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CHANDRA X-RAY TELESCOPE DISCOVERS COMPANION TO BRIGHT STAR IN THE SOUTHERN CROSS

Astronomers from Swarthmore College and West Chester University of Pennsylvania are announcing today, at the American Astronomical Society meeting in Seattle, the discovery of a previously unknown binary companion to the bright star, beta Crucis, in the Southern Cross. Beta Crucis, variously known as Mimosa, Becrux, or HD 111123, is the 19th brightest star in the sky. As a prominent member of the well-known constellation Crux, or the Southern Cross, it appears on five national flags: Australia, Brazil, New Zealand, Papua New Guinea, and Samoa. The companion star was discovered accidentally while the research team, led by Prof. David Cohen of Swarthmore College, was using the orbiting Chandra X-ray Observatory to study the x-rays emitted by beta Crucis itself. "We are interested in how the highly supersonic stellar winds of hot, luminous stars produce x-rays, and we were surprised to see two strong x-ray sources where we had expected to see only one in our Chandra observation," Prof. Cohen said.

This newly discovered companion appears 4 arc seconds away from beta Crucis. There are 3600 arc seconds in one degree, so the apparent separation between the stars is 1/900 of a degree. For a pair of automobile headlights to have an apparent separation of only 4 arc seconds, you would have to be about 60 miles away from the car. Although this angular separation is very small, it is well within the capabilities of NASA's Chandra X-ray Observatory to resolve the two stars in a single image (see the attached Figure). Optical telescopes can in principle also resolve a pair of objects separated by such a small angle, however no optical telescope has ever seen this companion of beta Crucis. This is most likely because it is so much dimmer than beta Crucis itself, which with a surface temperature of 27,000 degrees Kelvin (49,000 degrees F; nearly five times hotter than the Sun) and a diameter about eight times that of the Sun, is very luminous (giving off about 34,000 times as much energy as our Sun every second). The newly discovered companion may not even be as luminous as the Sun, and detecting a star that is 34,000 times, or more, dimmer at a separation of only 4 arc seconds is very difficult. It would be like trying to detect a firefly in place of one of those headlights at a distance of 60 miles.

The x-ray emission levels of the two stars are much more similar, however, and that is what enabled Chandra to detect the companion. Professor Cohen reports that the x-ray brightness of the companion is nearly 80% that of beta Crucis. His colleague, Prof. Marc Gagne, from West Chester University, notes that this implies that the companion's x-ray emission levels are very high for its apparently quite modest optical brightness. This is consistent with the companion being a low-mass (probably weighing less than the Sun) pre-main-sequence star. Pre-main-sequence stars are stars that are still in the process of forming. Because of the rapid rotation and strong magnetic fields found in such very young stars, strong x-ray emission is quite common. The two stars would presumably be the same age (about 10 million years old; compared to 5 billion years for the Sun). However, beta Crucis is a high-mass star, and high-mass stars form and evolve much more rapidly

than low-mass stars, so beta Crucis has already passed through its youth and even its middle age. It has apparently used up much of its nuclear fuel (providing its high luminosity) and is well on its way to being a giant star, which is the post-mid-life-crisis stage of a star's life. Meanwhile, the companion has not even started to burn its nuclear fuel.

The x-ray properties of the companion, as measured in the new Chandra observation, are completely consistent with it being a low-mass pre-main-sequence star, says co-investigator Prof. Eric Jensen, also of Swarthmore College. "Its x-ray emission is relatively high-energy and it shows a significant degree of time-variability in its overall x-ray emission levels, as we would expect from a young, low-mass star," Prof. Jensen said.

An undergraduate student at Swarthmore College, senior Michael Kuhn of Charlottesville, Virginia, is the lead author on the presentation at this week's American Astronomical Society meeting, and his work analyzing the x-ray data from both beta Crucis and its newly discovered companion is the basis for a paper on this project that the research group will soon be submitting to the Monthly Notices of the Royal Astronomical Society.

The beta Crucis system is 352 light years away from the Earth, and being in the Southern Cross, is only visible from the southern hemisphere (and very low latitudes in the northern hemisphere). At this distance from the Earth, the observed angular separation between the two stars, of 4 arc seconds, corresponds to an actual distance of 430 astronomical units between beta Crucis and the companion (1 astronomical unit, or A.U., is the distance between the Earth and the Sun). This means that their separation is about ten times the separation between the Sun and Pluto.

Follow up observations will be required to verify that the two stars are actually gravitationally bound (i.e. orbiting each other), and not just coincidentally near each other in the sky for a brief period of time. If they are indeed gravitationally bound, then the companion orbits beta Crucis with a period of about 2000 years. Measurements with optical and/or infrared telescopes would be very useful in characterizing the properties of the newly discovered companion; verifying, for example, that it really is a low-mass pre-main-sequence star. There is a large cluster of young stars in the vicinity (called the Lower Centaurus Crux subgroup of the Sco-Cen OB association), of which beta Crucis is a member. Many low-mass pre-main-sequence stars are already known to exist in this cluster, and those that have been observed with x-ray telescopes show x-ray properties similar to the newly discovered companion.

Note that on the scale of the Australian flag, the newly discovered binary companion to beta Crucis would be so close to that star that they would not be distinguishable, much as is the case in actual optical images of the star and constellation!

The observations Prof. Cohen's team made were carried out with the Advanced CCD Imaging Spectrometer (ACIS) instrument, using the High Energy Transmission Grating Spectrometer (HETGS), aboard the Chandra X-ray Observatory. NASA's Marshall Space Flight Center, Huntsville,

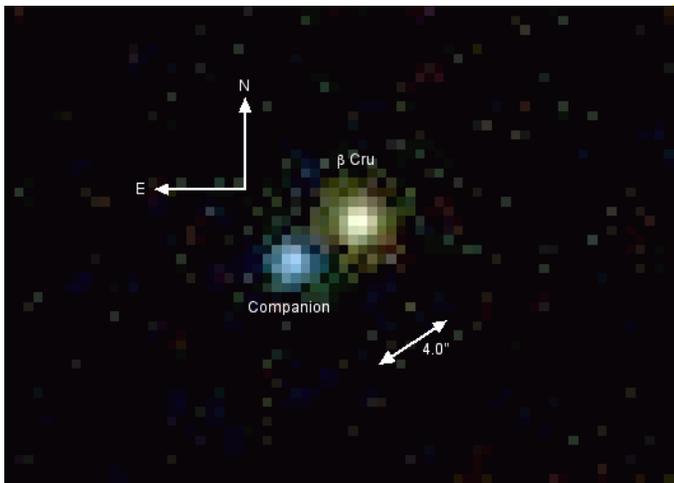
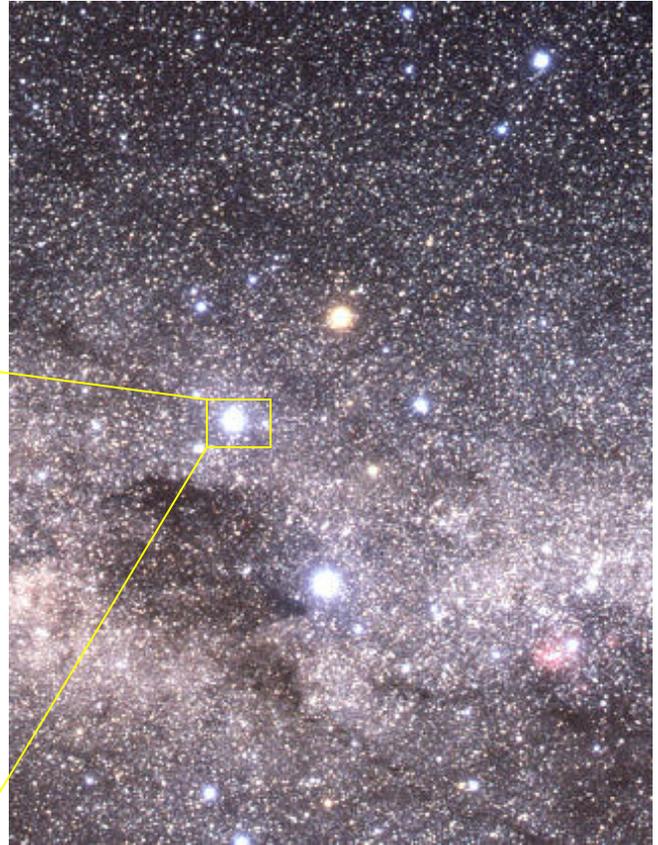
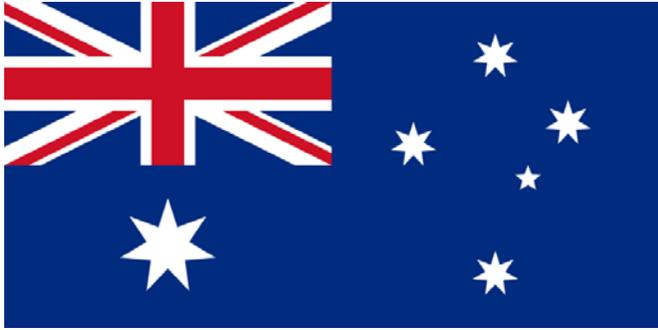
Ala., manages the Chandra program for the agency's Science Mission Directorate. The Smithsonian Astrophysical Observatory controls science and flight operations from the Chandra X-ray Center, Cambridge, Mass.

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Higher quality images from the press release, as well as supplementary images and information, are available at <http://astro.swarthmore.edu/~cohen/bcru>



An optical image (taken by a ground-based telescope) of the Southern Cross is shown on the right. Beta Crucis is indicated by the yellow rectangle. The new Chandra X-ray Observatory image, in which the companion was discovered, is shown at the lower left. The total area covered by this image is actually significantly smaller even than the yellow box. The Chandra image is color coded, with high energy x-rays colored blue, medium energy x-rays green, and lower energy x-rays red. Note that the x-ray emission from the companion is at significantly higher energies than that of beta Crucis itself. This is one indication that the companion is a young, low-mass star. The four arc second angular separation is denoted on the figure (4.0"). The Southern Cross is prominently featured on the national flag of Australia (above, left). Beta Crucis is the star just to the right of the Union Jack.