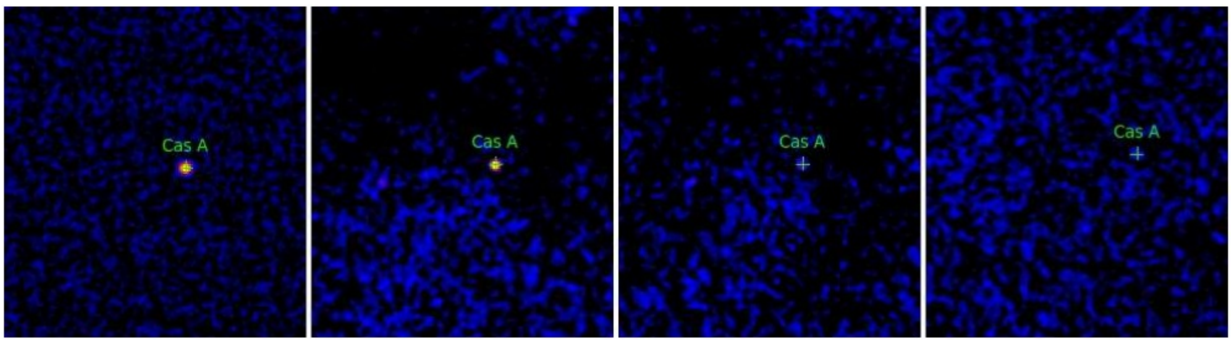
Astronomers spot hard X-ray emissions from a nearby supernova remnant Cassiopeia A

May 6 2016, by Tomasz Nowakowski



Significance mosaic maps around the supernova remnant Cassiopeia A in Equatorial J2000 coordinates as seen (panels from left to right) with INTEGRAL/JEMX in the range of 3 – 10 keV and INTEGRAL/IBIS in three energy bands: 20 – 60 keV, 60 – 90 keV and 90 – 200 keV. Credit: Wei Wang, Zhuo Li, 2016.

(Phys.org)—A nearby young supernova remnant named Cassiopeia A is an excellent candidate for astrophysical observations regarding supernova explosion processes. One of the recent studies focuses on hard X-ray emissions from this source, describing a non-thermal continuum emission for the first time. A paper detailing the findings appeared online on May 2 on the arXiv pre-print server.

Located about 11,000 light years away, Cassiopeia A is the brightest extrasolar radio source in the sky at frequencies above 1 GHz. It is bright in the electromagnetic spectrum, which makes it a unique laboratory for studying high-energy phenomena in supernova remnants.

To peek inside these phenomena, two Chinese astronomers have recently studied a 10-year dataset of Cassiopeia A observations provided by ESA's INTErnational Gamma-Ray Astrophysics Laboratory (INTEGRAL) spacecraft. By using these data, Wei Wang of the Chinese Academy of Sciences and Zhuo Li of the Peking University detected an X-ray emission from this source above 100 keV for the first time.

"We first detected the emission from Cassiopeia A above 100 keV, and found the spectrum has a power-law feature up to 220 keV without cutoff," Wang told Phys.org.

Cassiopeia A has a thermal emission in soft X-ray bands 0.1-10 keV, but in hard X-ray bands above 10 keV, it shows a non-thermal emission. Hard X-ray observations on this supernova remnant can also study the hard X-ray lines at 67.9 and 78.4 keV coming from the decays of radioactive ^{44}Titanium (Ti) – a short-lived radioactive isotope with a half-life of 59 years.

"Two ^{44}Ti emission lines at 68 and 78 keV were detected in Cassiopeia A," Wang said.

The scientists took measures to explain the physical origin of the non-thermal emission above 100 keV from the studied supernova remnant. One of the most plausible explanations offered by them is that there may exist a higher magnetic field in some small region in the remnant or the magnetic field might increase downstream with the distance away from the shock front.

"The magnetic field increases downstream with the distance away from the shock front, so that electrons may produce higher energy photons when flowing downstream. But so far there is no support from theory and observation for magnetic field increasing downstream," the paper reads.

Other hypotheses include synchrotron radiation of the secondary relativistic electrons that originate in the hadronic process and the radiation from the asymmetrical supernova explosion.

According to the research, recent direct imaging observations of the ^{44}Ti emission in Cassiopeia A could confirm the asymmetrical explosion theory. The studies suggested an intermediate asymmetry in this core-collapse supernova as the ^{44}Ti is extended along the jet axis seen in X-rays. Thus, Cassiopeia A may be a very special case of supernova explosions in our galaxy, and produced by an asymmetric or a relatively more energetic explosion.

The researchers underlined how much complex and time-consuming is their study. They also revealed plans for future observations.

"The data analysis is complicated and needs much time. It took about two years to finish the data analysis work. Some theoretical work will go on and new observations by the future Hard X-ray Modulation Telescope (HXMT) will be carried out," Wang said.

HXMT, scheduled for launch this year, is a Chinese astronomy spacecraft. It is designed to scan the galactic plane to find new transient sources and to monitor the known variable sources, and also to observe X-ray binaries to study the dynamics and emission mechanism in strong gravitational or magnetic fields.

More information: Hard X-ray emissions from Cassiopeia A observed by INTEGRAL, arXiv:1605.00360 [astro-ph.HE], arxiv.org/abs/1605.00360

Abstract
Cassiopeia A (Cas A) as the nearby young remnant of a core-collapse supernova is the best candidate for astrophysical studies in supernova explosion and its environment. We studied hard X-ray emissions from Cas A using the ten-year data of INTEGRAL observations, and first detected non-thermal continuum emission from the source up to 220 keV. The 44Ti line emissions at 68 and 78 keV are confirmed by our observations with a mean flux of ~(2.2±0.4)×10−5 ph cm−2 s−1, corresponding to a 44Ti yield in Cas A of (1.3±0.4)×10−4 ms. The continuum emission from 3—500 keV can be fitted with a thermal bremsstrahlung of kT~0.79±0.08 keV plus a power-law model of Γ~3.13±0.03. The non-thermal emission from Cas A is well fitted with a power-law model without a cutoff up to 220 keV. This radiation characteristic is inconsistent with the diffusive shock acceleration models with the remnant shock velocity of only 5000km s−1. The central compact object in Cas A cannot contribute to the emission above 80 keV significantly. Some possible physical origins of the non-thermal emission above 80 keV from the remnant shock are discussed. We deduce that the asymmetrical supernova explosion scenario of Cas A is a promising scenario to produce high energy synchrotron radiation photons, where a part of ejecta with the velocity of ∼0.1c and opening angle of ∼10∘ can account for the 100-keV emission, consistent with the "jet" observed in Cas A.

Citation: Astronomers spot hard X-ray emissions from a nearby supernova remnant Cassiopeia A (2016, May 6) retrieved 20 March 2024 from https://phys.org/news/2016-05-astronomers-hard-x-ray-emissions-nearby.html