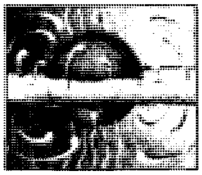

The Next Generation of Satellites

Within the next few years two planned satellites, one Japanese and one American, should begin gathering data vital to a deeper understanding of x-ray sources and their variability, The instruments aboard the satellites will allow both detection of previously invisible sources and much more detailed studies of bright sources.

The Japanese satellite, ASTRO-C (Fig. 1), which is being designed by the Japanese Institute of Space and Astronautical Science, will be launched in 1987. Its key instrument will be a proportional counter, called the large-area counter (LAC), with an effective area of 0.45 square meter. A proportional counter, the workhorse of x-ray astronomy, was chosen as the main instrument because it can be made with a large effective area, is rugged, and has good background rejection. It has moderate spectral resolution ($\Delta E/E \sim 0.2$). Signals from extraneous sources and the diffuse glow of the x-ray sky will be excluded with mechanical vanes that restrict the field of view to 0.8 by 1.7 degrees. The LAC will be sensitive to energies from 1.5 to 30 keV, a range that includes most of the output of neutron-star x-ray sources,

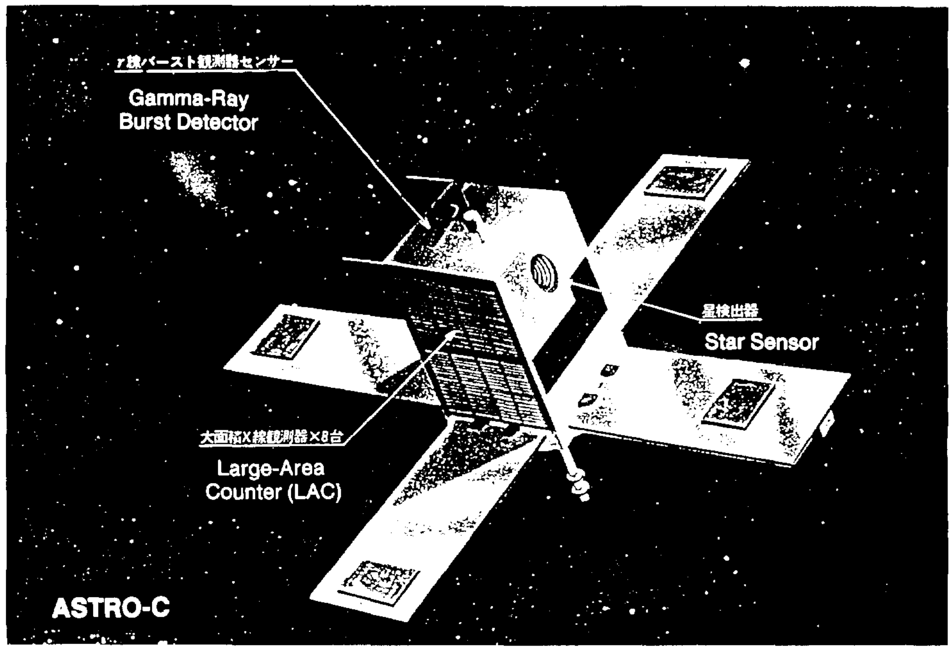

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Fig. 2. ASTRO-C, Japan's third x-ray astronomy satellite. The large-area counter (LAC) will consist of eight proportional counters containing a mixture of argon (70%), xenon (25%), and carbon dioxide (5%) and will be sensitive to x rays with energies from 1.5 to 30 keV. The gamma-ray burst detector will be a two-detector system: a 60-square-centimeter NaI(Tl) scintillation counter sensitive to photon energies from 15 to 480 keV and a 100-square-centimeter proportional counter sensitive to the same photon energies as the LAC. The all-sky monitor (out of view on the side opposite the LAC) will consist of two proportional counters. Also shown is the star sensor used to determine the orientation of the satellite.

NASA'S X-Ray Timing Explorer (XTE) (Fig, 2) will be larger than ASTRO-C and is planned to be launched from the Space Shuttle in the 1990s. Its kcy instrument will be a proportional counter array composed of eight separate detectors with a total effective area of a full square meter, The individual fields of view of the eight detectors will typically be nearly coaligned, but it will be possible for observers to command two detectors to an offset position to permit simultaneous observations of source and background intensititcs. This feature will make it possible to separate variations in faint or weakly varying x-ray sources from variations in the background. The field of view will be similar to that of ASTRO-C, but the use of xenon rather than an argon-xenon mixture will allow detection of higher energy x rays (2 to 60 kcV).

XTE will also carry a large-area (0.2-square-meter) hard x-ray telescope sensitive to energies from 20 to 200 kcV and pointed in the same direction as the proportional counter. In combination with the proportional counter array, this instrument will allow simultaneous spectral and variability measurements over the entire energy range from 2 to 200 keV. This capability will make possible detailed study of a host of kcy phenomena, such as the spectra of transient x-ray sources, cyclotron features in accretion-powered pulsars, the energy output from active galactic nuclei, and changes in the state of' certain galactic sources, such as the black-hole candidate Cygnus X-1.

The square-meter class of detector on the two satellites will allow the study of

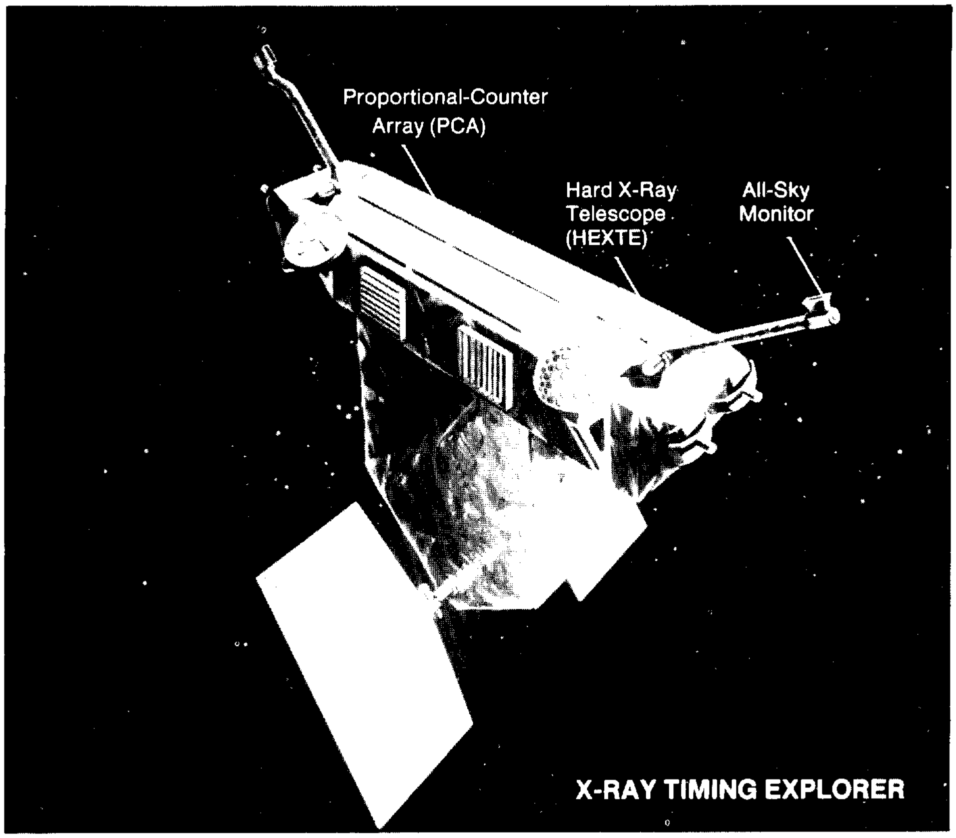

Fig. 2. ***NASA'S X-Ray Timing Explorer,*** or ***XTE. The observational objective of this satellite will be to measure photons from 2 to 200 keV on time scales ranging from 10 microseconds to months. To accomplish this objective, XTE will carry a 1-square-meter proportional counter (PCA), a 0.2-square-meter hard x-ray telescope (HEXTE) consisting of twelve scintillation detectors, and two ail-sky monitors that will scan the sky continuously.*** ➤

very faint sources and of changes in sources on very short time scales that have previously been inaccessible. Sources 10^5 times fainter than Scorpius X-1, for example, will be detectable in 100 seconds, allowing extensive study of active galactic nuclei and faint galactic binaries. Features of bright sources, such as fast variations in intensity, pulse frequency changes, and spectral changes during x-ray bursts. will be resolved without parallel. For example, XTE will be able to collect 2000 photons during a single pulse from the accretion-powered pulsar Hercules X-1, 200,000 photons during a bright x-ray burst. and even 45 photons during a 600-microsecond flare of the fascinating source of Cygnus X-1.

The x-ray transients discovered by EXOSAT, Tenma, and other recent satellites frequently turn out to be key examples for elucidating the physics of such systems. However, they are discovered mostly by luck because there is no all-sky coverage by these satellites. The transients were either detected by another satellite or were detected while the telescope was moving from one known source to another. Both of the new satellites will carry all-sky monitors. ASTRO-C will be able to scan the sky by executing a slow pirouette once each orbit, during the time the source being observed by the LAC is hidden by the earth. The monitor on XTE will continuously scan from two rotating platforms and will detect sources 1000 times fainter than Scorpius X-1 in a single 90-minute orbit. Data from these monitors can be used to redirect the main arrays toward sources showing unusual activity, The monitors will also provide unprecedented information on the day-to-day behavior of hundreds of sources.

ASTRO-C will carry a gamma-ray-burst detector, designed in collaboration with Los Alamos, whose viewing angle is half the sky. What is unusual about this instrument is the juxtaposition of a proportional counter sensitive to x-ray photons and scintillation counters sensitive to gamma-ray photons; such an arrangement means the critical spectra of burst events will be measured to lower energies than before.

ASTRO-C will be a free-flying satellite and will operate, with luck, for at least three to four years. The expectations for XTE are less clear. Its nominal design lifetime is that typical of NASA satellites—two years-but past NASA satellites have often functioned productively tor five or more years. (NASA'S international Ultraviolet Explorer, launched in 1978 with a similar design lifetime, is still pouring out results, and competition by scientists for its use has hardly eased.) Even though the XTE instruments can function almost indefinitely, NASA may choose to operate XTE aboard a recoverable platform and terminate its operation when the two-year design lifetime has elapsed. If so, the initial discoveries of XTE could not be followed up. Especially for the all-sky monitor, two years would provide only a tantalizing glimpse compared to the 10-year Vela 5B mission and the 5-year Ariel-5 studies of very long term changes in the x-ray sky. ■