

Edited by Emma Sanders

## X-rays come under the spotlight

In 1999 two new X-ray satellites were launched – Chandra and XMM-Newton. Here we mark a few of their discoveries and show some of the X-ray images that are now available to astronomers. For the first time there is comparable resolution between X-ray and radio observations.



Left: the XMM-Newton observatory. (ESA.) Right: the Chandra observatory, named after 1983 Nobel laureate Subrahmanyan Chandrasekhar (NASA).

### X-ray equipment

X-ray astronomy can only be carried out in space because X-rays are absorbed by the Earth's atmosphere. The telescopes differ from optical ones: owing to their high energy, X-rays penetrate into a mirror in much the same way as bullets slam into a wall; likewise, just as bullets ricochet when they hit a wall at a grazing angle, so too will X-rays ricochet off mirrors, allowing them to be focused.

Observations from Chandra and XMM-Newton are complementary. The latter has a larger collecting area than Chandra – better for observing faint sources – but lower resolution.

## New sources shed more light on active galaxy behaviour

With the improved resolution now available to X-ray astronomers, many new sources are being discovered. This wealth of new data gives a boost to understanding the energetic processes that are at work in the heart of active galaxies. Many of the new extragalactic X-ray sources are bright and point-like, and a significant number are probably caused by material accreting round black holes.

In the starburst galaxy NGC253, four black holes seem to be gravitating towards the centre of the galaxy, where they could coalesce to form a single supermassive black hole. The observers even suggest that NGC253 is undergoing a transition between starburst activity and a quasar-like galaxy. Quasars release huge amounts of energy, outshining galaxies of hundreds of billions of stars, from a space the size of our solar system. Each black hole would have a mass ten to thousands of times that of the Sun. This

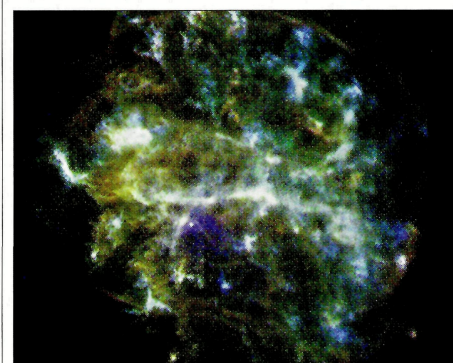
interpretation is a subject of great interest.

Another team surveyed 37 different galaxies suspected of containing a supermassive black hole in their centre. Some 25% contained extremely luminous sources.

For the first time the periodic variation of an X-ray source outside the Local Group of galaxies was clearly determined – proof that it originates from a binary system likely to contain a black hole of stellar mass.

Rapid X-ray flaring has been detected from the compact radio source in the Milky Way. The faintness of the associated X-ray radiation has in the past cast doubt on whether the emission really comes from matter accreting onto a supermassive black hole. Now, the rapid flaring means that the model is back on track. A factor of five change in the luminosity was detected in just 600 s. Given the finite speed of light, the emitting region could be no bigger than 20 times the black hole's event horizon.

## Chandra witnesses the death of a star



Supernova remnant G292.0+1.8. (NASA.)

The death throes of a star are shown up in X-rays by the Chandra Observatory. The young, oxygen-rich supernova remnant is lit up by a central radiating pulsar. Reading the pattern of the elements that make up the remnant helps to unravel the connection between the pulsar and the star from which it formed. The expanding shell is 36 light-years across. The blue knots of emission contain material that is enriched in oxygen, neon and magnesium.

## Ultraviolet camera reveals active galaxy



Active galaxy, M81. (ESA.)

This image was taken using the ultraviolet camera on XMM-Newton. Strong ultraviolet emission is a feature of star formation, supernova explosions and matter building up round black holes. The hottest regions are blue and highlight areas of intense star formation.

One of XMM Newton's strong points is that it can combine ultraviolet and X-ray data to give an idea of the processes at work across the spectrum. This helps in the case of M81, which belongs to a class of galaxy called low-ionization nuclear emission-line regions (LINERs). It is not certain what processes are at work in the centre of LINER galaxies. They could be fueled by starbursts – regions of intense star formation – or they may be a sort of mini-quasar, with a supermassive black hole round which gas and stars accrete slowly.

## Astro-E2 gets thumbs up from Japanese

Astro-E2, the X-ray space observatory that is programmed for launch in February 2005, has been given the go-ahead by the Japanese government. NASA will contribute the core instrument – the high-resolution X-ray spectrometer that operates at 0.1° above absolute zero. Five X-ray telescopes will be used to focus the X-rays onto four X-ray cameras and the spectrometer. The satellite replaces the Astro-E project, which was lost in launch in February (April 2000 p11).

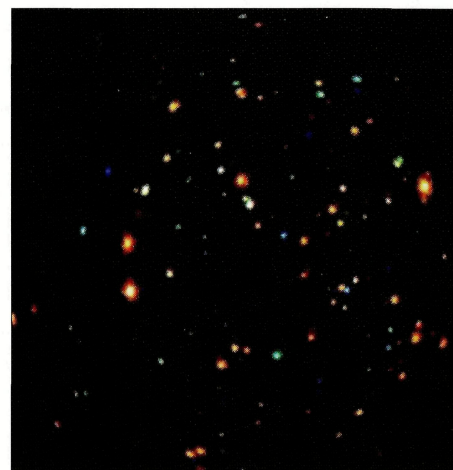
## Deep field is full of surprises

The “deep field” images of the depths of outer space revealed by the Hubble Space Telescope left astronomers speechless. Here, for the first time, on a region of sky less than the size of a pinhead held at arm's length, hundreds upon hundreds of galaxies were revealed. The faintest and often the most distant objects in the universe gave an unprecedented view of the early formation of galaxies. Five years on, the image still symbolizes the power of a telescope that has revolutionized observational astronomy.

Now, Chandra and XMM-Newton have revealed X-ray versions of this famous image. What was before seen as simply a diffuse X-ray background glow on the sky can now be resolved into individual sources. The number of X-ray photons and the energy levels coming from each object can be measured.

X-rays from approximately half of the sources are probably emitted by material accreting round supermassive black holes. The other sources are weaker, and in several cases they are fairly near. In these galaxies the emission is likely to be the net result of the X-rays coming from several bright sources within the galaxy, such as stellar-sized black holes in binary systems, the hot gas within the galaxy and the remnants of supernova explosions.

One focus for research has been to observe the X-ray output from galaxies known as



XMM-Newton's X-ray deep field view. (ESA.)

SCUBA sources (the Submillimetre Common User Bolometric Array first surveyed them). These luminous, dusty, star-forming galaxies radiate at infrared wavelengths and make a significant contribution to the total energy output of the universe. XMM-Newton observations show that the X-ray output is dim, suggesting that the galaxies are powered by intense bursts of star formation in the early universe, rather than by an obscured massive black hole at their centre.

In future, cross-checking the XMM-Newton and Chandra data will reveal objects with an X-ray output that varies with time. We haven't heard the last of the Hubble Deep Field.

## Telescope rockets to success

A low-cost alternative to current X-ray satellite observatories has made a promising start. Whereas traditional X-ray telescopes use grazing incidence mirrors, which are relatively inefficient (see box, p10), the new telescope, known as J-PEX, uses a multilayer coating on a normal incidence mirror, oriented as in an optical telescope. This gives greater sensitivity (because few photons are lost) and a much smaller payload.

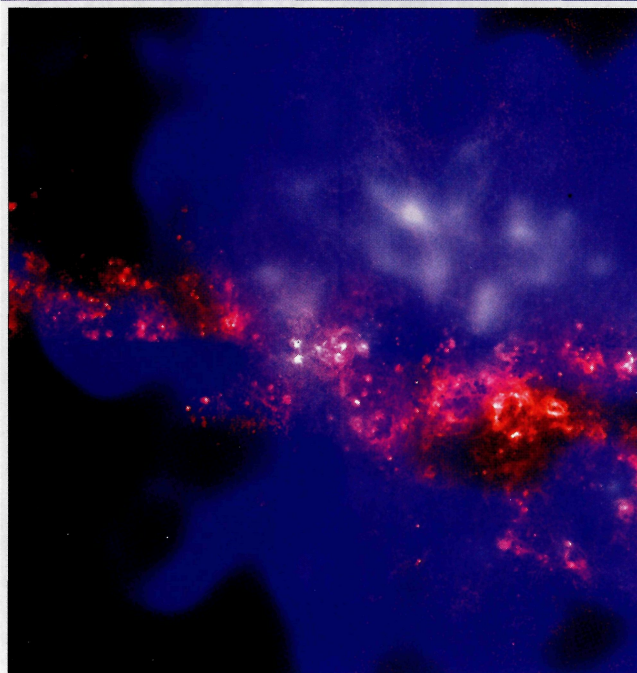
As a comparison, J-PEX has half the

effective area of the Chandra low-energy transmission spectrometer but 10 times the resolving power. The disadvantage is that multilayer mirrors only function in a very specific wavelength range.

J-PEX was flown on a NASA sounding rocket from the White Sands Missile Range in New Mexico. It observed its target star for five minutes before parachuting back down to Earth. The experiment was carried out by astronomers from the UK and the US.

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## Picture of the month



Using Chandra and the Hubble Space Telescope, astronomers have mapped the giant halo of hot gas that extends above the disk of a spiral galaxy, much like the Milky Way. The observations of galaxy NGC4631 indicate that there must be a close correlation between the outflows of hot gas seen in X-rays and the galaxy's magnetic field revealed by radio emission. The gas radiates at almost 3 million degrees and extends some 25 000 light-years from the galactic plane. (NASA.)

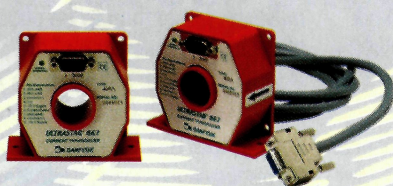
Non-X-ray news:  
UK is set to join ESO

On 1 July the UK will become the tenth member state of the European Southern Observatory (ESO). The other member states are Belgium, Denmark, France, Germany, Italy, the Netherlands, Portugal, Sweden and Switzerland.

ESO is Europe's major astronomy organization, operating world-class telescopes in the Chilean Atacama desert. When ESO was created nearly 40 years ago, the UK then chose a different route, using new southern hemisphere facilities in Australia.

In addition to paying its ESO contributions in the normal way, the UK will be supplying the VISTA infrared survey telescope as an in-kind contribution.

Prior to taking up residence in its headquarters at Garching, near Munich, Germany, ESO was based at CERN.

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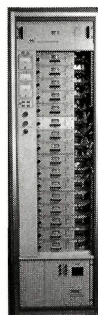


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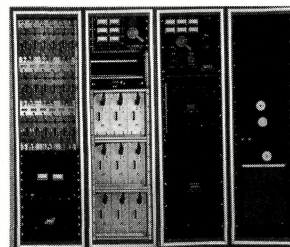
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