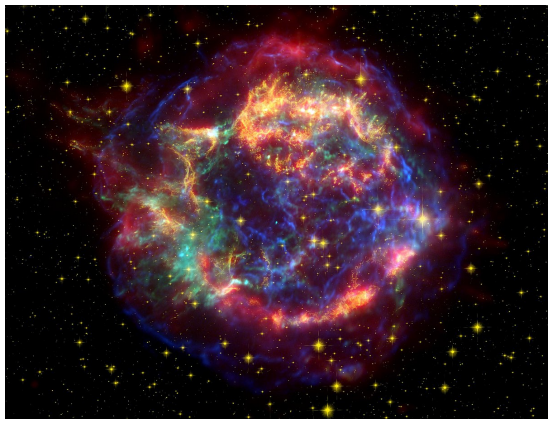
MAGIC
Major Atmospheric
Gamma Imaging
Cerenkov Telescope

Prime candidate to explain cosmic ray sea runs short of energy

Scientists have been advocating for decades that cosmic rays are accelerated in the remnants of supernova explosions. However the MAGIC telescopes have now observed that one of the best candidates, the supernova remnant Cassiopeia A, falls very short of the required energy.



MAGIC telescopes and a false-color multiband image of the supernova remnant Cassiopeia A (Cas A) obtained with the three big NASA observatories [(Spitzer (Infrared), HST (optical) and Chandra (X-ray)]. *(M. Lopez / IAC / NASA)*

Cassiopeia A is a famous supernova remnant, the product of a gigantic explosion of a massive star about 350 years ago. Although discovered in radio observations 50 years ago, now we know that its emitted radiation spans from radio through high-energy gamma rays. It is also one of the few remnants for which the birth date and the type of supernova are known. It was a type IIb, the result of a core collapse supernova explosion -. The precise knowledge of its nature makes Cassiopeia A one of the most interesting and investigated objects in the sky, and in particular the study of its connection with the cosmic rays, sub-atomics particles that fill our Galaxy with energies higher than anything achievable in laboratories on Earth.

The very high-energy part of the spectrum of Cassiopeia A results from the cosmic rays (either electrons or protons) within the remnant. Until now, this range of energy could not be measured with sufficient precision to pinpoint its origin. Sensitive observations above 1 Tera-electronvolts (TeV) were required but achieving them was daunting. An international team led by scientists from the Institute for Space Sciences (ICE - IEEC-CSIC, Spanish National Research Council-CSIC), the Institut de Fisica d'Altes Energies (IFAE) and the Institute of Cosmos Sciences of the University of Barcelona (ICCUB), in Spain, has finally

succeeded in doing those observations with the MAGIC telescopes (short for Major Atmospheric Gamma-ray Imaging Cherenkov Telescope). More than 160 hours of data were recorded between December 2014 and October 2016, revealing that Cassiopeia A is an accelerator of massive particles, mostly hydrogen nuclei (protons). However, even when those particles are 100 times more energetics than the ones we can reach in artificial accelerators such the one in CERN, their energy is not hugh enough to explain the cosmic ray sea that fills our Galaxy.

“Cassiopeia A is the perfect object to be a PeVatron, that is, an accelerator of particles up to PeV energies (1 PeV = 1.000 TeV): it is young, bright, with a shock expanding a great velocity and with very large magnetic fields that can accelerate cosmic rays up to at least, conservatively, 100 or 200 teraelectronvolts” explains Emma de Oña Wilhelmi, scientist of CSIC in the Institute for Space Sciences, “But contrary to what we expected, in Cassiopeia A the particle energies do not reach more than a few tens of tera-electronvolts. At these energies, the radiation suddenly drops and the emission stops abruptly: Either the remnant cannot accelerate the particles to higher energies, which challenge our knowledge of shocks acceleration, or maybe, the fastest ones escaped quickly the shock, leaving only the slowest ones for us to observe”, adds Daniel Guberman, at the Institut de Fisica d’Altes Energies.

“Those supernovae are natural accelerators of particles, therefore the perfect laboratory to study charge particles and plasma in conditions that are not possible in our labs in Earth", remarks Daniel Galindo, working at Institute of Cosmos Sciences of the University of Barcelona (ICCUB). “To understand the origin of the cosmic rays implies to unveil the origin of our own Galaxy”, concludes Razmik Mirzoyan, MAGIC Spokeperson from the Max Planck Institute for Physics (MPP) in Munich (Germany).

MAGIC telescopes

MAGIC telescopes are located at the Roque de los Muchachos Observatory, in La Palma (Canary Islands). MAGIC, a system of two 17m diameter Cherenkov telescopes, is currently one of the three major imaging atmospheric Cherenkov instruments in the world. It is designed to detect photons tens of billions to tens of trillions times more energetic than visible light. MAGIC also uses a novel technique to reduce the effect of the Moonlight in the camera, allowing for observations during moderated Moonlight nights.

MAGIC has been built with the joint efforts of an international collaboration that includes about 160 researchers from Germany, Spain, Italy, Switzerland, Poland, Finland, Bulgaria, Croatia, India, Japan, Armenia and Brazil.

For more information on MAGIC, visit: https://wwwmagic.mpp.mpg.de/

Published in the Monthly Notices of the Royal Astronomical Society (MNRAS, 2017): MAGIC Collaboration (M. L. Ahnen et al.) "A cut-off in the TeV gamma-ray spectrum of the SNR Cassiopeia A". DOI: 10.1093/mnras/stx2079

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