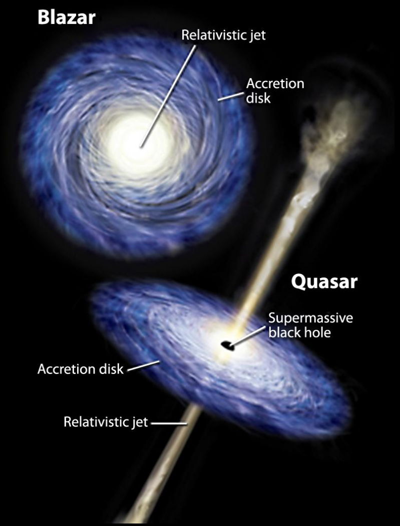
Cracow School of Theoretical Physics, 2019

Constraining the structure of the accretion disk in the closest vicinity of the SMBH in quasar 4C+74.26



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AGN – Physical picture

high luminosities

highly variable

Eddington limit
=> large mass

small size

Accretion onto SMBH

Central SMBH

$$(M_{\rm BH} \sim 10^5 - 10^{10} {\rm M}_\odot)$$

Powered by accretion

$$(L = \eta \dot{M} c^2)$$

Size scale : Swarzschild radius

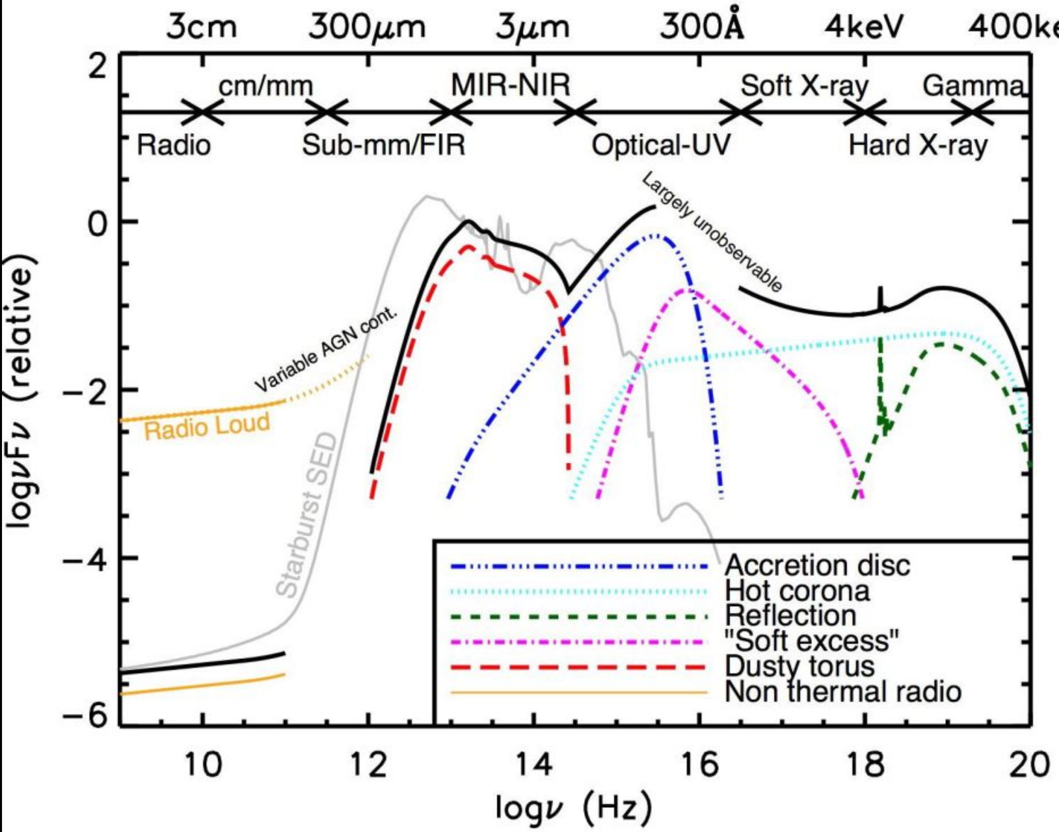
$$(R_S = \frac{2GM_{BH}}{c^2})$$

Luminosity : Eddington luminosity :

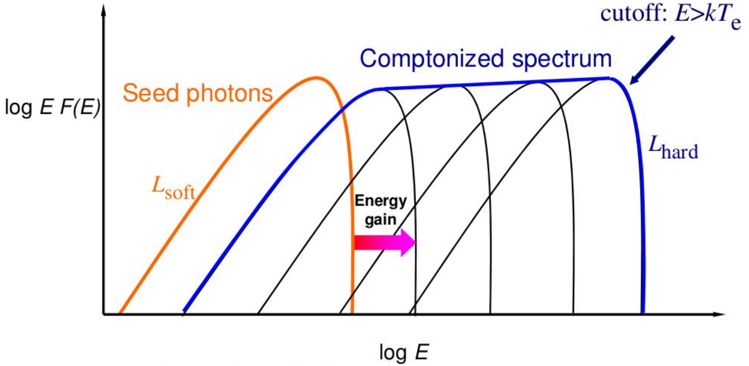
$$F_{rad} = F_{gravity}$$

$$=> L = 1.38 \times 10^{38} \left(\frac{M_{BH}}{M_\odot}\right) {\rm erg\ s^{-1}}$$

Multi-wavelength SED of AGN



Thermal Comptonization



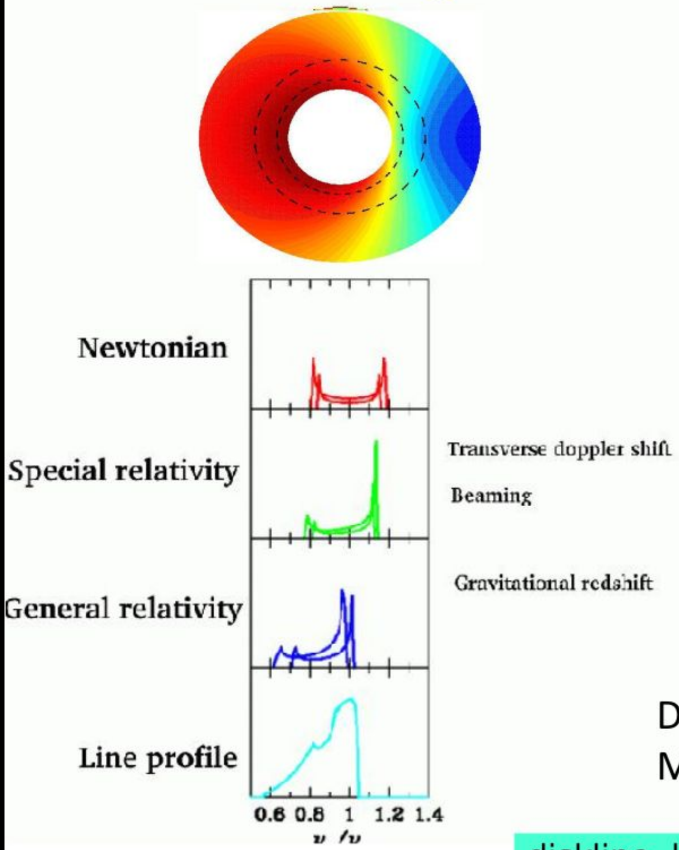
It is a first-order Fermi acceleration process.

The photon index, Γ, is a function of kT_e and τ (the Thomson optical depth).

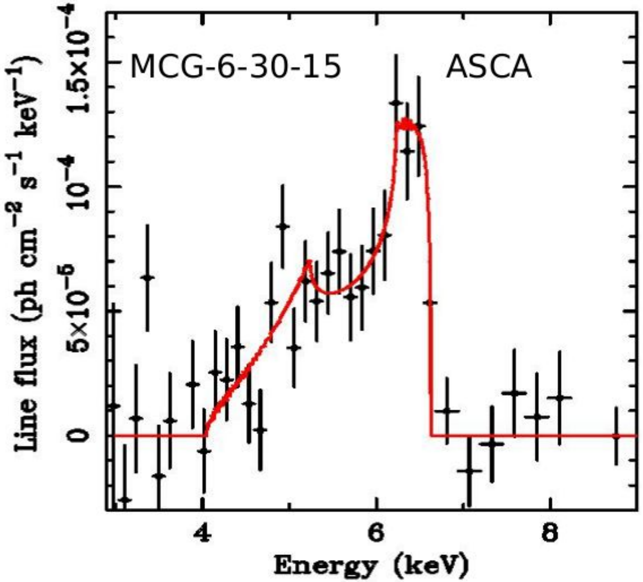
The parameters found in the hard state: $kT_e \approx 50$–100 keV, $\tau \approx 1$.

A .Zdziarski et al

Broadening of iron line – Strong gravity



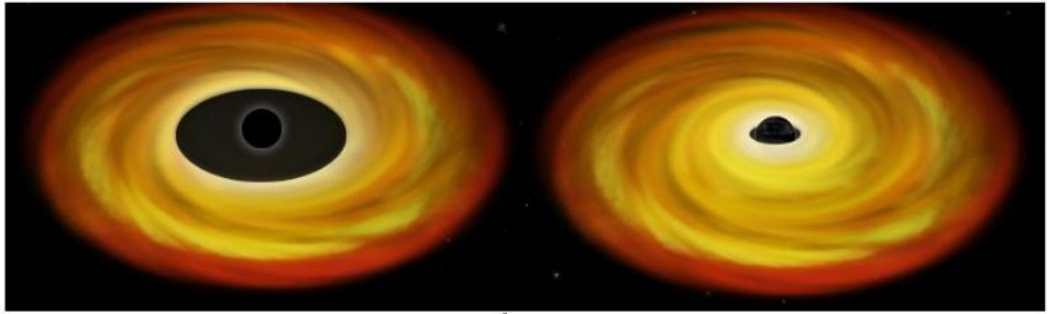
Fabian et al. (2000)

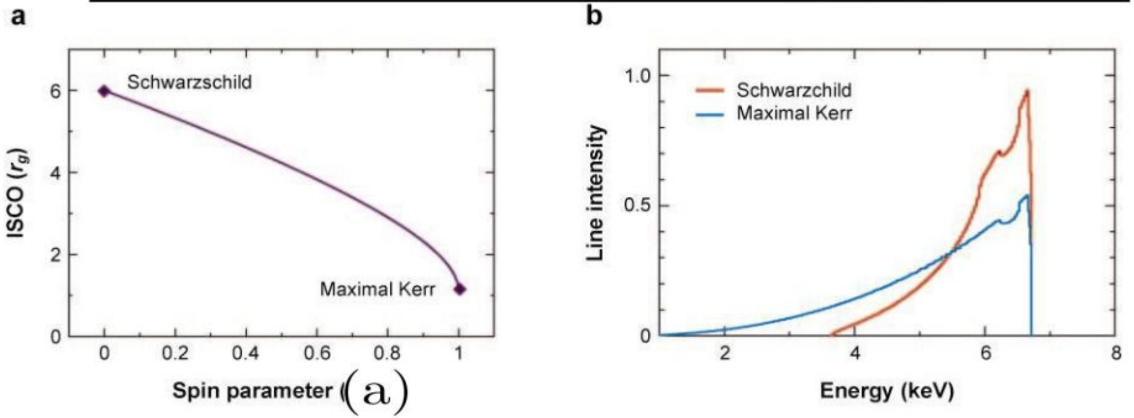


Discovery of broad Iron line profile in MCG-6-30-15 (Tanaka et al. 1995, Nature)

diskline, laor, relline models in XSPEC/ISIS/Sherpa

Broad Iron Line – Measuring BH spin



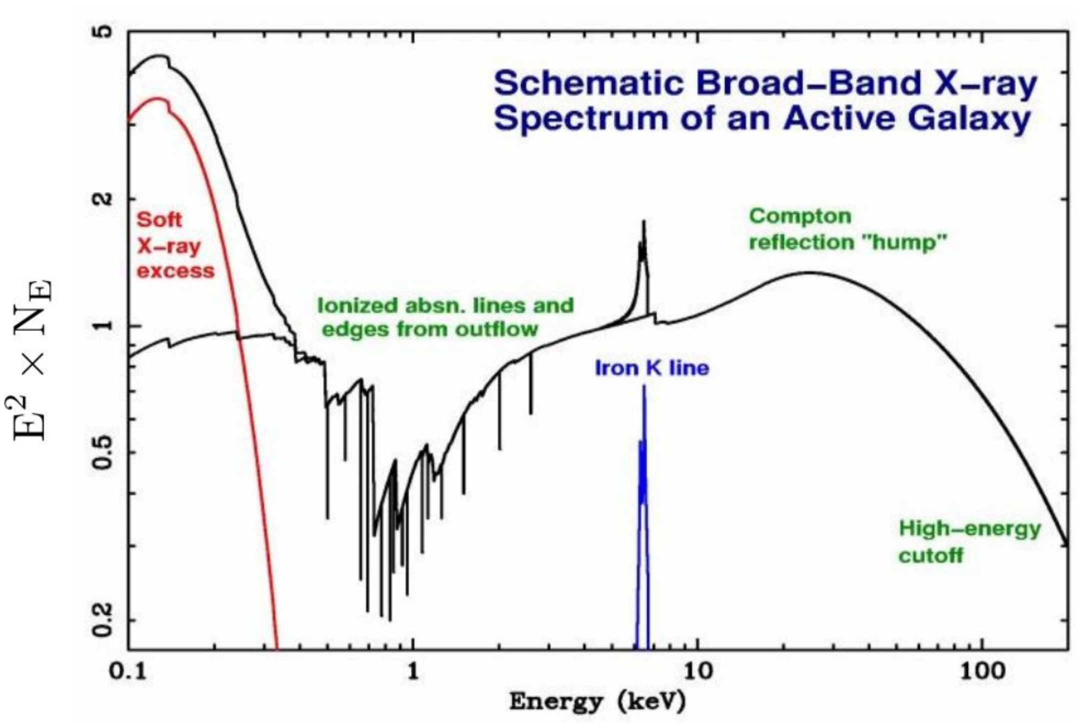


Miller JM. 2007.
Annu. Rev. Astron. Astrophys. 45:441–79

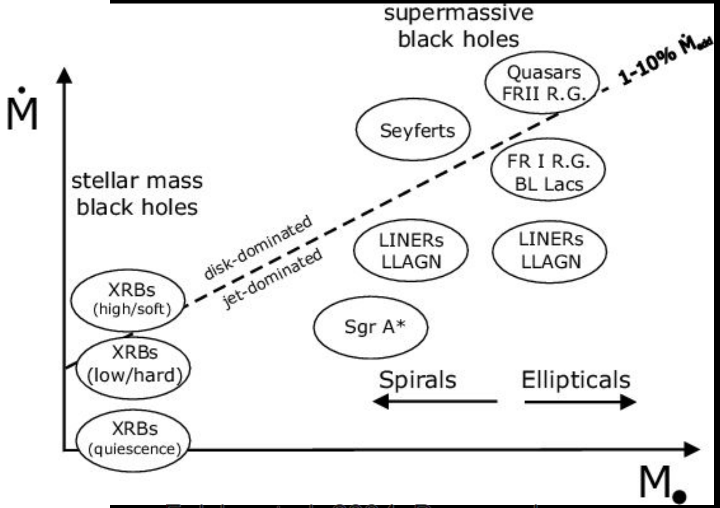
Dimensionless BH spin parameter

$$a = \frac{cJ}{GM^2)}$$

Schematic X-ray SED of type 1 AGN

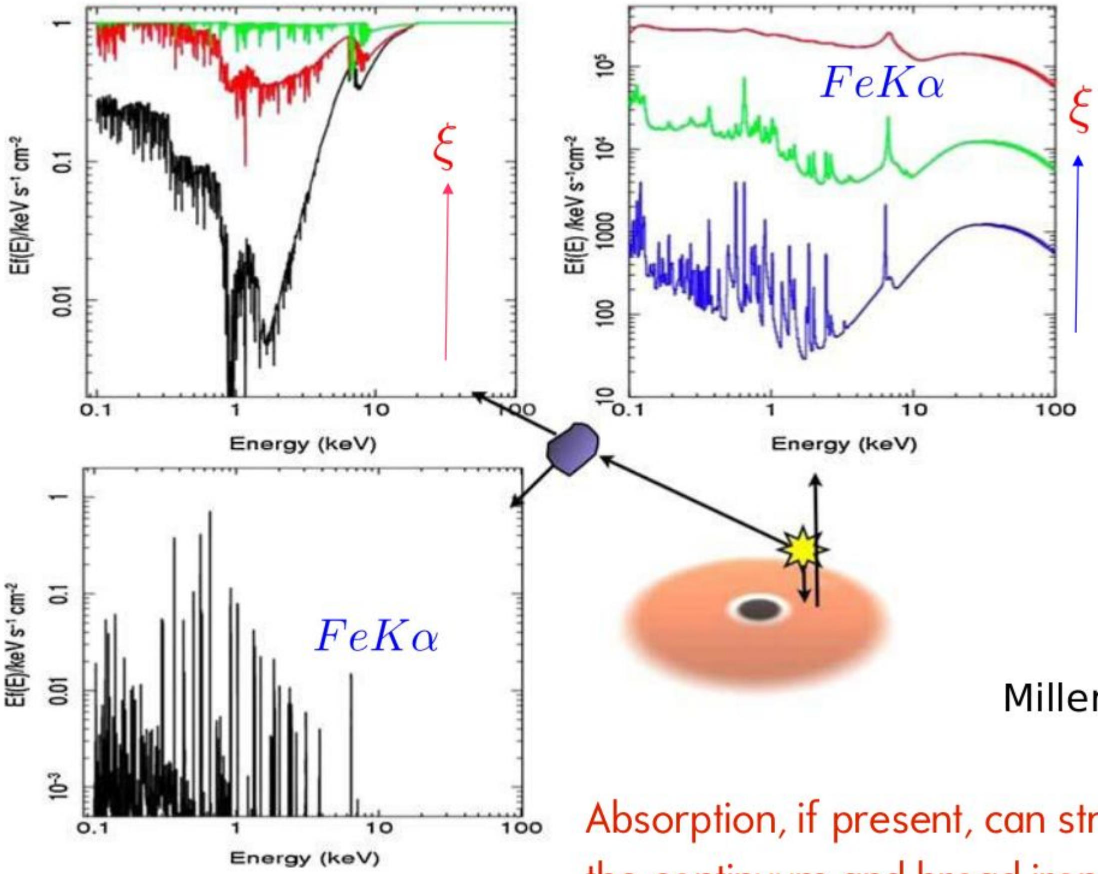


Credit: Neil Brandt



Falcke et al. 2004: Proposed unification scheme

Reflection & Absorption

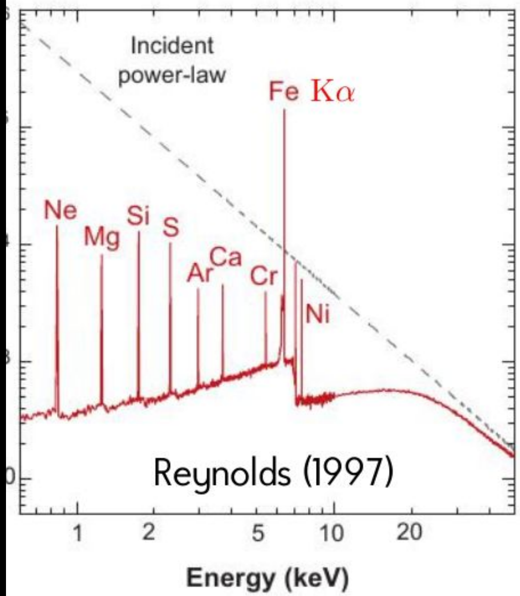


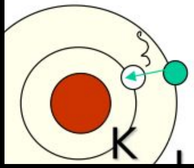
Simulated Spectra

Miller & Turner 2009

Absorption, if present, can strongly affect the continuum and broad iron line

X-ray Reflection Spectrum





Kα line

At soft X-ray energies, reflection is small due to photoelectric absorption by lighter elements

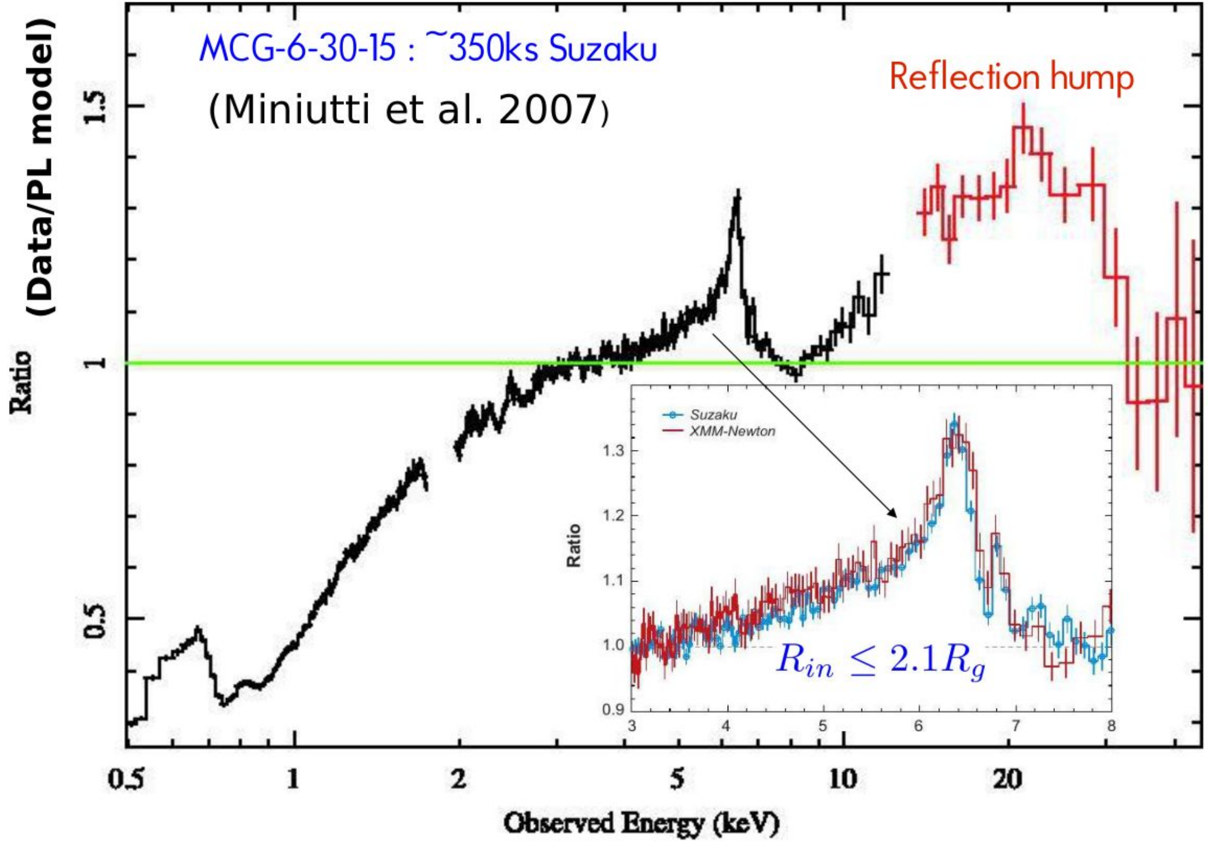
At hard X-rays, Incident photons are Compton back-scattered from the disk

A spectrum of fluorescent emission lines arises from the photoionization of metals in the disk

Iron Kα line at 6.40 keV the most prominent due to

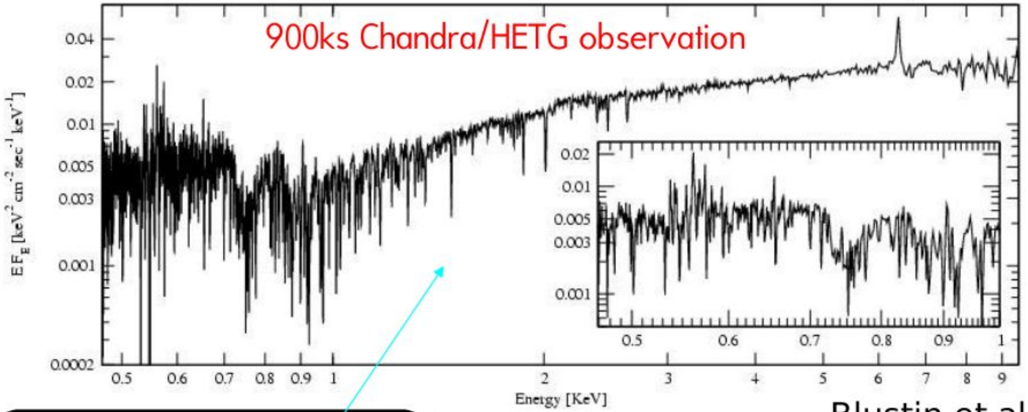
- high fluorescence yield
- large cosmic abundance.

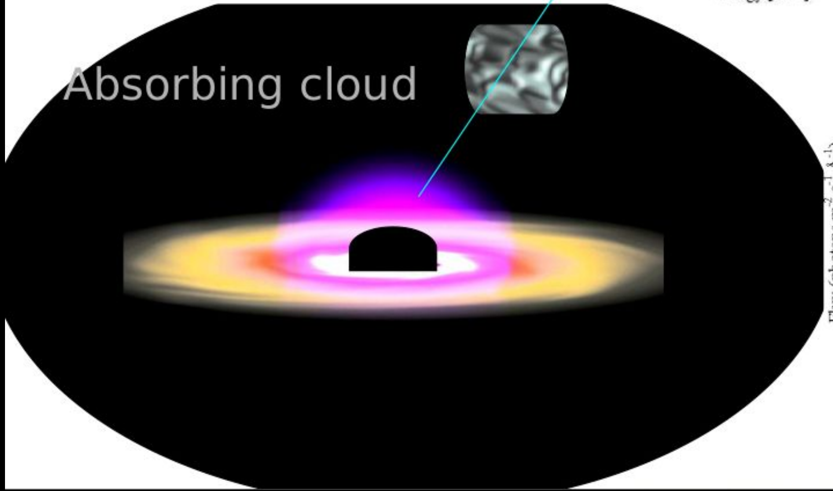
Broad Iron line and Reflection hump



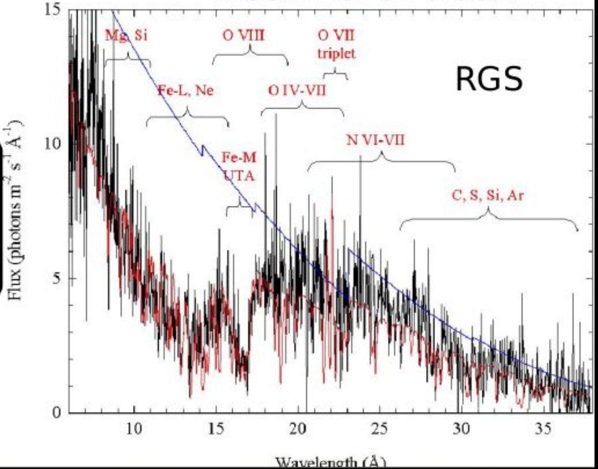
X-ray Absorption

Kaspi et al. (2002)





Blustin et al. 2002



Results :

Z = 0.104

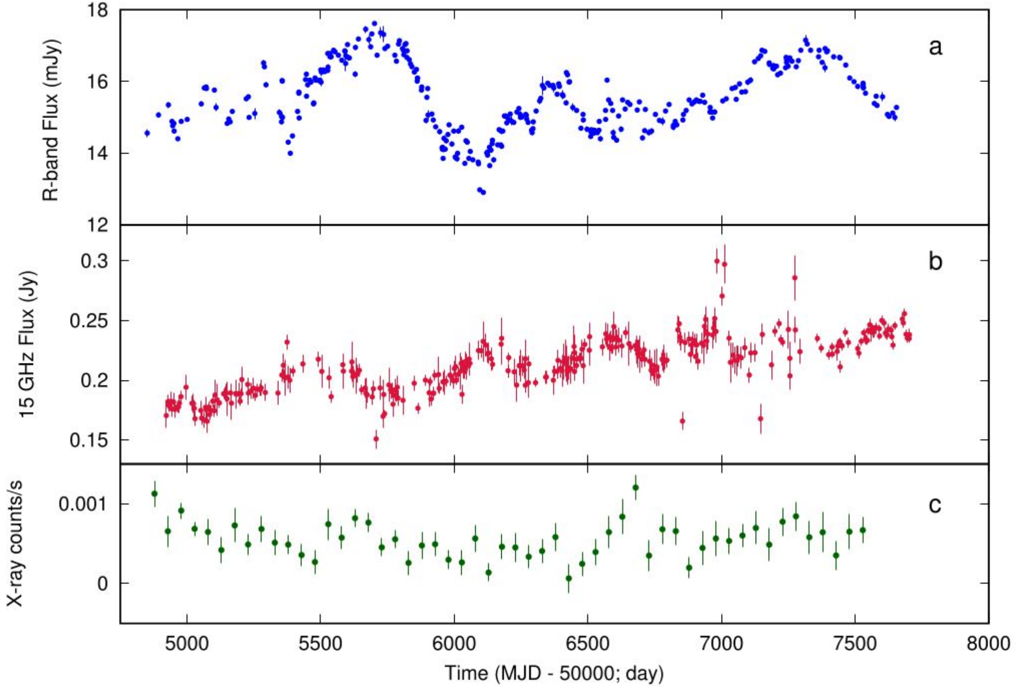
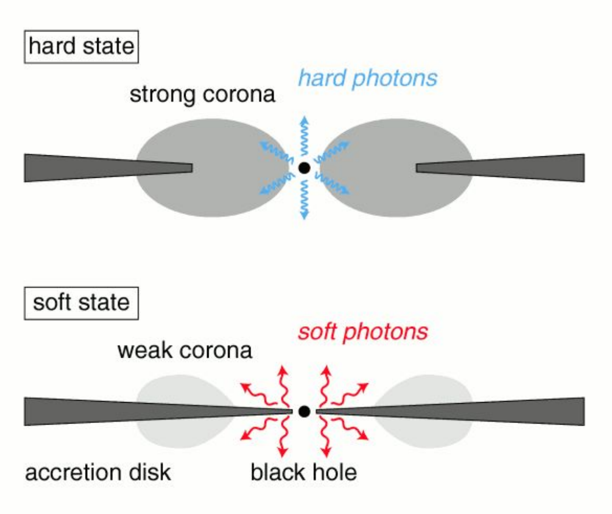


Figure 1. Multiwavelength long-term light curves of 4C+74.26 spanning nearly eight years, and including the optical (R-band) data mainly from the Suhora Observatory (a), the radio (15 GHz) data from the OVRO monitoring program (b), and the hard X-ray (14–50 keV) fluxes from the *Swift*-BAT Hard X-ray Transient Monitor program, weighted averaged in 50 day bins (c).



Hard state: m_dot<0.02 Galactic Center, LLAGN, LINER, etc
Soft state: m_dot>0.02
e.g. quasars, some of the Seyferts
An example of tentative spectral state transition Seyfert-LINER transition galaxy NGC7589 (Yuan et al. 2005) shows a possible low-to-high state transition in X-rays - Observations in AGN show the transition rate m_dot =0.02 (Maccarone et al 2003)

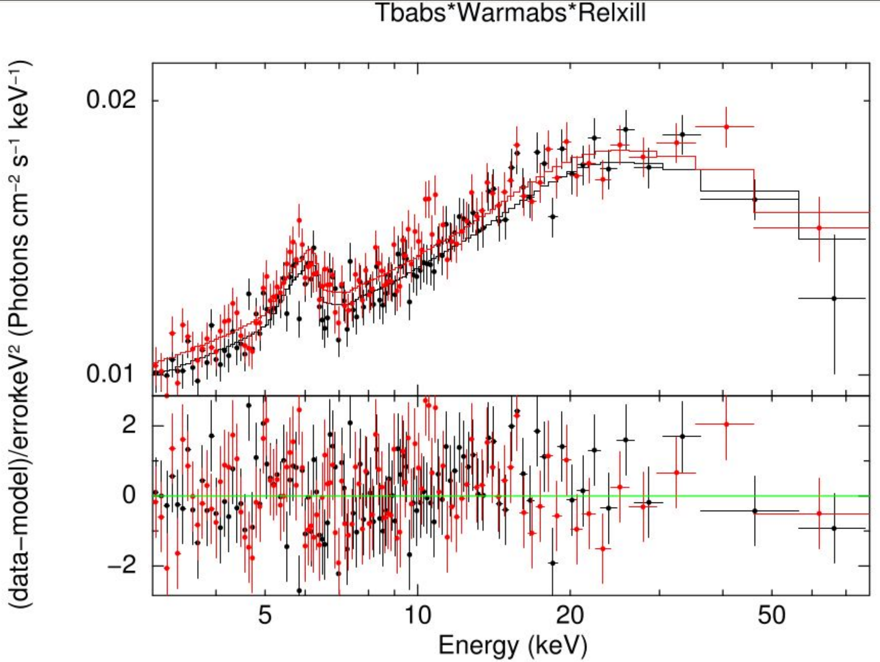
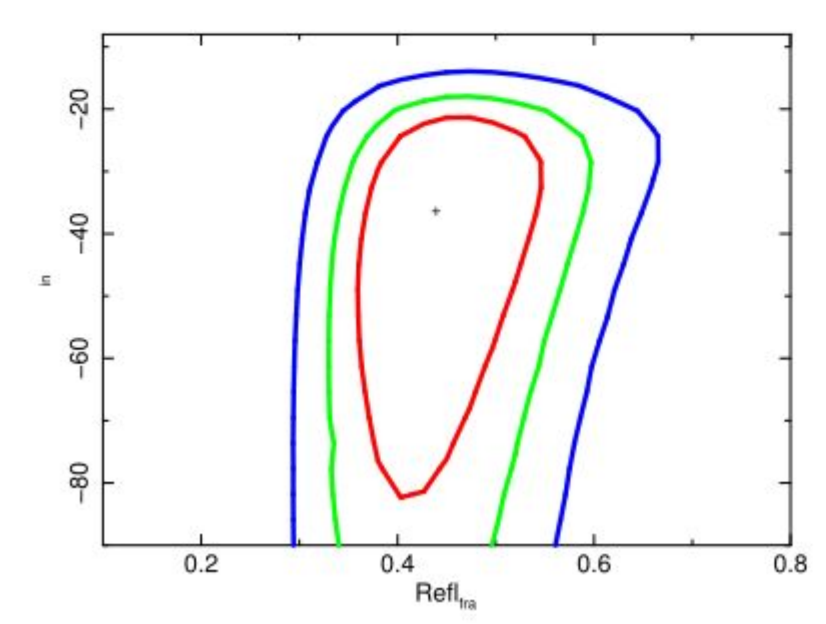


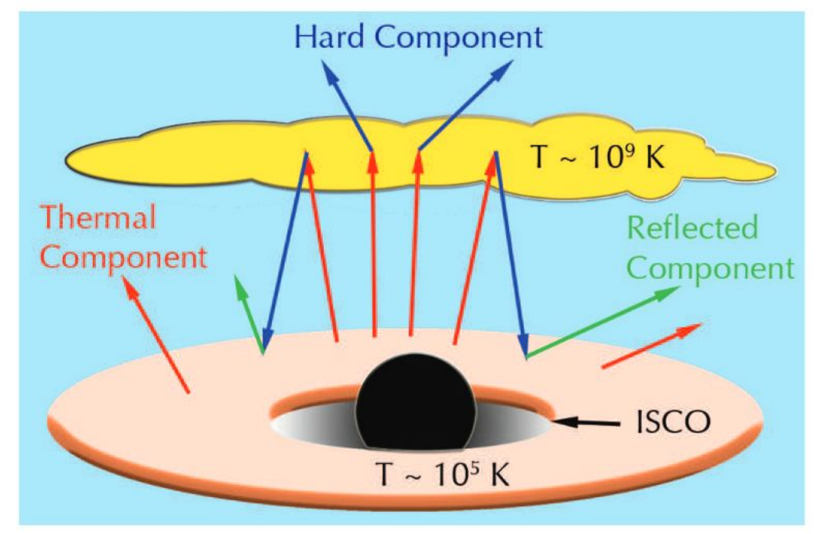
Figure 5. Spectral modeling of *NuSTAR* data for 4C+74.26 (obs. ID 60001080006, 2014 October 30), assuming the convolved model `tbabs*-warmabs*relxill` (upper panel), with the corresponding residuals (lower panel). For the model description and the best-fit model parameters see the text. Red and black symbols/curves correspond to the *NuSTAR* modules FPMA and FPMB.

$$\left(\frac{T}{10^{5.8}\ \mathrm{K}}\right) \simeq \left(\frac{\dot{M}}{\dot{M}_{\mathrm{Edd}}}\right)^{1/4} \left(\frac{\mathcal{M}_{\mathrm{BH}}}{10^{8}\ M_{\odot}}\right)^{-1/4} \left(\frac{r}{2R_{\mathrm{g}}}\right)^{-3/4}$$



Summary :

1. The optical and the radio emission components appear strongly correlated such that optical lags behind the radio emission by ~ 250 days.
2. From the spectral analysis of the NuSTAR observation using the model tbabs*warmabs*relxill, we estimate the inner disk radius of the truncated disk to be $R_{in}/R_{ISCO} = 35^{+40}_{-16}$
3. The results suggest a scenario where propagation of the magnetic instability around the innermost regions of a truncated disk of the AGN along the disk and into the jet.



Conclusions

- The optical and the radio emission components appear strongly correlated such that optical lags behind the radio emission by ~ 250 days.
- From the spectral analysis of the NuSTAR observation using the model tbabs*warmabs*relxill, we estimate the inner disk radius of the truncated disk to be $R_{in} = 35^{+40}_{-16}$ ISCO

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Signatures of the Disk–Jet Coupling in the Broad-line Radio Quasar 4C+74.26

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Thank you