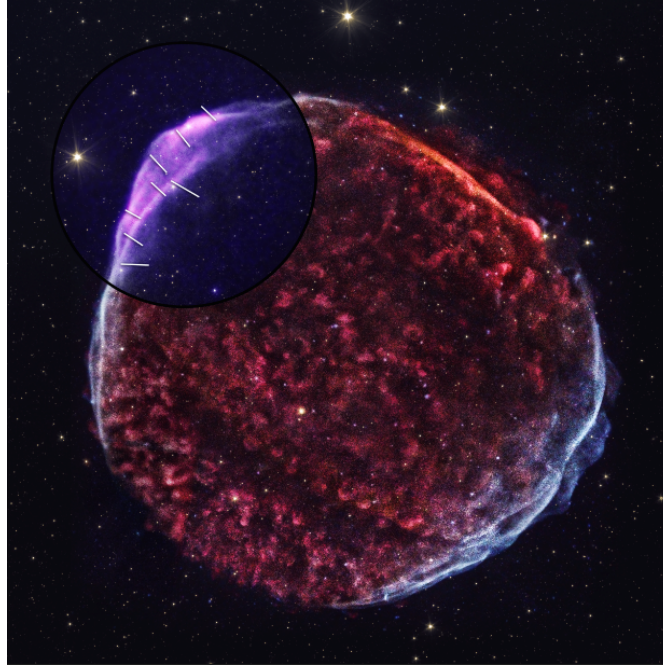


Press Release

For immediate release

HKU Astrophysicists Collaborates with NASA's IXPE Telescope Untangles Theories Surrounding Historic Supernova Remnant

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The figure shows a composite image of supernova remnant SN 1006. The upper left circle shows the IXPE observed area. The IXPE 2–4 keV emission is shown with the purple colour, with magnetic field orientation denoted with white lines. The red and white represent the soft and hard X-ray emission, respectively, taken with the Chandra X-ray observatory. The golden colour denotes the Spitzer infrared emission.

Image Credits: X-ray: Chandra: NASA/CXC/SAO, IXPE: NASA/MSFC/P. Zhou et al.; Infrared: Spitzer.

A team of international scientists, including Drs Stephen NG and Yi-Jung YANG from the Department of Physics at The University of Hong Kong (HKU), collaborated with NASA on research led by Nanjing University, utilising NASA's IXPE (Imaging X-ray Polarimetry Explorer) telescope to capture the first polarised X-ray imagery of the supernova remnant SN 1006. The new results expand scientists' understanding of the relationship between magnetic fields and the flow of high-energy particles from exploding stars. The discovery has been published in esteemed Scientific Journal *The Astrophysical Journal*.

'Magnetic fields are extremely difficult to measure, but IXPE provides an efficient way for us to probe them,' said Dr Ping ZHOU, an astrophysicist at Nanjing University in Jiangsu, China, and lead author of the new paper on the findings. 'Now we can see that SN 1006's magnetic fields are turbulent but also present an organised direction.'

Situated some 6,500 light-years from Earth in the Lupus constellation, SN 1006 is all that remains after a titanic explosion, which occurred either when two white dwarfs merged or when a white dwarf pulled too much mass from a companion star. Initially spotted in the spring of 1006 CE by observers across China, Japan, Europe, and the Arab world, its light was visible to the naked eye for at least three years. Modern astronomers still consider it the brightest stellar event in recorded history.

Since modern observation began, researchers have identified the remnant's strange double structure, markedly different from other rounded supernova remnants. It also has bright "limbs" or edges identifiable in the X-ray and gamma-ray bands.

'IXPE is a unique instrument. It can detect polarised X-rays, directly probing magnetic field structures in regions very close to the shock front, where high-energy particles are freshly accelerated. Such information is not available from any other telescopes,' said Dr Stephen NG, a high-energy astrophysicist at the Department of Physics at HKU.

'Close-proximity, X-ray-bright supernova remnants such as SN 1006 are ideally suited to IXPE measurements, given IXPE's combination of X-ray polarisation sensitivity with the capability to resolve the emission regions spatially,' said Dr Douglas SWARTZ, a researcher based at NASA's Marshall Space Flight Center in Huntsville, Alabama, through the Universities Space Research Association. 'This integrated capability is essential to localising cosmic-ray acceleration sites.'

Previous X-ray observations of SN 1006 offered the first evidence that supernova remnants can radically accelerate electrons and helped identify rapidly expanding nebulae around exploded stars as a birthplace for highly energetic cosmic rays, which can travel at nearly the speed of light. Scientists surmised that SN 1006's unique structure is tied to the orientation of its magnetic field and theorised that supernova blast waves in the northeast and southwest move in the direction aligned with the magnetic field and more efficiently accelerate high-energy particles.

'IXPE's new findings helped validate and clarify those theories,' said Dr Yi-Jung YANG, co-author of the paper and a high-energy astrophysicist at the Department of Physics of HKU, as well as a member of HKU Laboratory for Space Research. 'The polarisation properties obtained from our spectral-polarimetric analysis align remarkably well with outcomes from other methods and X-ray observatories, underscoring IXPE's reliability and strong capabilities,' Yang said. 'For the first time, we can map the magnetic field structures of supernova remnants at higher energies with enhanced detail and accuracy – enabling us to better understand the processes driving the acceleration of these particles.'

Researchers say the results demonstrate a connection between the magnetic fields and the remnant's high-energy particle outflow. The magnetic fields in SN 1006's shell are somewhat disorganised, per IXPE's findings, yet still have a preferred orientation. As the shock wave from the original explosion goes through the surrounding gas, the magnetic fields become aligned with the shock wave's motion. Charged particles are trapped by the magnetic fields around the original point of the supernova blast, where they quickly receive bursts of acceleration. Those speeding high-energy particles, in turn, transfer energy to keep the magnetic fields strong and turbulent.

IXPE has observed three supernova remnants – Cassiopeia A, Tycho and now SN 1006 – since launching in December 2021, helping scientists develop a more comprehensive understanding of the origin and processes of the magnetic fields surrounding these phenomena.

Scientists were surprised to find that SN 1006 is more polarised than the other two supernova remnants but that all three show magnetic fields oriented such that they are pointing outward from the centre of the explosion. As researchers continue to explore IXPE data, they are re-orienting their understanding of how particles get accelerated in extreme objects like these.

IXPE is a collaboration between NASA and the Italian Space Agency with partners and science collaborators in 12 countries. IXPE is led by NASA's Marshall Space Flight Center in Huntsville, Alabama. Ball Aerospace, headquartered in Broomfield, Colorado, manages spacecraft operations together with the University of Colorado's Laboratory for Atmospheric and Space Physics in Boulder.

This news release was adapted from the original version from NASA.

The research paper can be accessed at the following link: <https://iopscience.iop.org/article/10.3847/1538-4357/acf3e6>

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