distance of about nine billion light years.



NASA, ESA and P. Kelly (Univ. Minnesota)