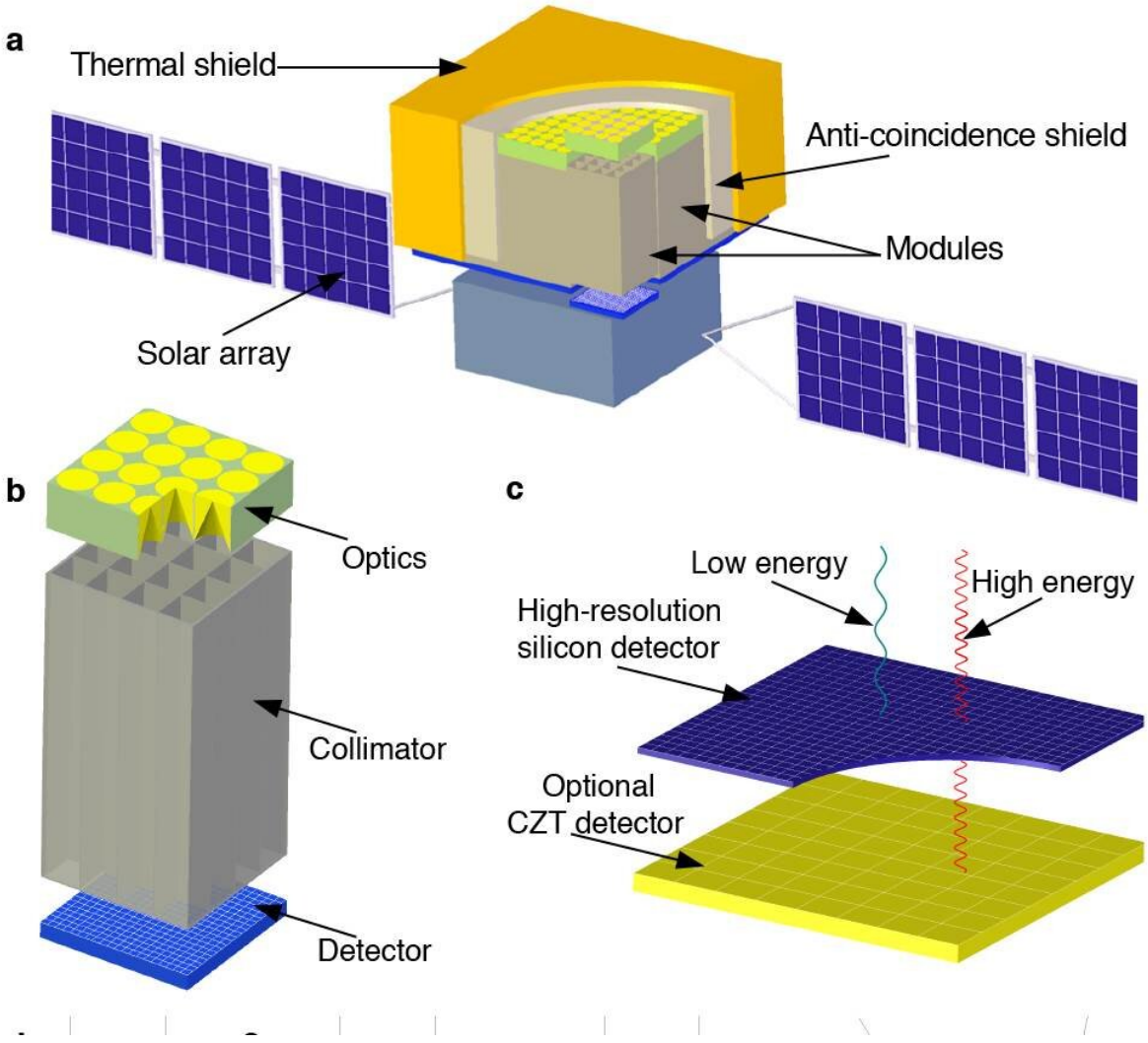
Radically different telescope design offers deeper look into space

June 18 2019



The design marks a radical departure from the so-called Wolter type space X-ray telescopes, which rely on mirrors to direct X-ray beams. Instead the proposed optics are built by stacking disks embedded with prismatic rings, created with

photoresist by focused ultraviolet lithography. Credit: KTH The Royal Institute of Technology

A radically different type of X-ray space telescope has been designed by scientists in Sweden, using advanced optic techniques that were originally developed in medical imaging research.

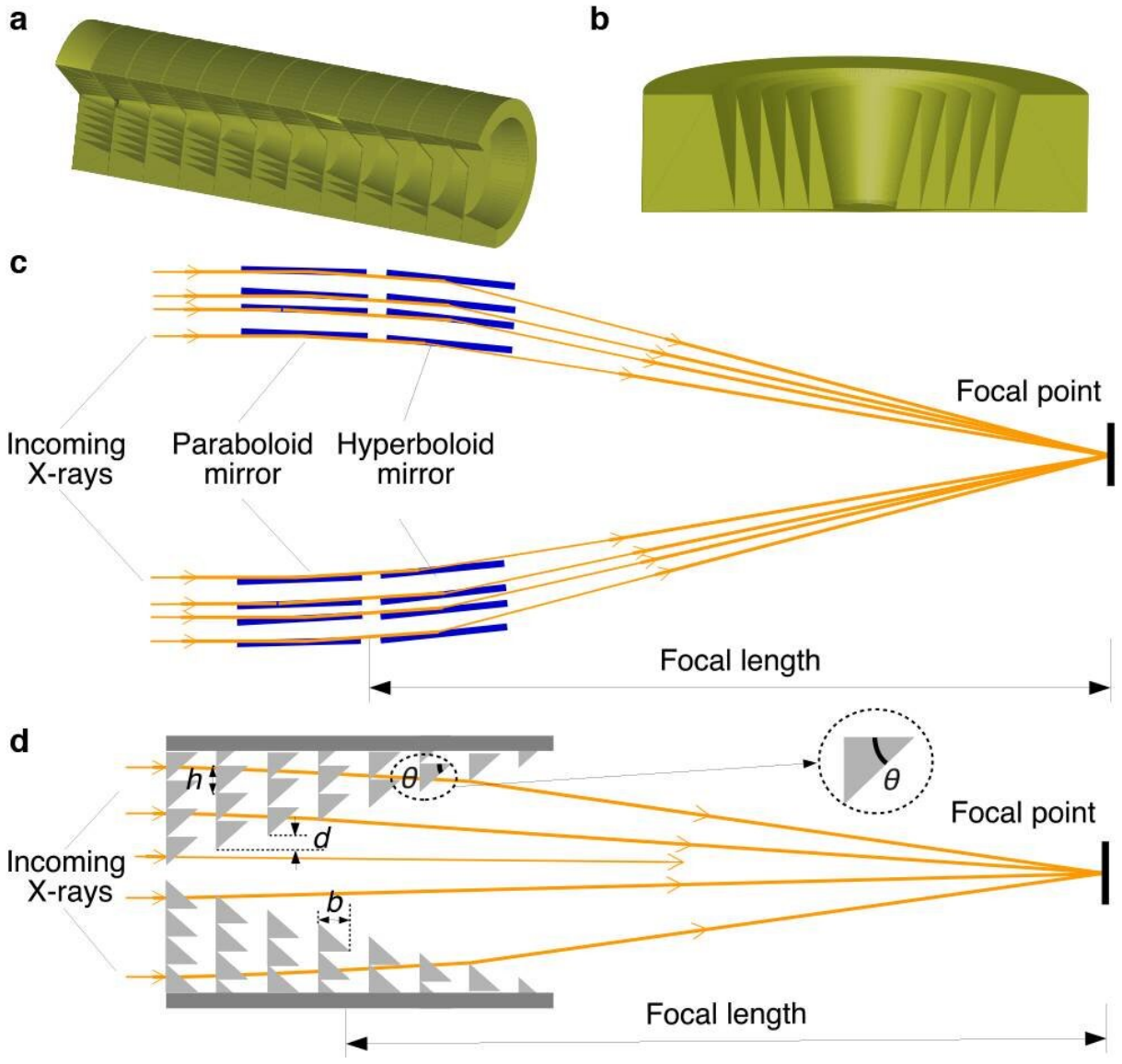
The telescope, which focuses X-rays with a unique Stacked Prism Lens, was unveiled this week in an article in *Nature Astronomy*. The researchers, from KTH Royal Institute of Technology in Stockholm, report on how they have dispensed with light-reflecting mirrors in favor of a network of microengineered plastic prisms.

Mats Danielsson, a researcher in medical X-ray technology, and astrophysicist Mark Pearce, say the design reduces the focal length and weight of the telescope, allowing large collecting areas with high spatial resolution so that space observations can delve deeper into the universe and examine objects that are now too faint to be detected.

The most commonly-used technique for focusing X-rays in space telescopes is through the use of an array of curved mirrors that gradually bend light toward the focal point. Because this light is difficult to focus, the focal length of such a telescope is typically long. NASA's Chandra X-Ray Observatory, for example, has a focal length of 10m. With the KTH telescope's shorter focal length of less than 50cm, Danielsson says the system would provide greater optical power, bending the rays more sharply to the focal point.

"This allows you to build a telescope that can collect more than a thousand times as much light as today's X-ray space telescopes can handle," Danielsson says. "Another advantage is that it will have good

spatial resolution, which means that you can see more details in the pictures you take. This is important in order to make correct physical interpretations."



A cross section representation of how the new design differs from Wolter type X-ray telescopes. An assembly of disks with microengineered prisms guides the beam toward the focal point, rather than paraboloid and hyperboloid mirrors. Credit: Wujun Mi

X-ray telescopes are deployed aboard spacecraft since X-rays are readily absorbed by Earth's atmosphere and cannot be observed on the ground. So payload size and weight matter. One such telescope, the PoGO+ mission which operated at an altitude of 40 km suspended from an enormous helium filed balloon, enabled Pearce and his colleagues to make new observations of X-rays originating from the vicinity of a pulsar and a black hole—a study he hopes to build on using the new telescope design.

"We are looking forward to developing the new lightweight optics with Mats since this will allow us to eventually build a large area and lightweight telescope that produces more precise measurements than are possible today."

The system's improved ability to collect light will reveal objects too faint to be seen. "We will see extremely distant objects in the early universe and can also discover new objects that have never before been observed with X-rays," Danielsson says.

"This opens a whole new window to answer basic questions about the universe," he says.

A first prototype of the telescopic technique has already been designed at KTH and tested in a laboratory. The next step is to optimize the design of the lenses and associated sensors, mechanics and electronics. "Now is the time to take the step from the first proof-of-principle to a fully developed module for a telescope to be sent up in space," Danielsson says.

More information: Wujun Mi et al. A stacked prism lens concept for next-generation hard X-ray telescopes, *Nature Astronomy* (2019). DOI:

10.1038/s41550-019-0795-y