

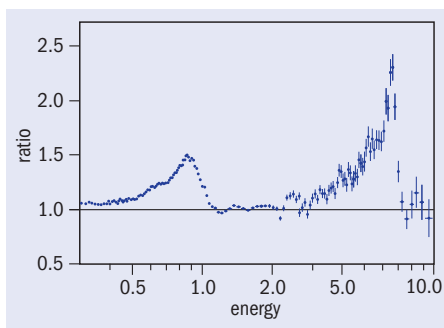
XMM-Newton observes emission from matter around a black hole

A recent observation by the XMM-Newton satellite revealed two prominent emission lines in the X-ray spectrum of the Seyfert galaxy 1H 0707-495. These lines are attributed to iron fluorescence and appear skewed towards lower energies as expected from relativistic effects in the close vicinity of a black hole. This is the strongest evidence yet for matter swirling just outside the event horizon of a super-massive black hole.

Seyfert galaxies are the less luminous analogues of quasars. They are named after Carl Seyfert, who in 1943 published the properties of 12 galaxies with peculiar optical emission lines emanating from the nucleus. These lines are now known to be emitted by atoms in gas clouds located light-weeks away from super-massive black holes.

Another emission line, this time in X-rays, has fascinated astronomers for more than a decade. Emitted at an energy of 6.4–7.0 keV, it arises from the fluorescent de-excitation of K-shell electrons in iron atoms. Excitement arose in 1995 when the Japanese Advanced Satellite for Cosmology and Astrophysics observed such a line strongly skewed towards lower energies. This was consistent with the relativistic distortion expected for matter orbiting a black hole.

With the potential to probe the inner-most stable orbit around a black hole, the precise characterization of the iron K line



Ratio of the spectrum of the Seyfert galaxy 1H 0707-495 observed by XMM-Newton and a simple model for the continuum emission. The prominent lines of iron K and L emission are clearly detected above 2 keV and below 1 keV, respectively. They are skewed towards lower energies owing to relativistic effects in the vicinity of the black hole. (Courtesy A Fabian.)

was an important scientific justification for ESA's XMM-Newton satellite launched in December 1999 (*CERN Courier* September 2000 p17). The superior spectral resolution of this mission enabled the identification of a rapidly spinning black hole in the galactic source XTE J1650-500 based on the shape of the iron K line (*CERN Courier* November 2003 p13). But the detailed XMM-Newton spectra also brought some confusion to the field with several studies showing evidence that the observations in some Seyfert galaxies can be

interpreted without invoking a relativistically broadened iron line. The detection of similarly looking iron lines around neutron stars and even white dwarfs is also puzzling the community.

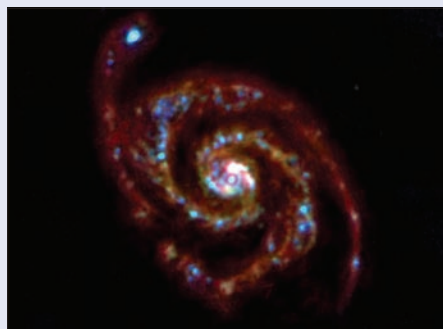
Is the relativistic broadening scenario a misinterpretation of the data?

The latest, extremely accurate observations by XMM-Newton of the Seyfert galaxy 1H 0707-495, published by Andy Fabian from the Cambridge Institute of Astronomy and collaborators, give renewed and unprecedented evidence for the relativistic interpretation. Besides the usual iron K line, for the first time they detect a second line attributed to iron L-shell transitions at an energy just below 1 keV. Both lines are so strongly distorted towards lower energies that they imply a black hole spinning at an almost maximum rate. A measured delay of about 30 s in the variations of the iron L line with respect to the continuum emission gives additional evidence for the relativistic scenario. The two iron lines would thus originate from the illumination of the inner accretion disk about one gravitational radius away from the horizon of the black hole by an X-ray continuum source located a little further out.

Further reading

A C Fabian *et al.* 2009 *Nature* **459** 540.

Picture of the month



This far-infrared view of the spiral galaxy Messier 51 is the first image taken by the Herschel space observatory. This spacecraft, equipped with a 3.5 m mirror – the largest ever sent into space – was launched together with the Planck mission on 14 May (p6). In its final orbit at a distance of 1.5 million km from the Earth in the opposite direction to the Sun, Herschel will be in an ideal location for observing the infrared and sub-millimetre sky, undisturbed by the radiation from the Sun, Earth and Moon. While the commissioning and performance verification of the two missions continue, this image of the “whirlpool galaxy” by the Photoconductor Array Camera and Spectrometer (PACS) instrument on Herschel already demonstrates the observatory's unique capabilities. It is a composition of images taken in three far-infrared bands at 70, 100 and 160 μm shown in blue, green and red, respectively. (Courtesy ESA and the PACS Consortium.)