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Perspectives

Mission to study x-rays emitted from the most violent events in the universe

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In September of 2023, a bus-size x-ray telescope was launched into low-Earth orbit from the Japanese Space Center located on an island off the country's southern tip. This 2300 Kg satellite (Figure 1) called XRISM (X-Ray Imaging and Spectroscopy Mission; pronounced 'crism') now orbits around the Earth every 96 minutes at an altitude of 550 Km. XRISM is led by the Japan Aerospace Exploration Agency (JAXA) in collaboration with the U.S. National Aeronautics and Space Administration (NASA) and the European Space Agency.

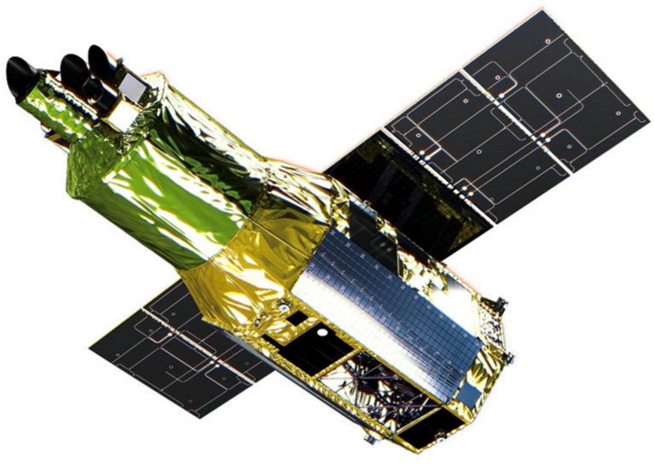

Figure 1. *Artist's depiction of XRISM telescope. Credit: NASA website (https://heasarc.gsfc.nasa.gov/docs/xrism/gallery/index.html), accessed 5 Dec 2023.*

X-rays from space do not penetrate the Earth's atmosphere (Figure 2), protecting humans but also limiting their study. In the 1960s and 70s, rockets and then satellites overcame this limitation and allowed x-ray detectors to be utilized above the atmosphere. The most successful so far is NASA's Chandra X-ray Observatory which was launched in 1999. But it is aging and plans were made to replace it with Japan's Hitomi satellite which was launched in March of 2016. But after collecting data for only one month (Figure 3), control of Hitomi was unfortunately lost and the satellite broke up in late April of that year. Facing a multi-year gap in the ability to carry out x-ray astronomy, JAXA and NASA approved a rebuild (with improvements) of the Hitomi, the new version becoming XRISM.

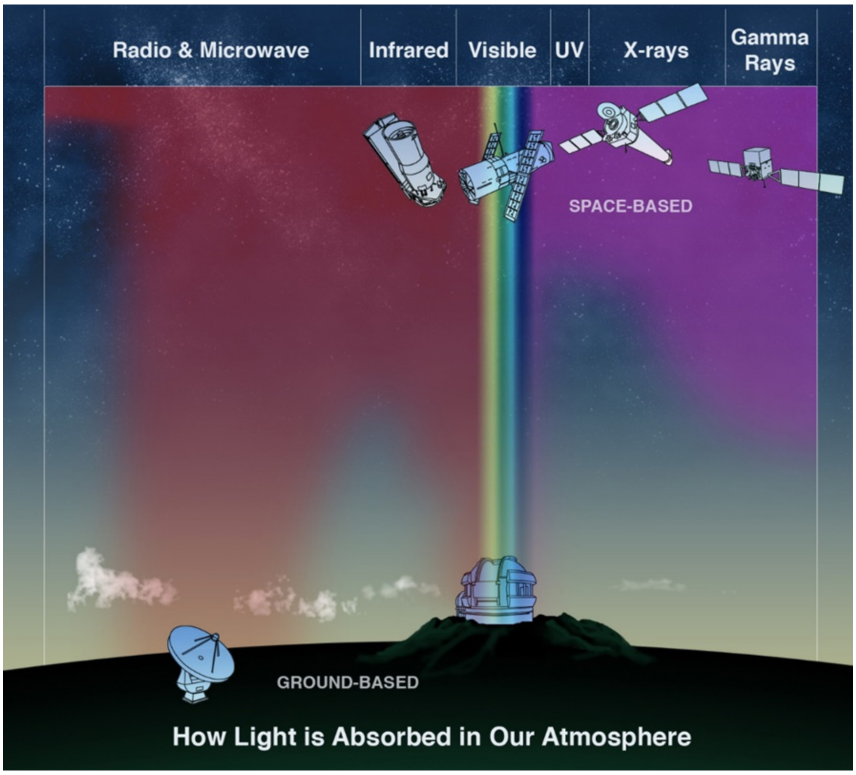

Figure 2. *The differential penetration of electromagnetic energy through the Earth's atmosphere. Penetrating radio waves and visible light can be studied with ground-based telescopes, while space-based telescopes are required to study x-rays originating in space. Credit: Chandra X-ray Observatory website (https://chandra.harvard.edu/graphics/resources/illustrations/absorption_new_300.jpg), accessed 6 Dec 2023.*

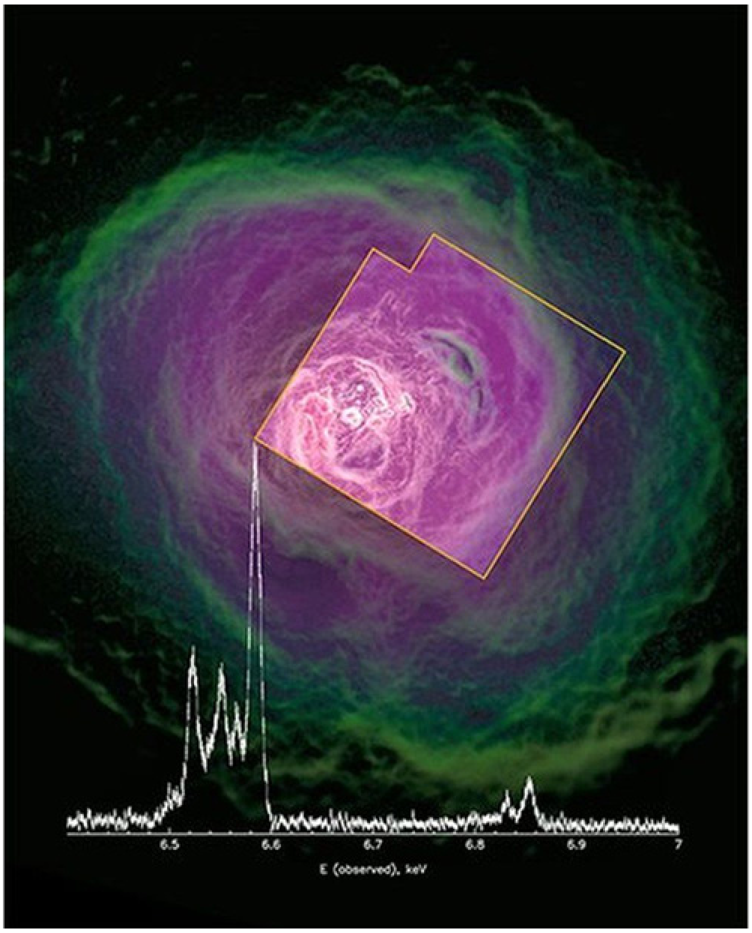

Figure 3. *Image of a galaxy cluster in the Perseus constellation taken by NASA's Chandra X-ray Observatory, overlaid with data collected by the Hitomi X-ray Satellite (just before it ceased functioning), outlined by an orange box, showing X-rays emitted by hot gases between the galaxies. Note the enhancement provided by Hitomi. Credit: BBC News (https://www.bbc.com/news/world-asia-36732336), accessed 5 Dec 2023.*

Some of the universe's most interesting objects and most explosive events emit x-rays. These include galaxy clusters, remnants of exploded stars and black holes. But this radiation cannot be studied even by such very sensitive telescopes as the James Webb Space Telescope which was launched in 2019, because it detects only the orange to mid-infrared part of the electromagnetic spectrum and not x-rays. Dr. Brian Williams, an astrophysicist at NASA who was on both the Hitomi and XRISM research teams, said "we realized that we really had to go and build this mission again, because this is the future of x-ray astronomy" [1].

XRISM carries two instruments, one called ‘Resolve’ and the other ‘Xtend’. Resolve analyzes x-rays with a spectroscope which must be kept at a temperature close to absolute zero so that tiny temperature changes caused by the x-rays hitting the detector can be detected. Its resolution of spectroscopic data will be about 30-fold better than those of the Chandra X-ray Observatory. Working in parallel, Xtend will expand current imaging, observing areas of space about 60% larger than the apparent size of the full Moon.

The high frequency and short-wave lengths of x-rays determine the shape of x-ray telescopes. The mirrors essential in all telescopes to increase capture of light and focus it are large and require an extreme smoothness (at the microscopic level). But while mirror assemblies in telescopes for visible light are close to perpendicular to the path of the photons being studied, they would not work for x-rays. They would pass right through the mirrors. Instead, mirror assemblies for x-ray telescopes are set nearly parallel with the path of the photons, causing only tangential ‘grazing’ at very low angles. Thus, x-ray telescopes are long, with their mirrors lining the inner sides of a very elongated cone. For example, the main telescope of XRISM is 45 cm in diameter while having a focal length of 5.6 meters.

Scientific operations of XRISM are expected to begin in January 2024, but it may be a year or longer before data become public. JAXA and NASA worked hard on the $190M XRISM to minimize the likelihood of a repeat of the previous failure. This included improving safety measures and giving up some of Hitomi’s instruments. Professor Makoto S. Tashiro, an astrophysicist and the XRISM Principal Investigator, states on the JAXA website “learning from the successes and failures of ASTRO-H [Hitomi], XRISM will open a new doorway for the x-ray astronomy world” [2]. Dr. Williams told the journal Science that XRISM “will be the predominant x-ray mission of the 2020s” [3].

Conflicts of Interest and Source of Funding

The author has no conflicts of interest to declare; no funding was involved in this article.

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