X–raying Active Galaxies: Exploring the Environments of Supermassive Black Holes

Niel Brandt (Penn State)
The Importance of Spatial Resolution: The Center of M82

ROSAT
~ 5"

Chandra
~ 1"
Nuclear Region of an Active Galaxy

$10^{13}$ cm scale $\sim$ light minutes
Rapid X-ray Variability of Active Galaxies

X-ray light curve of the active galaxy 1H0707–495

Solar flare light curve

Solar flare loops
X-rays from the Inner Accretion Disk

Inner Accretion Disk

Broad iron K line from the active galaxy MCG–6–30–15

XMM–Newton

Line flux $F_E$ (keV cm$^{-2}$ s$^{-1}$ keV$^{-1}$)

Energy (keV)
X–raying an Active Galaxy Wind

An early Roentgen image (1896)

W.C. Roentgen

Scattering Material

BEL Clouds

Featureless Continuum Source

Dusty Torus?

$10^{17}$ cm scale

~ light weeks
Chandra Grating Spectrum of the Wind from NGC 3783

Chandra HETGS

Chandra HETGS spectrum of the active galaxy NGC 3783

Absorption lines and edges from outflow

Power Law

Fe K
NGC 3783 Spectral Details

Wind kinetic power > Photon power!
Active Galaxies at the Highest Redshifts

Evolution in the space density of luminous quasars from $z = 0–6$
X–rays from the First Supermassive Black Holes

Combined Chandra X–ray spectrum of 46 quasars at z > 4

Indistinguishable from nearby quasar X–ray spectra!

\[ \Gamma = 1.9^{+0.1}_{-0.1} \]

Quasar numbers evolve, individual quasars don’t.
Black hole + gas = Same thing, every time!
The Chandra Deep Field–North

Chandra ACIS–I
1.95 Ms over 2.3 yr

Red: 0.5–2 keV
Green: 2–4 keV
Blue: 4–8 keV

448 arcmin²
(~ 60% Moon)

~ 582 point sources
~ 6–7 extended sources

50–250 times the sensitivity of pre–Chandra surveys!
Active galaxies more numerous and varied than previously thought.
Proto-Quasars
Black Holes from the First Stars at z ~ 15

(Eddington limit for < 300 solar masses)

Some Future Prospects and Upcoming Missions

Constellation-X

Small-to-Medium Missions

Swift
DUO

Long-Term, Large Missions

tesa
XEUS
Gen-X

Proto-Quasars
Black Holes from the First Stars at z ~ 15

(Eddington limit for < 300 solar masses)