An X-ray View of NLS1

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With thanks to
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See also Puchnarewicz+92

Ultrasteep
Extreme X-ray variability

IRAS 13224–3809
ROSAT monitoring

Boller+98
1H0707-495

Gallo+04
X-rays and NLS1

- None in Piccinotti HEAO-1 A2 sample
- (But 1H0707 from HEAO-1 A4 instrument)
- 10% in Einstein low z AGN samples
- 40% in ROSAT samples
- Few in deep fields
- Mostly due to very steep soft X-ray spectra of NLS1
  (from Grupe00)
• Extreme variability supports low mass BH
• High luminosities then imply high Eddington fraction → close to Eddington limit

• XMM reveals sharp drop around 7 keV in some objects
1H0707 Boller+02; Gallo+04
Long-term spectral changes in 1H 0707–495

Gallo+04
Is it absorption or a line?

Fabian+02,04

1H0707
Issues raised by Rapid Variability

- Doubling time $t$ implies from causality that emission and absorber region have size $r < vt$

- If $t < 1000s$ and $M \sim 3 \times 10^6$ $M_{\odot}$ (e.g. NLS1) and $v$ is dynamical velocity, then $r < 10 r_s$

- The rapid variability seen in 1H0707 and IRAS13224 cannot be due to an extensive ($r \sim 100s$ $r_s$) emission, absorption or scattering region but must be compact and from $< 10r_s$

Partial covering absorption models must address cloud survival
Why might we expect to see a broad iron line?
Reflection from cold matter
Ross+
Fabian05

STRONG IRRADIATION

Temp

O ions

Si ions

Thomson depth in slab
Conserve energy

$\Gamma = 2.0$

$A_{Fe} = 1$

$\xi = 10^2$
Strong Gravity Effects

- Gravitational redshift
- Gravitational light bending
- Dragging of inertial frames in Kerr metric (ISCO depends on BH spin)

NB In rapid spin objects most of power emerges from a few rg
Schwarzschild

Kerr

Fabian+89, Laor 90...
Black Hole Spin

No spin

Max spin

Brennemann+Reynolds08

Energy

Flux

a=0.0
a=0.25
a=0.5
a=0.75
a=0.998
Reflection in accreting BH

- Soft excess
- Broad iron line
- Compton hump

Add relativistic blurring

Reflection spectrum
Suzaku AGN Spin Survey
BH X-ray binaries

Originally compiled by J. M. Miller
Neutron Star Binaries

4U1705-44
Reis+09
R_{in}=10.5r_{g}
Strong light bending close to BH

Martocchia&Matt, Miniutti&Fabian

GR + lightbending make emissivity steep
Broad iron-L and iron-K emission lines in NLS1 1H0707-495

Fabian+09
0.3 keV vs 1-3 keV

Rapid variations
(< 15 min)
Powerlaw leads reflection: Reverberation

See Abdu Zoghbi’s talk for more on reverberation
IRAS13224 Ponti+09

![Graph showing data/model ratio against observed energy (keV)](image1)

![Graph showing data/model ratio against Energy/E_{line})](image2)
2011 Update
1H0707-495

SWIFT monitoring by T Dwelly & P Uttley
Reflection models

Energy (keV)

keV$^2$ (Photons cm$^{-2}$ s$^{-1}$ keV$^{-1}$)

2008

Jan 2011
Behaviour consistent with powerlaw source moving closer to the BH

D. Wilkins
In progress
Blurred reflection is standard ingredient in accreting BH

Soft excess - broad iron line - Compton hump

Add relativistic blurring

Reflection spectrum
MCG-6-30-15  Chiang+Fabian11
see poster outside
Summary

- (Some) NLS1 are extreme X-ray sources
- Consistent physical explanation for behaviour of 1H0707-495, one of the most extreme objects, involves a steep power-law continuum originating just a few gravitational radii from a rapidly spinning black hole
- Such a model may be relevant to other NLS1
Exploring the frequency-energy axes.
 Galactic BH: Disk hot, so line Comptonized

Ross+Fabian07
Reflection in accreting BH

Reflection spectrum

Add relativistic blurring

Soft excess - broad iron line - Compton hump