X-Ray Observations of Active Galactic Nuclei with Relativistic Jets

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Co-Evolution of Galaxy & Central Black Hole

Almost all galaxies have supermassive black hole.
\[ M_{BH} = 10^6 - 10^9 \, M_{\odot} \quad (M_{\odot} = 2 \times 10^{33} \, g) \]

Correlation of black hole mass and galaxy mass

→ **Black hole growth = galaxy evolution**

Tremaine et al. (2002)

Active Galactic Nuclei (AGN)

- Active gas accretion
- Growing state of BH
- Key of galaxy evolution

velocity dispersion (km/s) \( \propto \) mass of galaxy
AGN Feedback to the galaxy

AGN with Jet (~10% of AGNs)

with Jet

without Jet

AGN jets stop the star formation in the host galaxy(?)

AGN with jets: key object to understand the AGN feedback to galaxy evolution.

BUT...

Structure of the central engine in AGNs with jets is not known well.
X-Ray Study of Central Part in AGN

**Around black hole**: high energetic space
(Gravitational potential energy ~ GeV @ ~ 1 \( R_s \))
(Schwarzchild radius \( R_s \); gas velocity ~ speed of light)

Fluorescence line of Fe-K\( \alpha \) @ 6.4 keV from an AGN without jets

Asymmetry by relativistic beaming & gravitational redshift

Difference of inner part of accretion disk between AGNs with jets and without jets?

X-ray emission line has the information on relativistic field.
X-Ray Study of Torus, Surrounding Central Engine

Hard X-ray transmits the torus.

→ **Signal detection of obscured AGN**

Information from X-ray spectrum

- torus absorption
- torus reflection

**Suggest the torus structure**

**Torus**: gas supply to black hole

**Important factor to clear the galaxy evolution**
X-ray Study of AGN with Relativistic Jets

- What is the difference between AGNs with jets and without jets?

**Inner part of accretion disk**
- Relativistic space close to black hole

**Surrounding torus structure**
- Key of black hole growth and galaxy evolution
Study of AGN with Jets

Targets of AGNs with Jets

4C 50.55 (type 1); bright source

3C 403 & IC 5063 (type 2)

3C 206 (type 1) & PKS 0707-35 (type 2);
luminous source

Physical properties of hot corona.
Accretion disk geometry.

Torus geometry and
amount of scattering gas.

Detailed study of torus geometry
in the luminous AGN with Jets.
(Unknown relation between the AGN
structure and the central engine power.)
Inner Part of Accretion Disk

Inner radius of accretion disk

\[ R_{\text{in}} > 100 \ R_s \] (\( R_s = 2GM/c^2 \))

Truncated disk

\( R_{\text{in}} \approx 6 \ R_g \) (innermost stable orbit)

Cold accretion disk in AGN with jets is truncated, and does not expand close to the black hole.
Torus Structure of Luminous AGNs

Luminous AGNs evaporate the gas and dust in the torus?

Reflectors:
- torus (narrow line)
- accretion disk (broad line).

EW (~ line intensity) of narrow line confines torus size

equivalent width (EW) (line intensity normalized with continuum flux)

Large amount of absorption gas

Small amount of absorption gas

Small amount of absorption gas in torus and/or small size torus

Luminous AGNs evaporate the gas and dust in the torus?
Summary
～ X-Ray Study of AGN with Relativistic Jets～

- Study of active galactic nuclei (AGN) spouting jets with X-ray satellite Suzaku.

- AGNs with jets (possibly):
  - have truncated accretion disk (bright AGN; 4C 50.55) Related to the mechanism of jet ejection (?)
  - have a trend that luminous AGNs have small torus (luminous AGNs with jets; 3C 206 and PKS 0707-35). Central source irradiation → Torus evaporation (?)

We need statistical study with larger sample!!