ACTIVITY IN THE CENTRAL PART OF GALAXIES

Chairperson and Editor: **V. TRIMBLE**

X-ray AGN; The View from ASCA

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ASCA capability of X-ray imaging spectroscopy up to 10 keV. allows us to examine the emission and absorption feature from AGN. Warm absorber, low energy lines and broad iron K lines are confirmed from Sy I's. High sensitivity in broad energy band makes it possible to distinguish multiple components emerged by different processes. Detection of X-rays from faint sources tells us various galaxies may harbor AGN sometimes with obscuration tori. They might have considerable contribution to CXB.

1. ASCA satellite

The fourth Japanese X-ray astronomy satellite ASCA was launched on February 20, 1993. Four high throughput X-ray telescopes (XRT: Serlemitsos et al. 1994) are placed at the top, and two Solid-state Imaging Spectrometers (SIS) and two Gas Imaging Spectrometers (GIS) are mounted on the focal plane at a distance of 3.5 m. The effective area is 1200 cm^2 and 600 cm^2 in total at 1 and 7 keV, respectively. The field of view is 24 and 16 arcmin at 1 and 7 keV. 50 % of collected photons are concentrated in a circle of 3 arcmin diameter on the focal plane. The energy resolution at 6 keV is 120 and ~500 eV with SIS and GIS.

2. Seyfert I galaxies

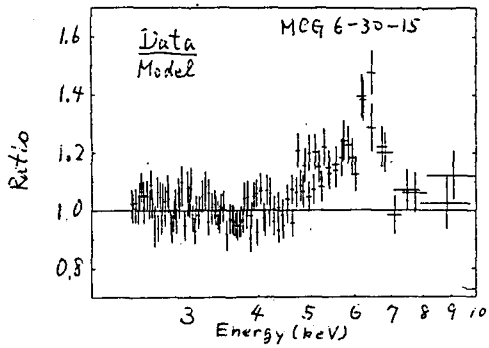
(1) Warm Absorber

Energy spectrum of a typical Sy I galaxy MCG-6-30-15 is observed to be a power law (Γ = 1.9 - 2.0) in high energies above 3 keV(Fabian et al. 1994a). However, clear deficit is found in the low energy data from an extension of the power law determined in high energies. The residual exhibits clear edge structure at about 0.75 keV, which are consistent with ionized oxygen edges at 0.73(OVII) and 0.85 keV(OVIII). Warm absorber at a temperature of 10^5 K on the line of sight is evident. In two observations with 20 days in between, the edge energy was constant, while the depth increased by a factor of two. It indicates that ionization state of warm absorber is stable, but column density increased on the line of sight with the time scale of tens of days.

I. Appenzeller (ed.), Highlights of Astronomy, Vol. 10, 513–516.

(2) Broad Iron K Line Profile

The iron K emission lines have been reported to be 100 -200 eV equivalent width by GINGA. Though much higher peaked line feature is expected with ASCA SIS energy resolution, narrow line component is much smaller from MCG-6-30-15. However, broader component is found around 6 keV(Fig. 1). Exccess is seen from 5 through 7 keV. It is assumed to be Doppler broadening of iron lines reprocessed on the accretion disk close to the central object. Accord-ing to the models (Stella et al. 1990) the data can be explained with following parameters; inclination angle of 40 degree, inner radius of 10 Rs and outer radius of 100 Rs (Rs : Schwarzschild radius). Similar features are found in IRAS 18 325-5926, NGC5548, IC 4329A.



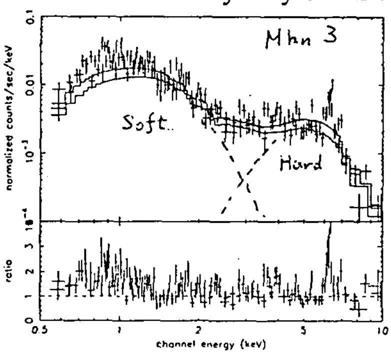
3. Seyfert II Galaxies

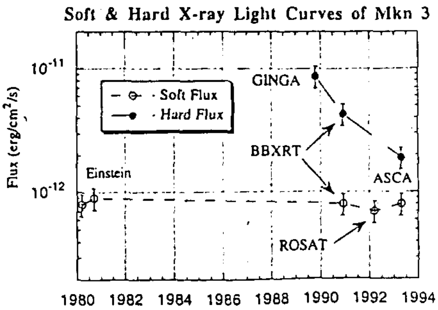
(1) Low Energy Continuum

The spectrum from a typical Seyfert II, Mkn 3 in Fig. 2, consists of a strongly absorbed power law component with Γ of 1.7 and NH of 5 x 10^{23} H/cm^2 and of the newly confirmed soft component, which is represented by a power law of 1.7 and with galactic absorption. The former power law is coming from the central object through thick absorption torus. The latter one is due to the electron scattering.

As is shown in Fig.3 for Mkn 3, a light curve of the absorbed hard component dropped by a factor of 6 from 1989 through 1993, while the scattered soft one seemed to be constant over 13 years. This fact strongly supports the idea that hard component is the direct flux from AGN and that the soft one is scattered by extended(r > 13 light years) electron cloud.

In the residual plot of Fig. 2, several emission lines are seen bellow 3 keV, coinciding to K emission lines from He like ions of S, Si, Mg, and to L lines from Fe. They may be emerged from photo-ionized plasmas.





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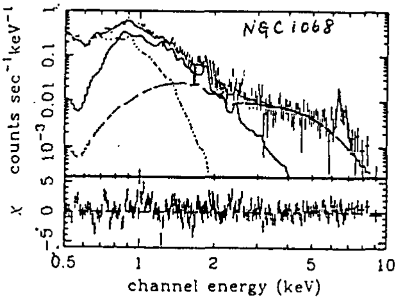
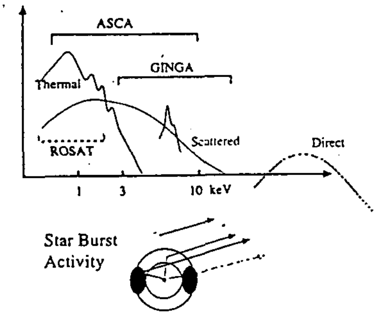
(2) Emission from Thermal Plasmas

From another important example of Sy II, NGC 1068, the X-ray flux observed by GINGA and ASCA above several keV is assumed to be the scattered component without strong absorption feature (the direct component is so much absorbed that it went above the GINGA energy range). Strong iron K lines at 6.4 and 6.7 keV are due to the reprocess of the flux from the nucleus. ASCA found another softer component below 3 keV with emission lines from H and He like ions of O, Ne, Mg, Si and S (Ueno et al. 1994). They can be represented by the thermal component of kT~0.6 and 0.14 keV. This suggests hot thin thermal medium extending over the absorption torus.

Note that NGC 1068 is a galaxy with strong star burst activity. It may energize such a hot plasma emitting the low energy continuum.

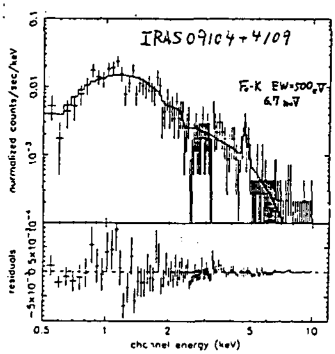


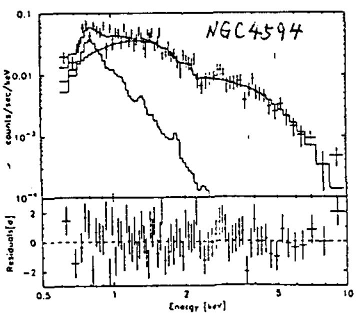


4. Faint Objects

(1) Discovery of Type II QSO?

The spectrum of a QSO, IRAS 09104+4109 (z = 0.442), is shown in Fig. 4 (Fabian et al 1994b). The Γ is 1.96 and $N_H = 2.4 \times 10^{21}$. Line feature is seen at 4.5 keV, which is converted to 6.7 keV in the QSO frame. The equivalent width of 450 eV is much larger than Sy I but comparable to Sy II, though the N_H is just galactic. Therefore the observed X-rays are scattered component on the analogy of NGC 1068. The intrinsic luminosity has to be 5×10^{47} erg/s. This may the first evidence of type II QSO in X-rays.





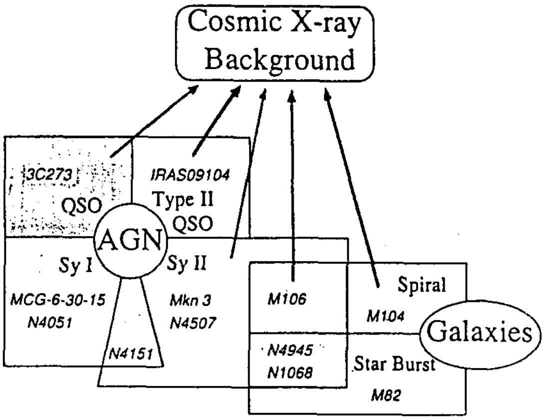
(2) Hidden AGN and LLAGN

Form some spiral galaxies (NGC4258, 4594), point sources are found in higher energies above 3 keV accompanied by extended soft emission below 3 keV (Makishima et al 1994). The energy spectrum is consisted of hard power law continuum and soft thermal emission. The hard point source from NGC4258 shows strong absorption of 1.5 x 10^{23} H/cm^2, suggesting hidden AGN at the center. On the other hand, that of NGC 4594 does not show strong absorption, similar to the Sy I's.

5. Summary

The improved energy resolution opens up the possibility of iron line diagnostics of Seyfert galaxies, leading to the direct evidence of accretion discs around the inferred black hole in AGN. Low energy absorption and emission features are clear evidences of hot plasmas around the nucleus, some are thermal and some are photo-ionized. The broad band coverage revealed multiple components, such as direct(absorbed), scattered, and extended(thermal) components. High sensitivity and imaging capability allow us to recognize hidden AGN or low luminosity AGN (LLAGN) in normal galaxies. It also helps us to discover a type II QSO.

AGN and galaxies observed with ASCA are summarized in Fig 7. Improving sensitivity, ASCA expands the field to be examined in X-rays toward right and top direction of Fig. 7. These new objects detected with ASCA fill the gap between galaxies and AGN and should have considerable contribution to the Cosmic X-ray Background(CXB).



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