UCSD to launch instrument aboard NASA's X-ray Timing Explorer to study galactic and extragalactic compact objects

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An instrument developed at the University of California, San Diego to study some of the most exotic phenomena in the universe is scheduled to be launched Dec. 10 aboard NASA's X-ray Timing Explorer.

Called the High-Energy X-ray Timing Experiment (HEXTE), the UCSD instrument will provide astronomers with new information on the nature of X-ray emitting compact stellar objects, such as black holes, neutron stars and white dwarfs, as well as distant galaxies.

HEXTE is one of three instruments scheduled to be launched into low-earth orbit aboard a Delta II rocket from the Cape Canaveral Air Station. The 1,000-pound instrument is comprised of two clusters of four detectors that are sensitive to X-rays over a very broad range in energy -- 15 to 250 kilo-electron volts. Together with the Proportional Counter Array (PCA), provided by NASA's Goddard Space Flight Center, HEXTE will spy on bright and dim X-ray sources deep in space.

"This is the Keck Telescope, so to speak, of X-ray astronomy in that both the HEXTE and PCA will be the largest ones of their kind flown in their energy range," said Richard Rothschild, a research physicist, and principal investigator for HEXTE, in UCSD's Center for Astrophysics and Space Sciences. "That will allow us to see fainter objects or to see time variations that are faster than we've ever seen before."

While HEXTE and the PGA will analyze X-ray sources in detail, the All Sky Monitor developed by the Massachusetts Institute of Technology will continually scan the sky and alert astronomers to flares and changes of state in other X-ray sources. Scientists are particularly interested in observing objects in the X-ray band because X-rays are produced by some of the most violent activity taking place in the universe. X-rays can be detected from quasars, black holes, white dwarfs and neutron stars -- very dense objects with extremely strong gravitational fields.

One of the chief characteristics of X-rays produced by such compact objects is that they vary in intensity over time. The intensity of X-rays emitted by spinning neutron stars, for example, appears to vary at regular intervals due to the star's rotation. This effect is similar to the bright pulse of light seen from a lighthouse -- as the neutron star rotates, its beam of energy flashes past us with each revolution. These sweeping pulses of energy can be used to calculate how fast a neutron star is spinning. Some neutron stars are observed to rotate faster than 30 times a second despite weighing as much as the sun.

The X-ray Timing Explorer will for the first time allow astronomers to observe the most rapid variations in X-ray emissions. XTE's instruments can detect X-ray emissions occurring at rates faster than a millisecond (1/1000 of second.) By studying the temporal variability of compact objects over periods that range from fractions of a second to months, scientists hope to explain how matter is transferred from one star to its binary companion, how this matter interacts with the intense magnetic fields present, how strong gravity affects the X-rays and how X-ray beams are formed. The mission also will provide researchers with new understanding of the dynamics and life history of X-ray emitting objects.

Rothschild is particularly interested in observing Cygnus X-1, a well-known object in the Milky Way that many astronomers believe is a stellar-sized black hole. Because black holes have extremely strong gravitational fields, even light cannot escape their interiors. Thus, scientists try to study them by measuring the effect they have on matter around them.

"Since the work of Einstein, John Wheeler, and others, we have known that black holes warp, or change, the shape of space nearby and matter is sucked toward the black hole by the tremendous forces of gravity," Rothschild said. "By studying the flickering of the X-rays near Cygnus X-1, I hope to convince skeptics that Cygnus X-1 is indeed a black hole."

Rothschild also hopes to determine if Cygnus X-1 is spinning by studying the rate at which matter orbits it. If the black hole is rotating, then matter should be orbiting even closer to its "edge" and at higher speeds. To date, astronomers have been unable to confirm whether any black holes in the universe are spinning.

Rothschild plans to take advantage of XTE's ability to detect rapid changes in the intensity of X-ray emissions by observing energy released from matter such as protons and electrons as it makes its final plunge before disappearing into the depths of a black hole. Theory holds that matter takes only about five milliseconds to complete its final orbit.

Rothschild's team, which includes Michael Pelling, Duane Gruber, Jim Matteson, Philip Blanco, and William Heindl, was first awarded a contract from NASA to develop HEXTE in 1982. Construction of the instrument began in 1989. The total cost for the UCSD project, including maintaining its operation after launch, is about $25 million.

The X-ray Timing Explorer will be the first American X-ray astronomy spacecraft to be launched in more than 15 years.

"I'm going to be nervous," admitted Rothschild, who is one of the UCSD researchers who will travel to Florida to watch the launch of the spacecraft. "But I know I'm going to be yelling ' Go, Go, Go' with the rest of them."

The HEXTE detectors are improved versions of detectors developed by Laurence Peterson, director of the UCSD Center for Astrophysics and Space Sciences, for the High Energy Astronomical Observatory-1 (HEAO-1) launched by NASA in 1977.

Each detector consists of a sodium iodide crystal coupled with a cesium iodide crystal. When an X-ray hits a crystal, it causes it to give off a flash of light, the brightness of which is dependent upon the energy level of the X-ray. Photomultiplier tubes record the flash of light and convert it into an electric signal that is routed to amplifiers and analyzed by computers. The data is then sent via two of NASA's Tracking and Data Relay Satellites to a ground station in White Sands, New Mexico, and then forwarded to Goddard before being routed to UCSD.

The X-ray Timing Experiment is scheduled to complete a prime mission of two years. At least one year of extended operations has currently been approved. An option to extend operation of the 6,700-pound spacecraft for a total of four to five years will be considered after early results from XTE are assessed. Science operations are scheduled to begin in October 1995, after a check-out period is completed.

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