Exosat

Achievements: detailed observations of celestial X-ray sources
Launch date: 26 May 1983
Mission end: reentered 6 May 1986 (designed for 2-year life, science operations began August 1983)
Launch vehicle/site: Delta from Vandenberg Air Force Base, California
Launch mass: 510 kg (science instruments 120 kg)
Orbit: 2919x189 000 km, 71.4°
Principal contractors: MBB headed the Cosmos consortium: SNIAS-Cannes (F)/ CASA (E)/Contraves (CH)/BADG (UK) (structure/thermal/mechanisms/solar array mechanical); MBB (D)/SNIAS-LM (F)/MSDS (UK)/Sodern (F)/Ferranti (UK)/SEP(F)/TPD-TNO (NL)/NLR (NL) (AOCS); Selenia (I)/Laben (I)/Saab (S)/Crouzet (F)/LM-Ericsson (S) (data handling/RF); ETCA (B)/Terma (DK)/Saft (F)/AEG (D) (power/solar array electrical)

ESA's X-ray Observatory Satellite (Exosat) studied the X-ray emissions from most classes of astronomical objects, including active galactic nuclei, white dwarfs, stars, supernova remnants, clusters of galaxies, cataclysmic variables and X-ray binaries, in 1780 observations. It measured the locations of cosmic X-ray sources, their structural features and spectral, as well as temporal, characteristics in the wavelength range from extreme-UV to hard X-rays. Its primary mission was to study sources already detected by earlier satellites, although it did discover many new ones serendipitously as it slewed from one target to the next or focused on specific areas.

Exosat was the first ESA/ESRO science satellite totally funded by the Agency. Its observations and data were not restricted to the groups that had built the three instruments, but were made available to a wider community. The satellite was operated as a true astronomical observatory. A unique feature was the highly eccentric orbit which, although it subjected Exosat to higher background radiation dependent on solar activity, provided up to several days at a time for uninterrupted viewing of a source. More than 450 publications of Exosat data in leading scientific journals have been made. Notable discoveries include:

— Exosat searched for neutron stars in double-star X-ray sources, by looking for regular flashes. None was found but quasi-periodic oscillations were discovered. In GX 5-1, a narrow pulse was replaced by an irregular flickering – apparently caused by gas falling into a neutron star or black hole from a companion star.

— Exosat discovered two stars orbiting each other every 11 min – the shortest period known. XB 1820-30 emits X-rays 10^{11} more intense than from the Sun as material falls onto its neutron star.

— The X-ray binary SS433 is probably a massive star feeding a black hole 10 times the mass of the Sun. Two giant jets near the black hole are ejecting material at a quarter the speed of light. The X-ray jets wave back and forth every 167 days, which Exosat discovered is the same period as variations in the optical lines. This is helping to explain the enigmatic nature of jets from black holes – still one of the hot topics in astrophysics.

Exosat in operating configuration. On the front, from left to right, are two startrackers, the two low-energy imaging telescopes and the four quadrants of the medium-energy instrument. The gas scintillation proportional counter is visible to the right of the medium energy instrument.

Exosat Mission Objectives

Precise location of sources: within 10 arcsec at 0.04-2 keV, 2 arcmin for 1.5-50 keV.

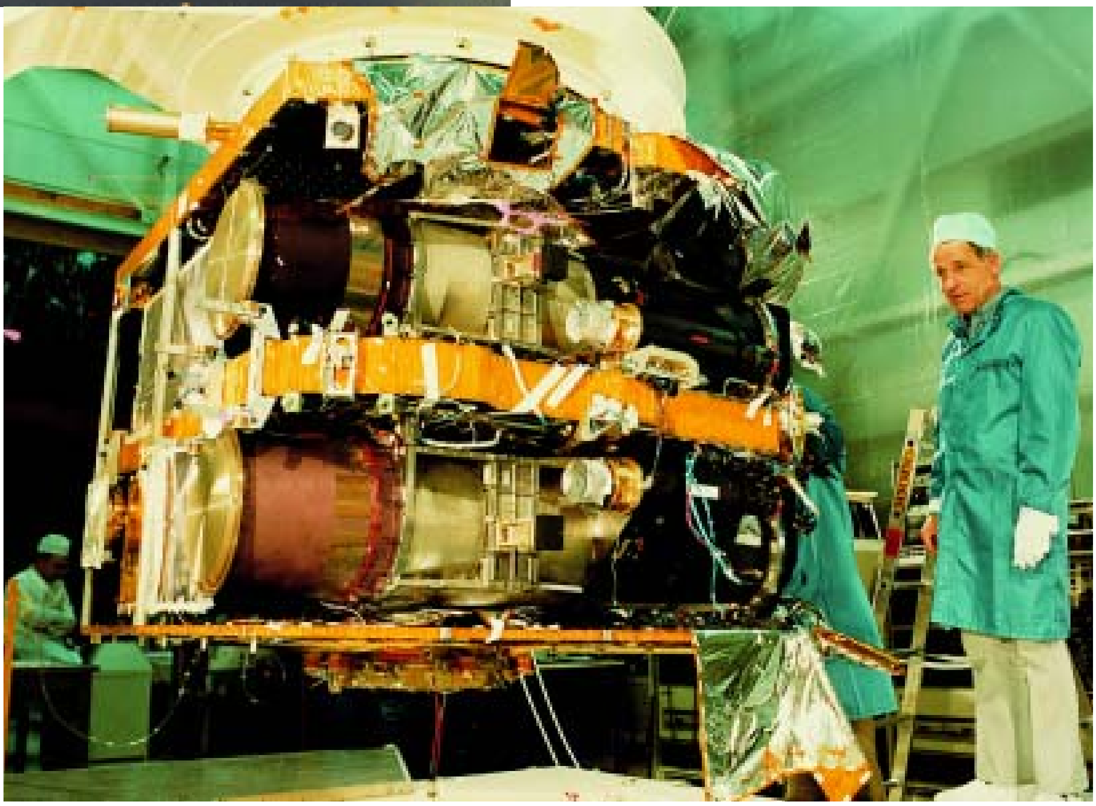
Mapping diffuse extended objects: at low energies using imaging telescopes.

Broadband spectroscopy of sources: with all instruments between 0.04 keV & 80 keV.

Dispersive spectroscopy: of point sources using gratings with imaging telescopes.

Time variability of sources: from days to sub-millisec.

New sources: detection.



Inside Exosat. The two low-energy imaging telescopes are prominent, with their apertures at left and their detectors at right.

— Exosat surveyed 48 Seyfert galaxies, which have giant black holes at their centres and are strong X-ray emitters. Exosat discovered a soft X-ray component, now thought to be emission from matter swirling into an accretion disc before disappearing into a black hole.

— observations of the pulsing X-ray nova EXO 2030+375 provided new insights into how material from a companion is captured by the intense magnetic field of a pulsing neutron star.

Exosat Scientific Instruments

Low-Energy Imaging Telescope *(LE)*

Two grazing incidence telescopes, 0.04-2 keV, 1 m focal length, 1° FOV to provide X-ray images using channel-multiplier arrays. Passband filters provided coarse spectral information; diffraction gratings for high-resolution spectroscopy (mechanical failure limited grating use to first few months of operations). Each telescope 30 kg, 5 W.

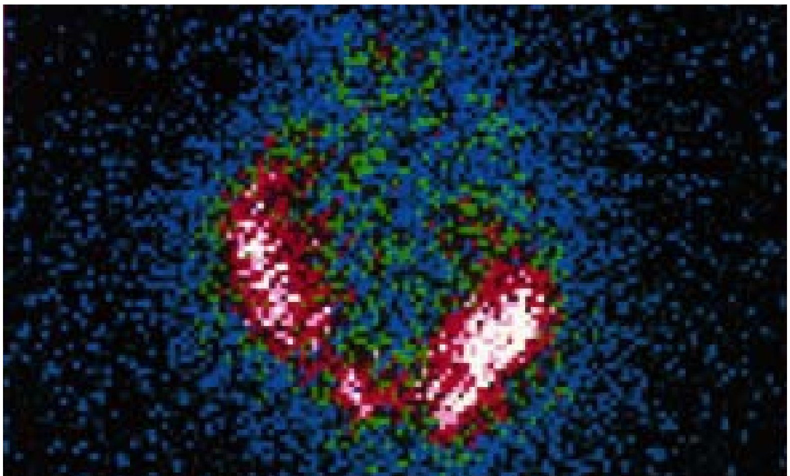
Medium Energy Experiment *(ME)*

Array of eight proportional counters, total area 1600 cm^2, 1.5° FOV, for moderate spectral resolution over 1-50 keV. Four detectors could be offset by up to 2° for simultaneous off-target background monitoring. 48 kg, 17 W.

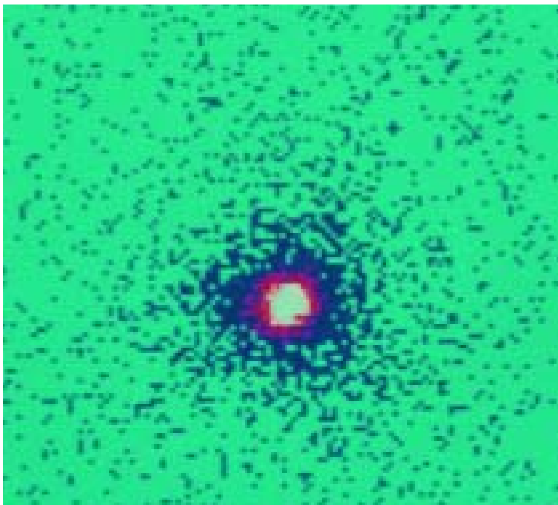
Gas Scintillation Proportional Counter *(GSPC)*

Higher-resolution spectrophotometry, collecting area 100 cm^2, 2-20 keV, 1.5° FOV. 8 kg, 1.5 W.

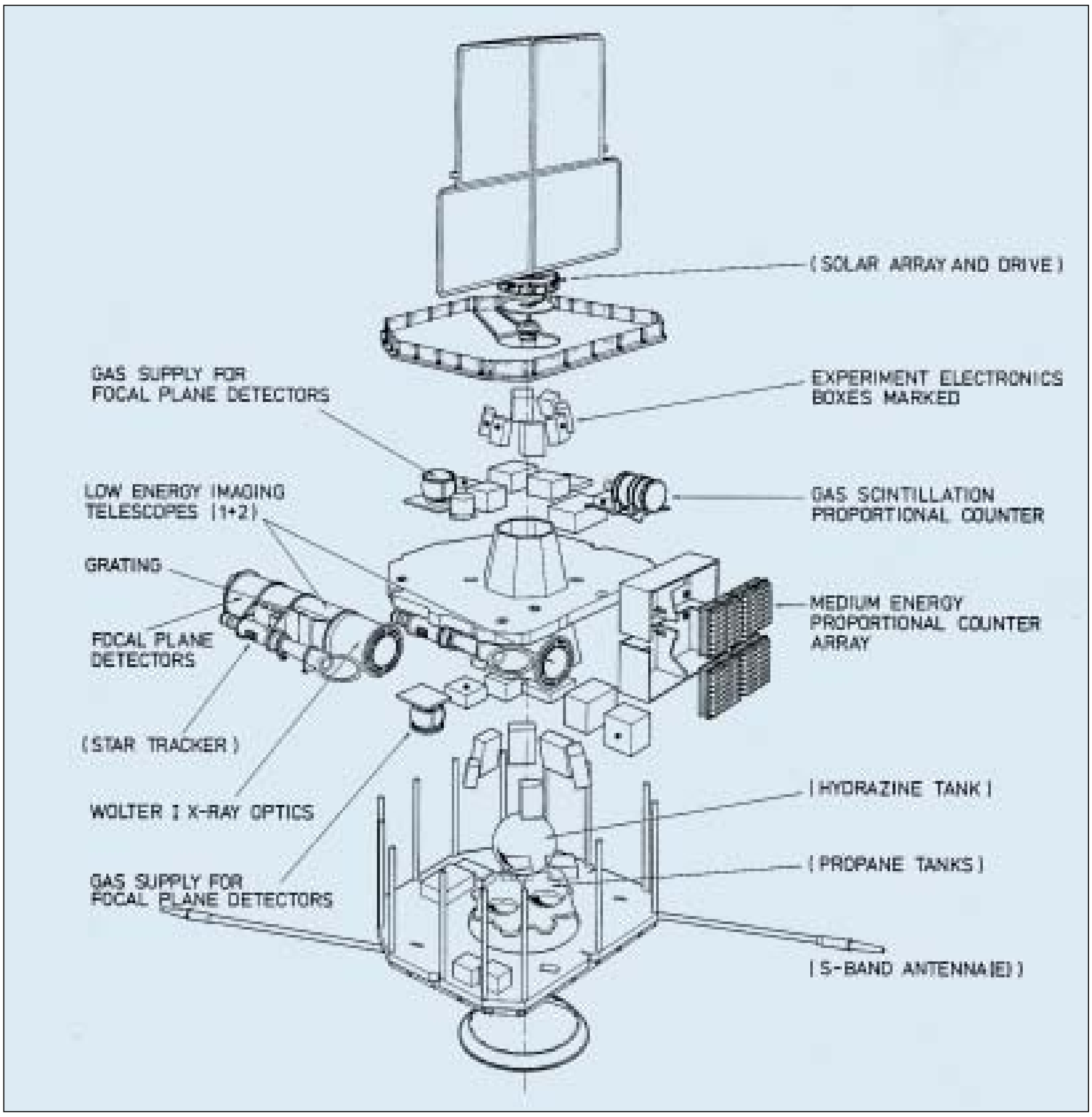
Exosat being prepared for launch from Vandenberg Air Force Base, California. The medium-energy and low-energy instruments are protected by their shutters on the left-hand face. These shutters were opened in orbit to act as sun shades for the telescopes.



A low-energy X-ray image of the bright supernova remnant Cas-A. X-rays are generated by interaction between the interstellar medium and stellar material ejected in the supernova event



Exosat image of the black hole candidate Cygnus X-1



Satellite configuration: box-shaped bus, 2.1 m square, 1.35 m high, topped by 1.85 m-high solar array. The science instruments viewed through one wall, covered by flaps during launch that opened in orbit to act as thermal and stray-light shields. Primary structure comprised central cone supporting one main and two secondary platforms. All alignment-sensitive units (science instruments and fine attitude-measurement units) were mounted on the highly-stable carbon fibre main platform.

Attitude/orbit control: 3-axis control by redundant sets of six 0.05-0.2 N propane thrusters. Attitude determination by gyros, Sun sensors and star trackers to 10 arcsec for Y/Z-axes and few arcmin for X-axis. Orbit adjust by 14.7 N hydrazine thrusters; delta-V measured by redundant accelerometers. AOCS equipment housed in central cone, with thrusters mounted on edges of platforms.

Power system: 260 W provided by 1-degree-of-freedom solar sail, following Sun to within 3°. Supported by two 7 Ah NiCd batteries.

Communications: the orbit was designed for Exosat to be in continuous realtime contact with Villafranca in Spain for the scientifically significant part of the orbit – the 76 h out of the 90 h orbital period when it was beyond the disturbing influence of Earth's radiation belts. Spacecraft control and science operations were conducted from ESOC. Science/engineering data returned at 8 kbit/s (no onboard recorder) via 6 W S-band transmitter.