AGN disk emission through X-ray and UV absorbers

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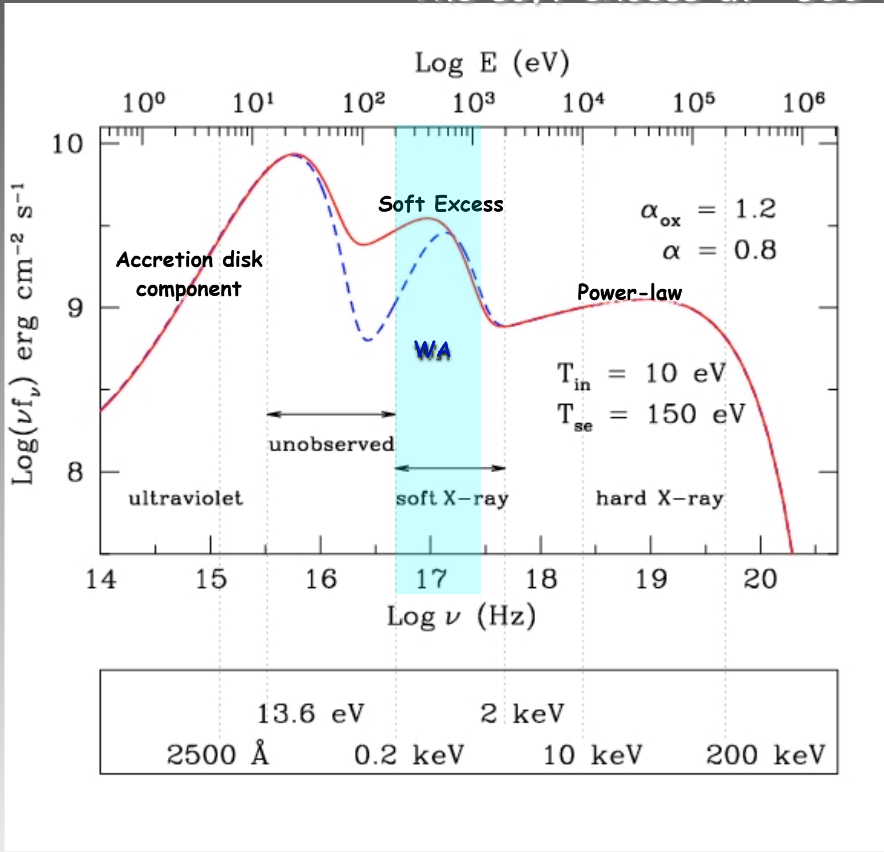
Background

- Warm Absorber signatures – 0.3 to 2 keV
- X-ray spectral components of the AGN SED
  - The 1-10 keV powerlaw
  - The soft excess at ~500 eV



Another significant component AGN disk at ~ 10 ev

Plan of talk

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- **Can we decipher the exact shape of the accretion disk spectrum?**

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    - Can we derive physical parameters like M_{BH} and $\dot{m}$?

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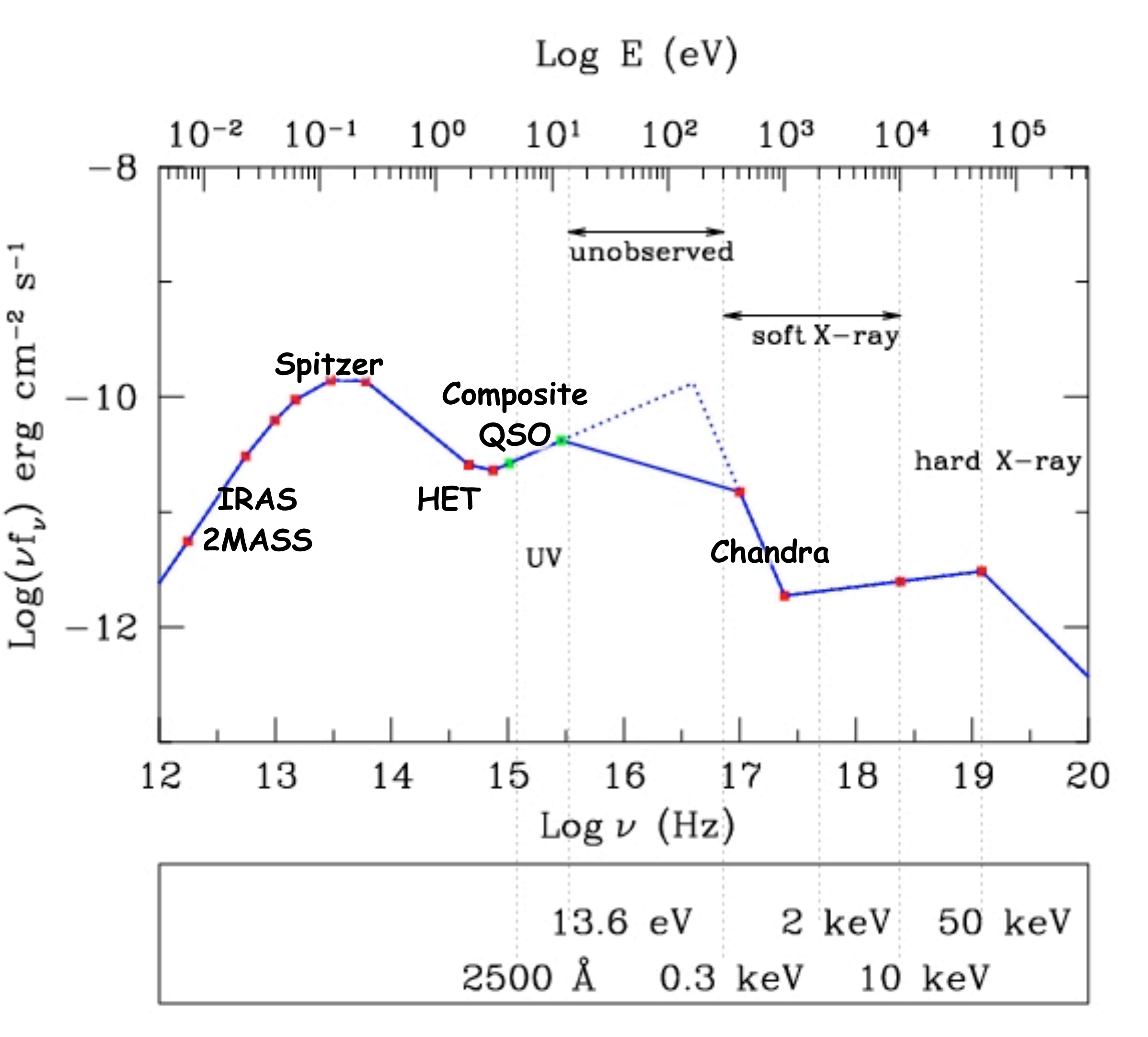
  - Can we derive physical parameters like M_{BH} and $\dot{m}$?

- Use the UV to X-ray ionizing continuum
  - Does it affect the warm absorber?
  - What are its effect on the UV absorber?
  - Can we draw conclusions on the stability properties of the warm absorber?
  - Possible implications for the metallicity of the absorber

Constraining M_{BH} and $\dot{m}$ for AGN

Multi-wavelength SED for AGN



- Red filled squares are observed data points.
- Near simultaneous X-ray and Optical data.
- Infrared from Spitzer, 2MASS and IRAS.
- Green filled squares are `average SED for AGN' in UV (Telfer et.al. 2002).
- The blue lines are arbitrary, simplistic joins between EUV and X-ray.

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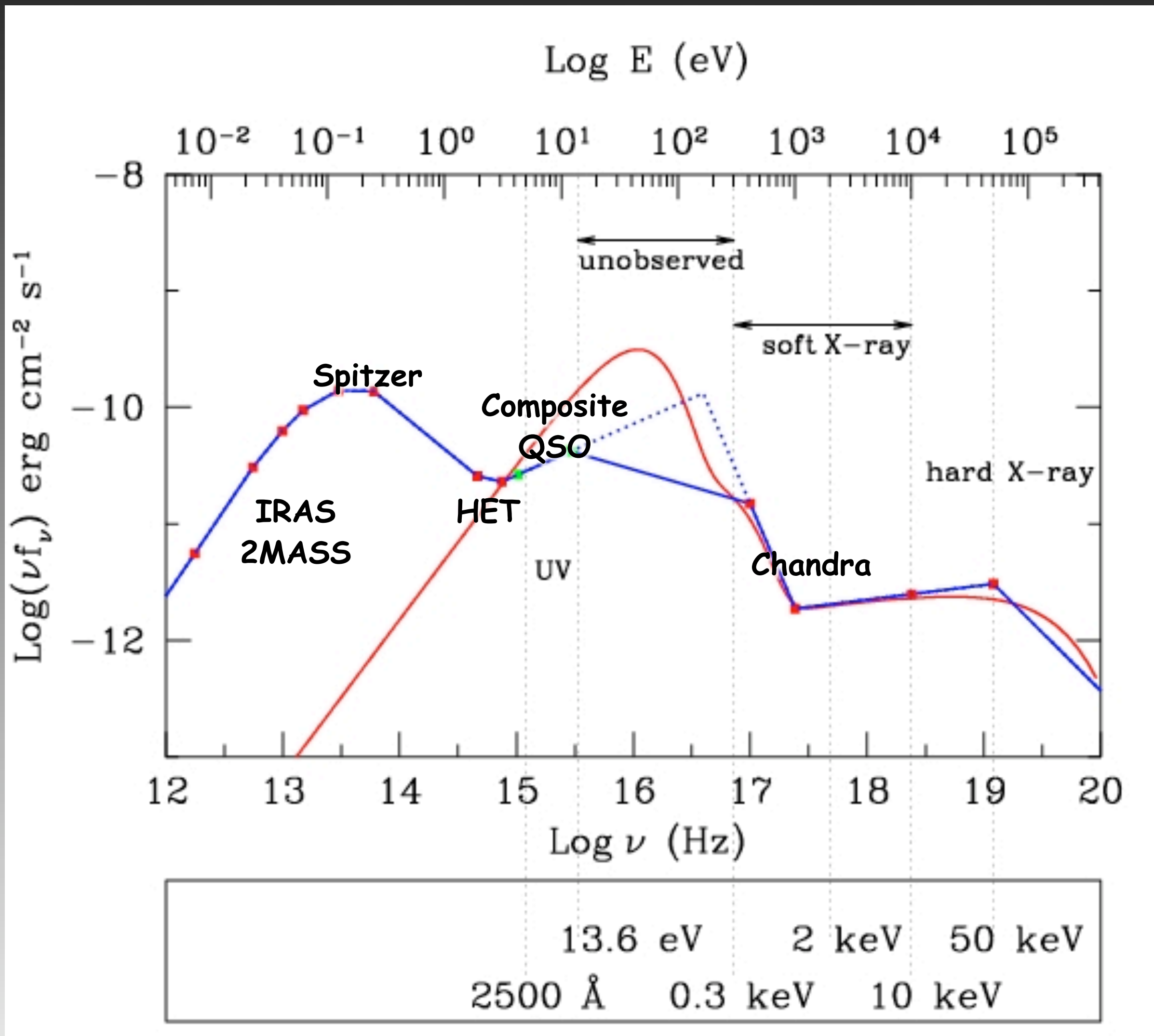
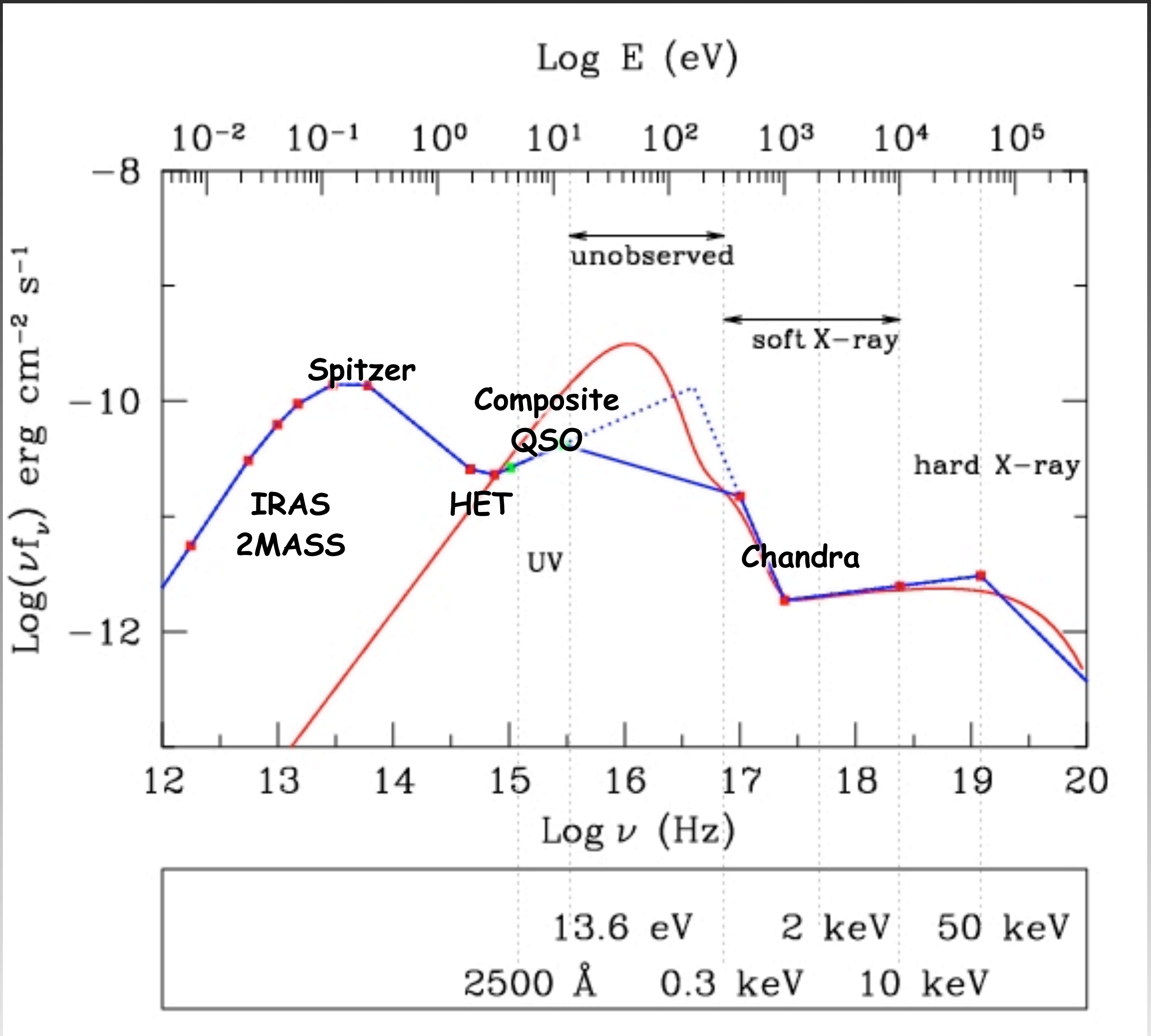


Multi-wavelength SED for AGN



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- We wish to model the far UV part of the SED with "diskbb".

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- Disk model - iso-temperature annuli of accreted matter; each annulus radiating as a blackbody (Shakura & Sunyaev 1973)

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has dependance on M_{BH} and m

- T_{in} = $T(R_{in})$ is an input in the "diskbb" model, where R_{in} is radius of innermost stable annulus

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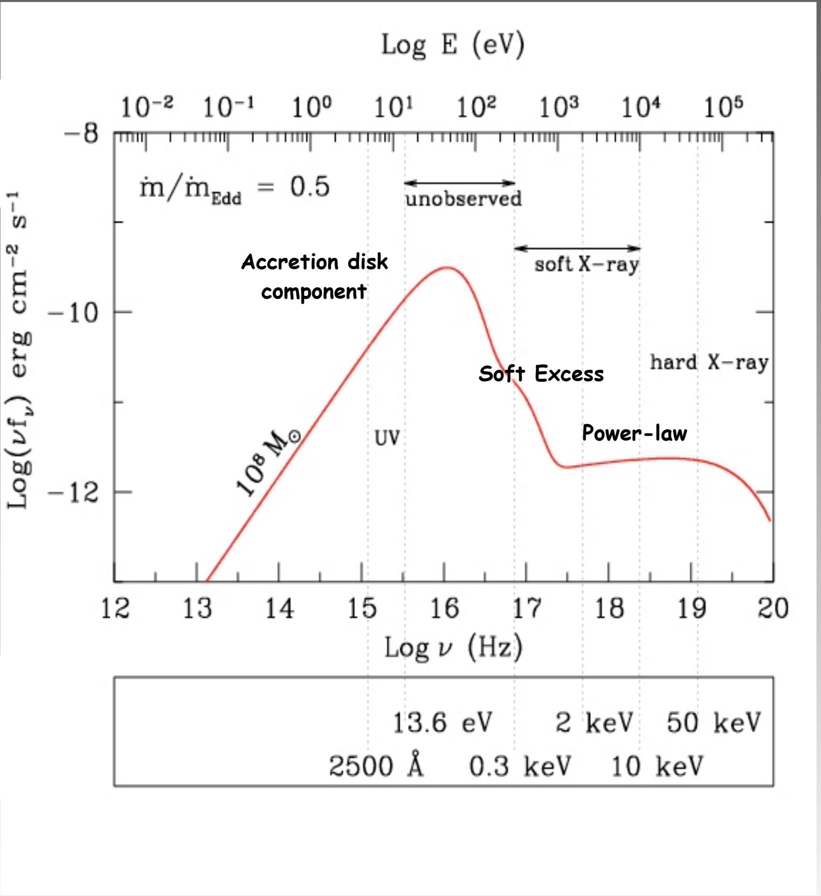
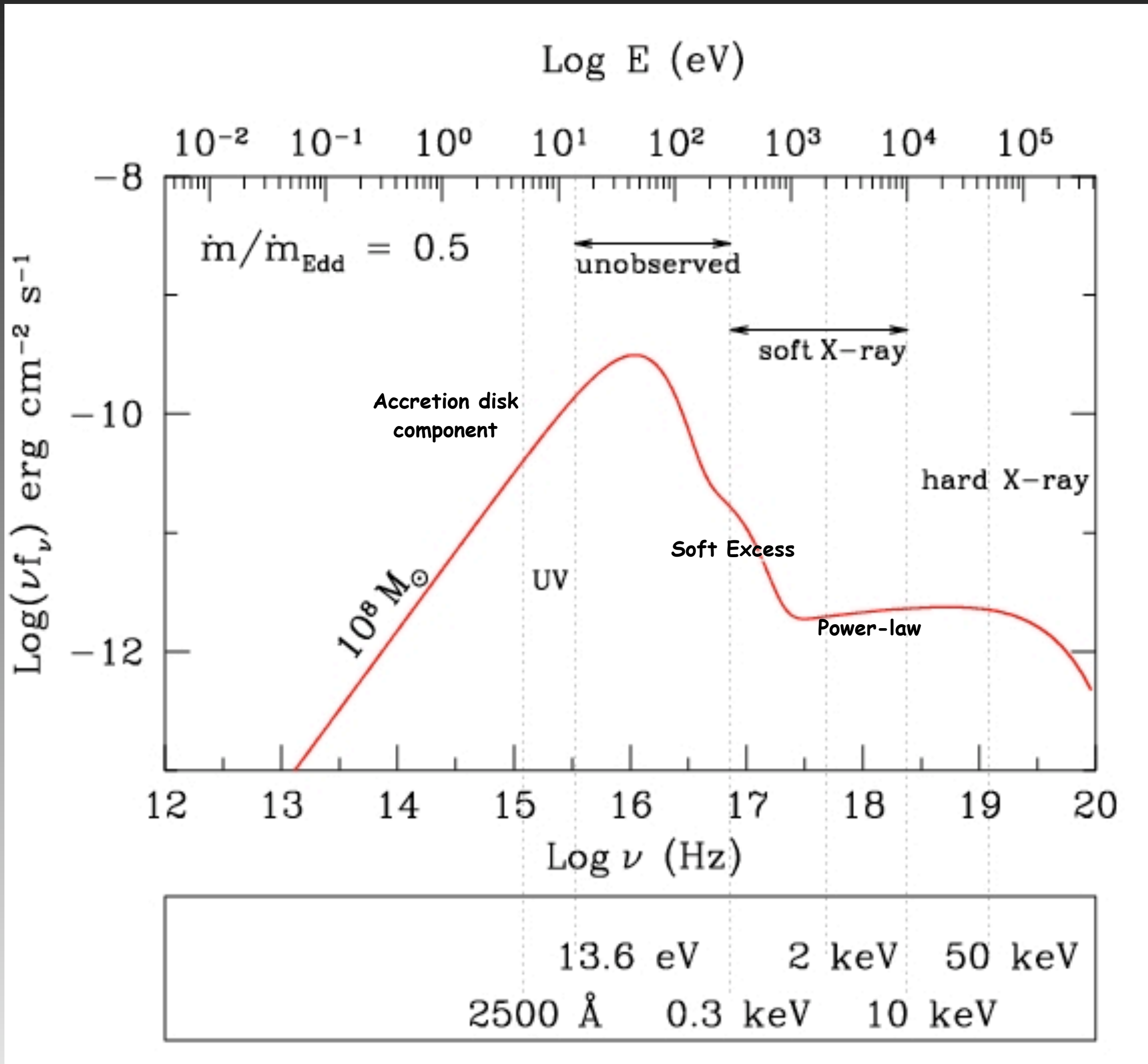


Ionizing continuum



- Accretion disk component by "diskbb"

- Soft Excess

· Compton reflection of disk photons by plasma at 100 eV, modeled by "nthcomp.

· Blackbody at 100 eV - X-ray photons reflected off the disk.

- **Powerlaw**

- **Siemiginowska et.al. 1995**
- **Vasudevan & Fabian 2009**

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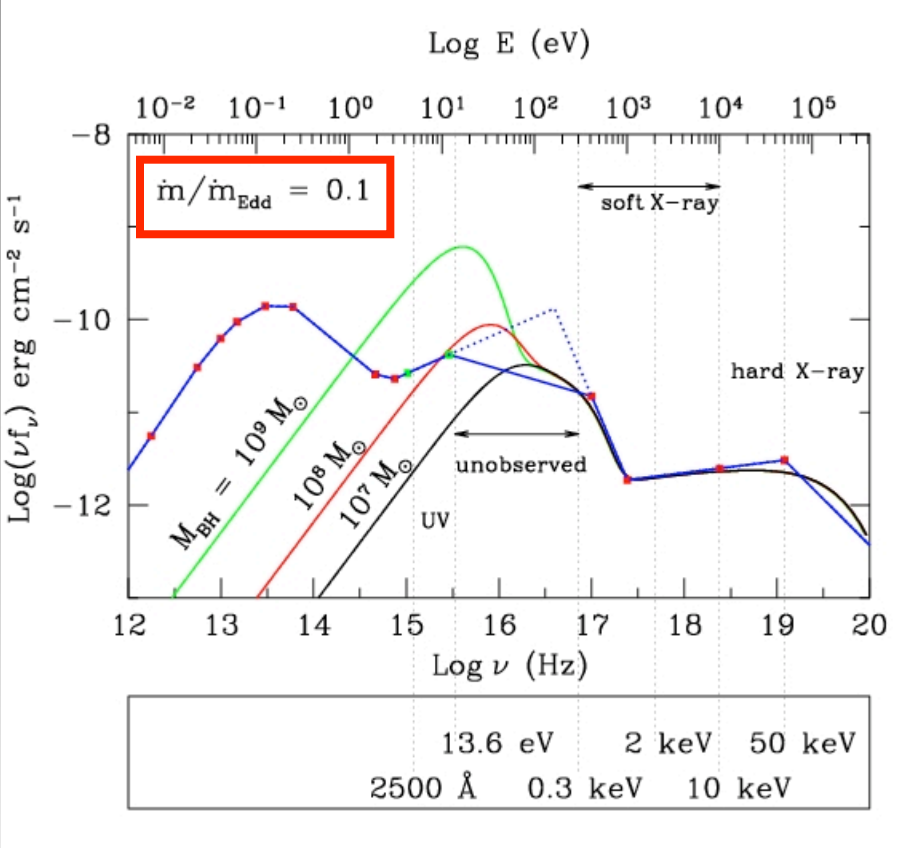

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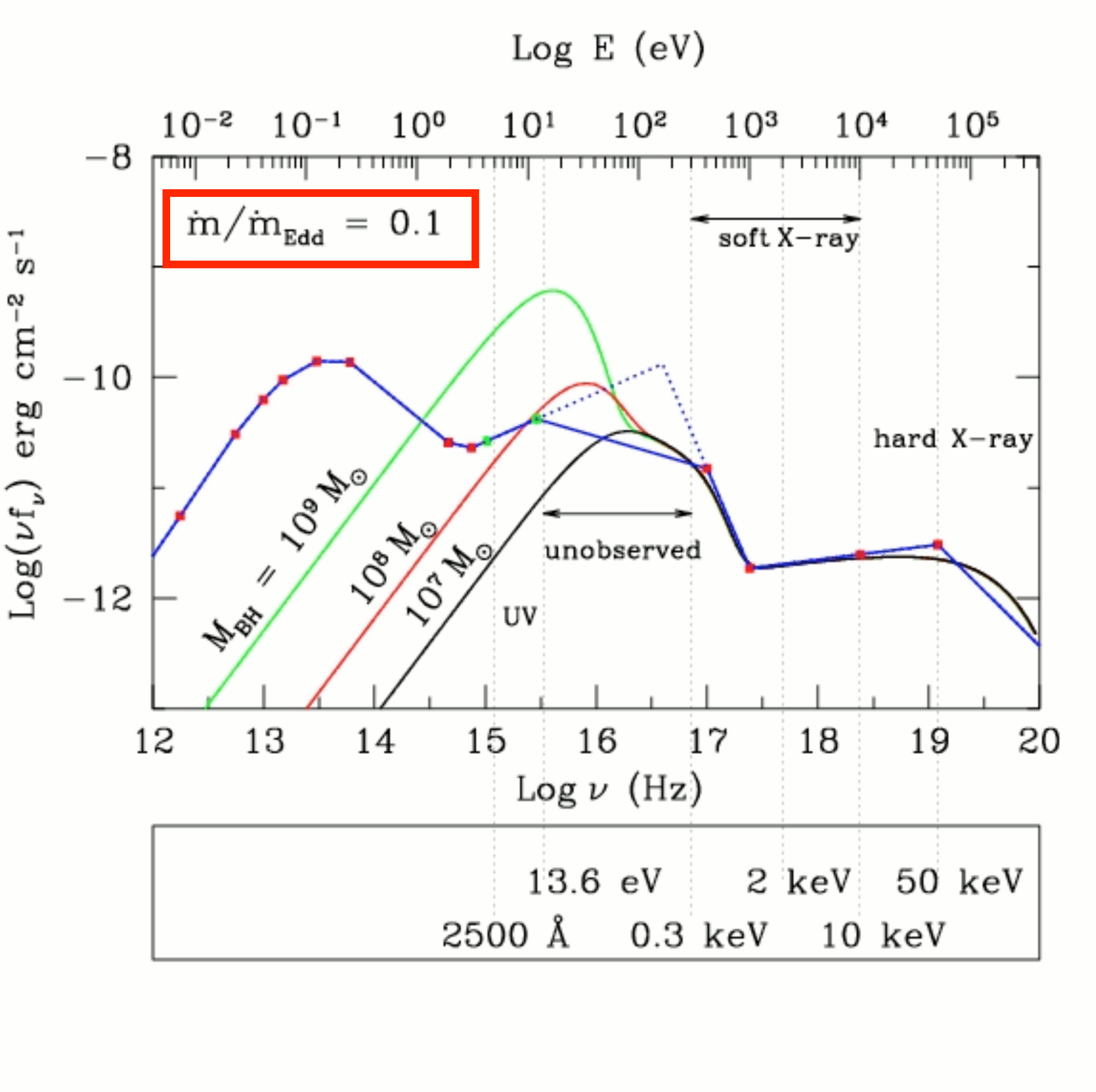

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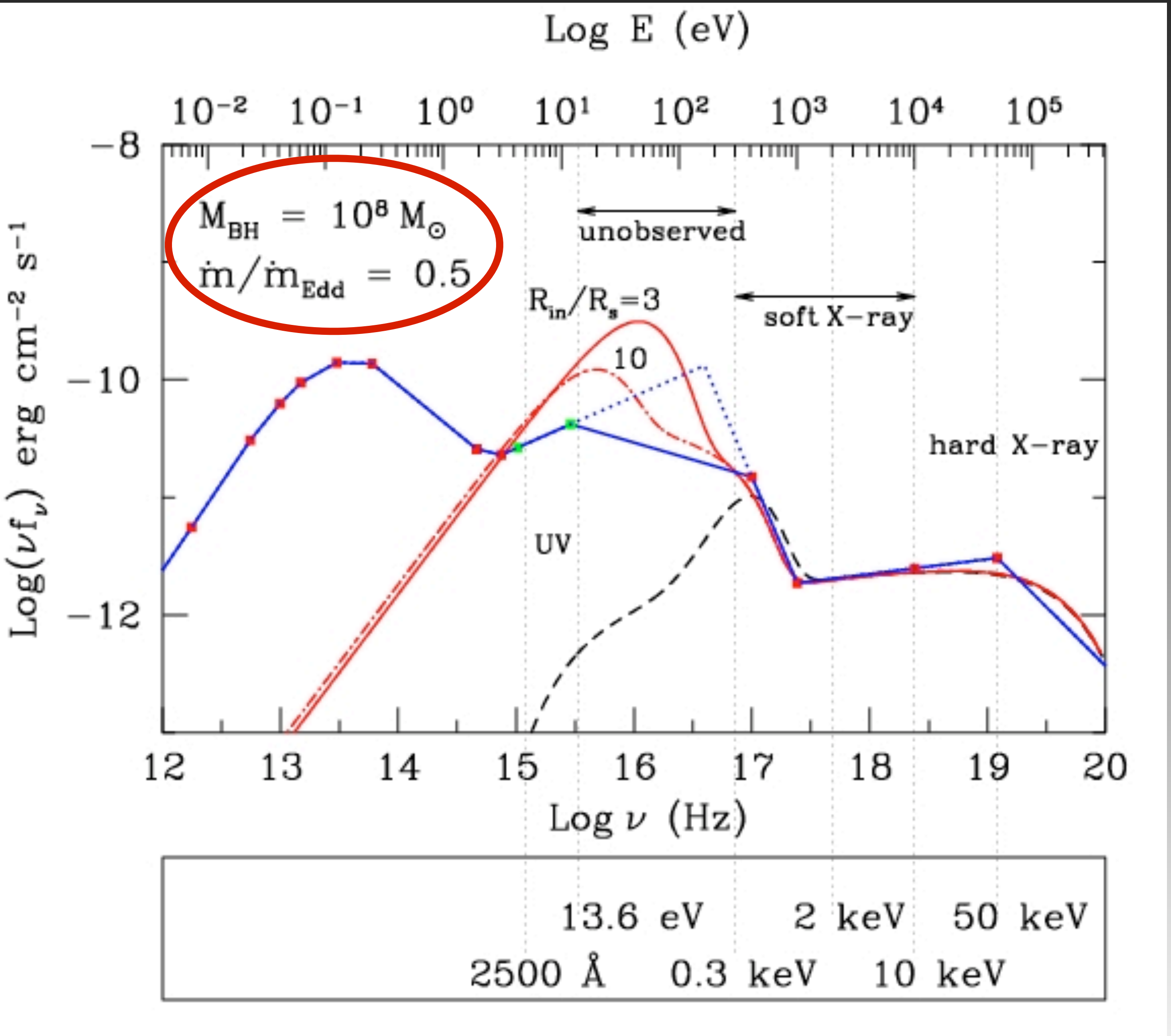


Ionizing effect of disk on warm absorber

Warm Absorber

Signatures

- Absorption features in the Soft X-ray Spectra

CV CVI OVII OVIII NeIX NeX MgXI MgXII SiXIII SiXIV

C (V & VI) O (V - VIII) Fe (XVII - XXII) Ne (IX & X) Mg (XI & XII)
Al (XII & XIII) Si (XIII - XVI) S (XV & XVI)

- **Absorption features are blue shifted relative to optical emission lines, indicating outflow.**

- $N_H \sim 10^{22\pm1}$ cm^{-2}

Warm Absorber

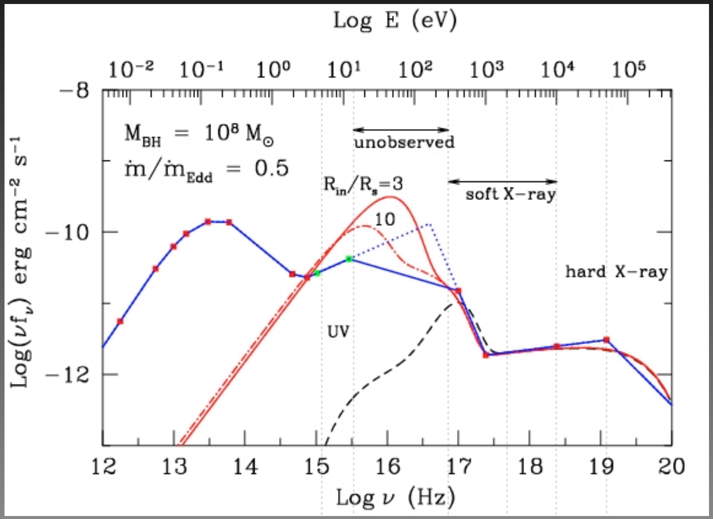
Derived properties

- Partially ionized gas in our line of sight to AGN
- $\xi = L/nR^2 \sim 10 - 1000$ erg cm s^{-1} -- Ionization parameter
- $T_{gas} \sim 10^4$ K $- 10^{6.5}$ K -- Temperature of the gas
- $n_H \sim 10^9$ cm^{-3} $(10^5 - 10^{12})$ -- Density of the gas
- $R_{gas} \sim 0.01 - 100$ pc -- Distance of the gas from the central engine
- **Mass loss rate is a substantial fraction of the accretion rate, or exceeds it.**

(Mathur et.al. 1995, 1998, Crenshaw et.al. 1999)

- The X-ray warm absorber could coexists with a UV absorber

Effect of accretion disk on the warm absorber



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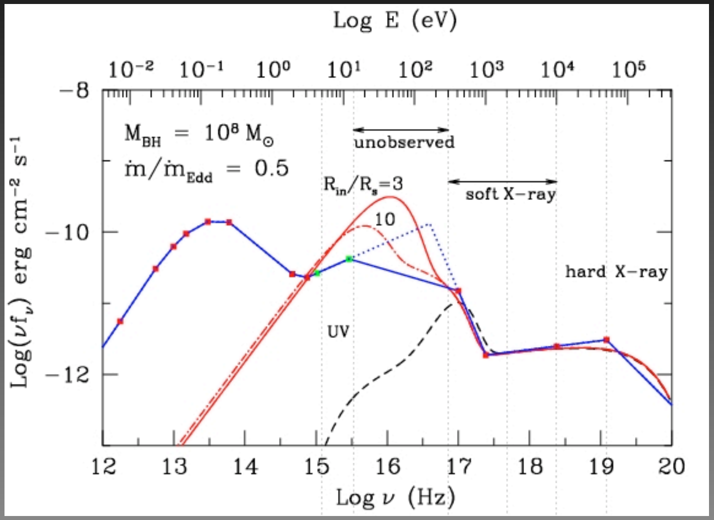
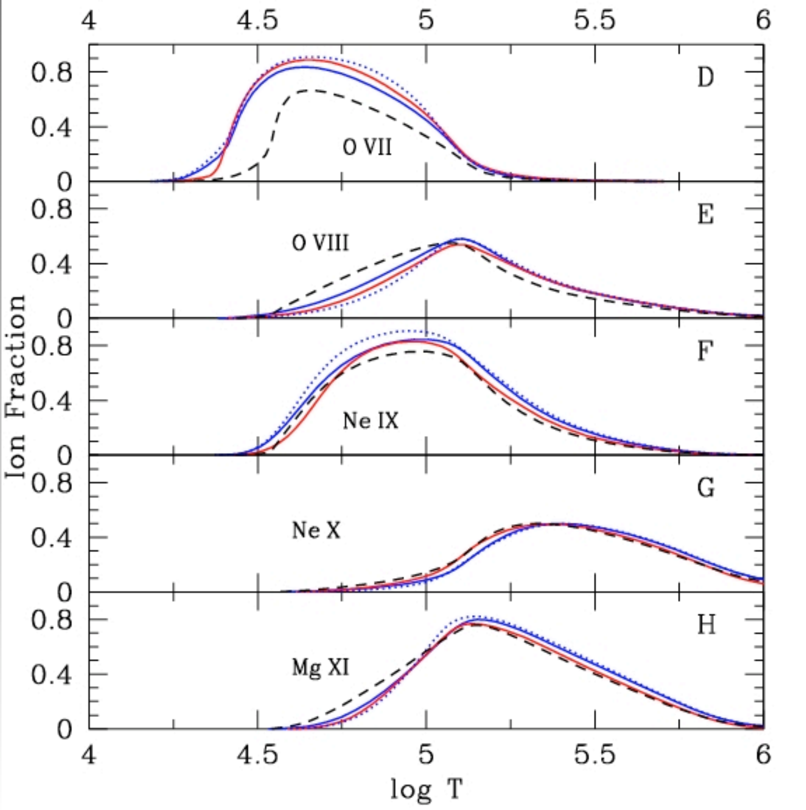


- The high ionization species of X-ray absorber remain unaffected by the presence of UV photons.

- However, OVII ion fraction under estimated by 30% without UV part of SED.



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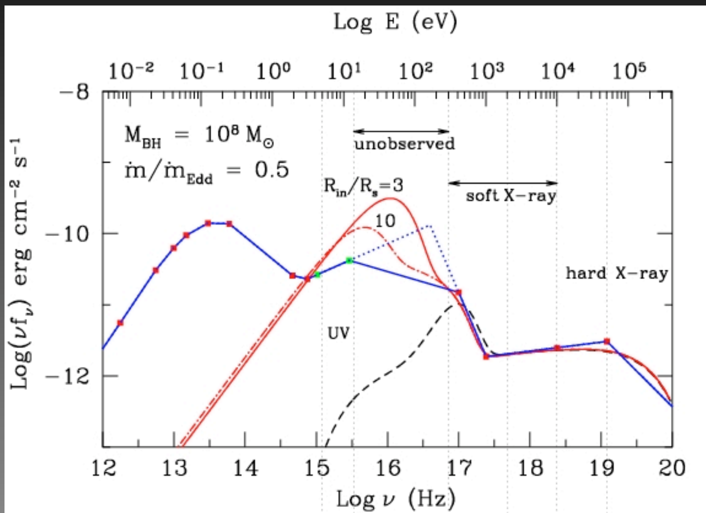
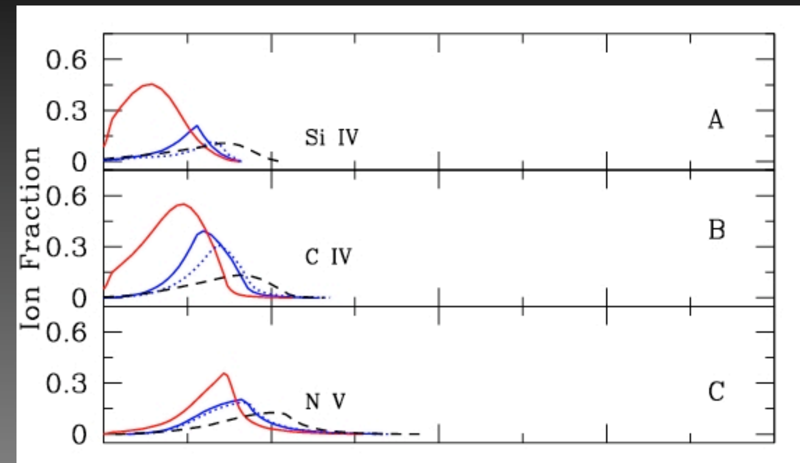
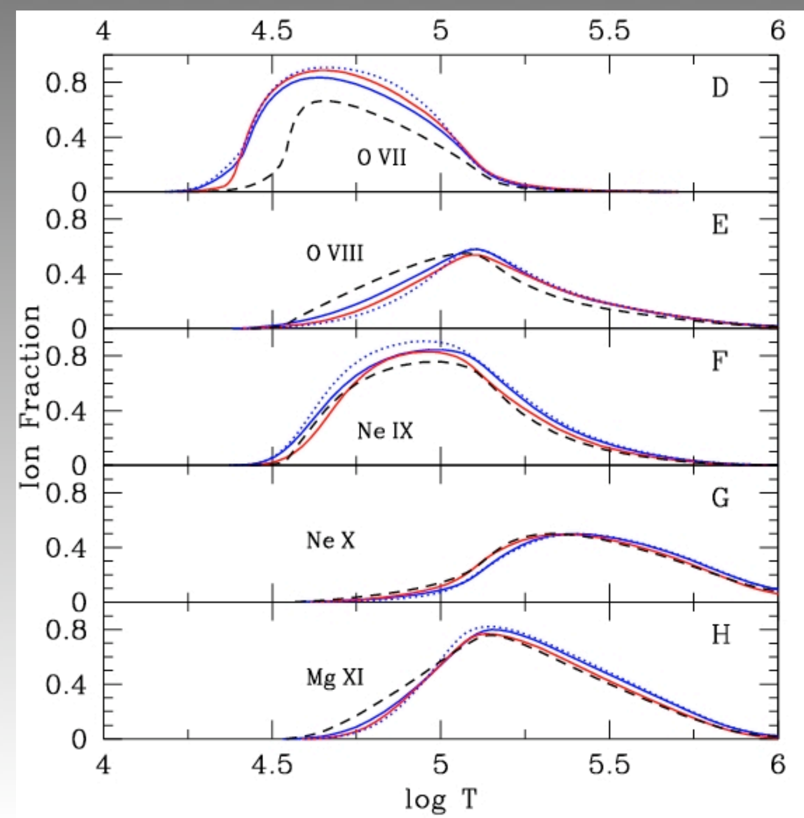
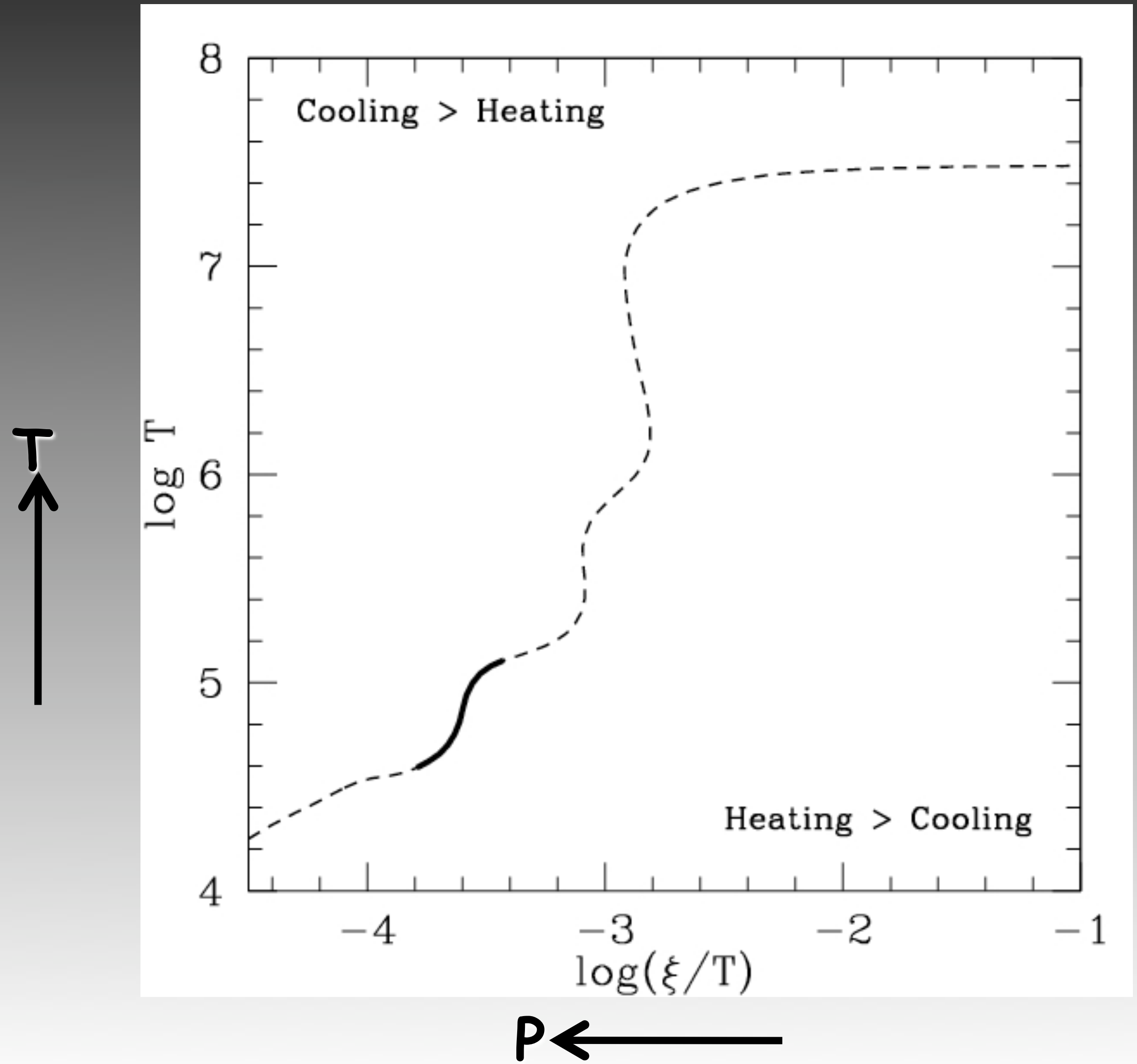






- The high ionization species of X-ray absorber remain unaffected by the presence of UV photons.
- However, OVII ion fraction under estimated by 30% without UV part of SED.
- For reasonable ion fractions of the UV ions, the accretion disk component is necessary.
- Demonstrates the need to know the SED in the ultraviolet for a complete description of the absorbing ions.

On the thermodynamic stability of the warm absorber



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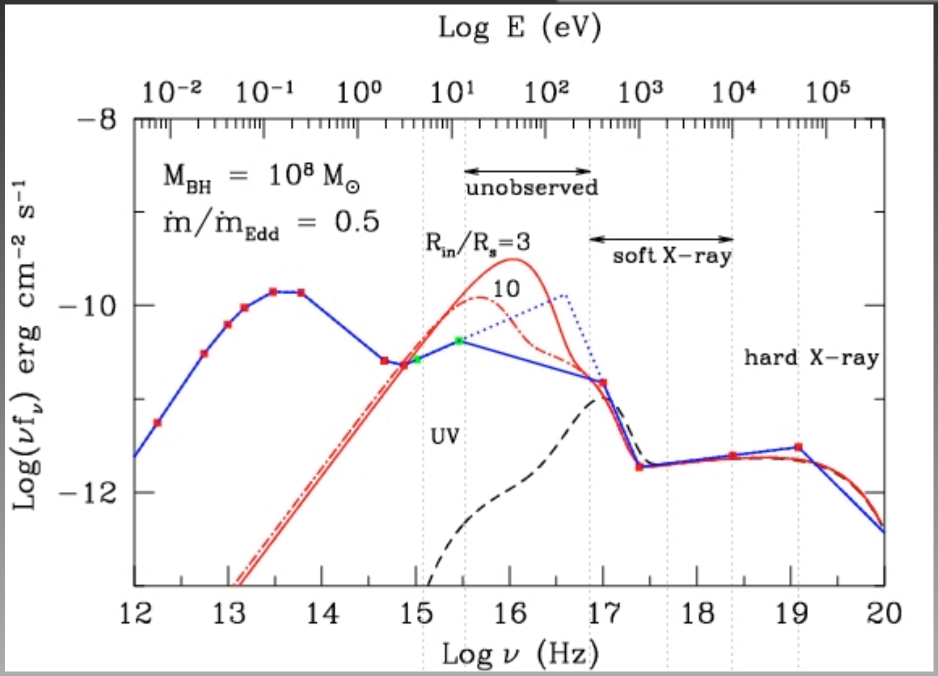
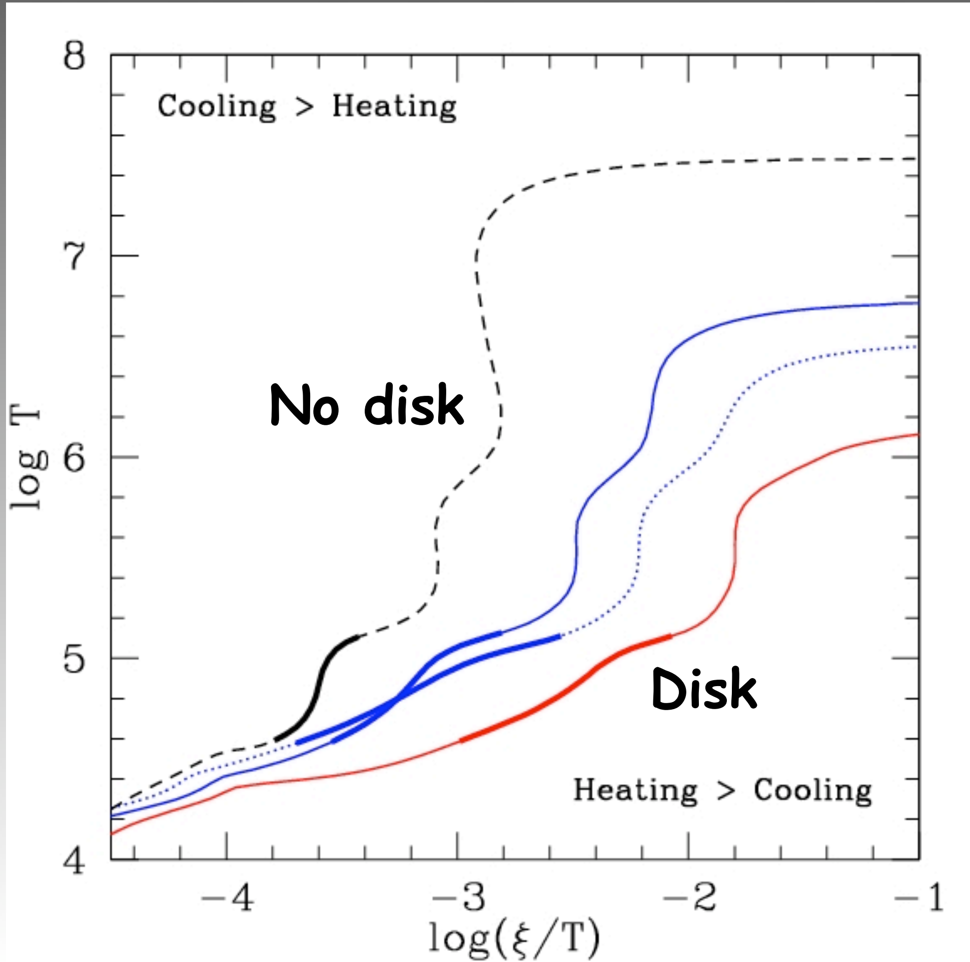
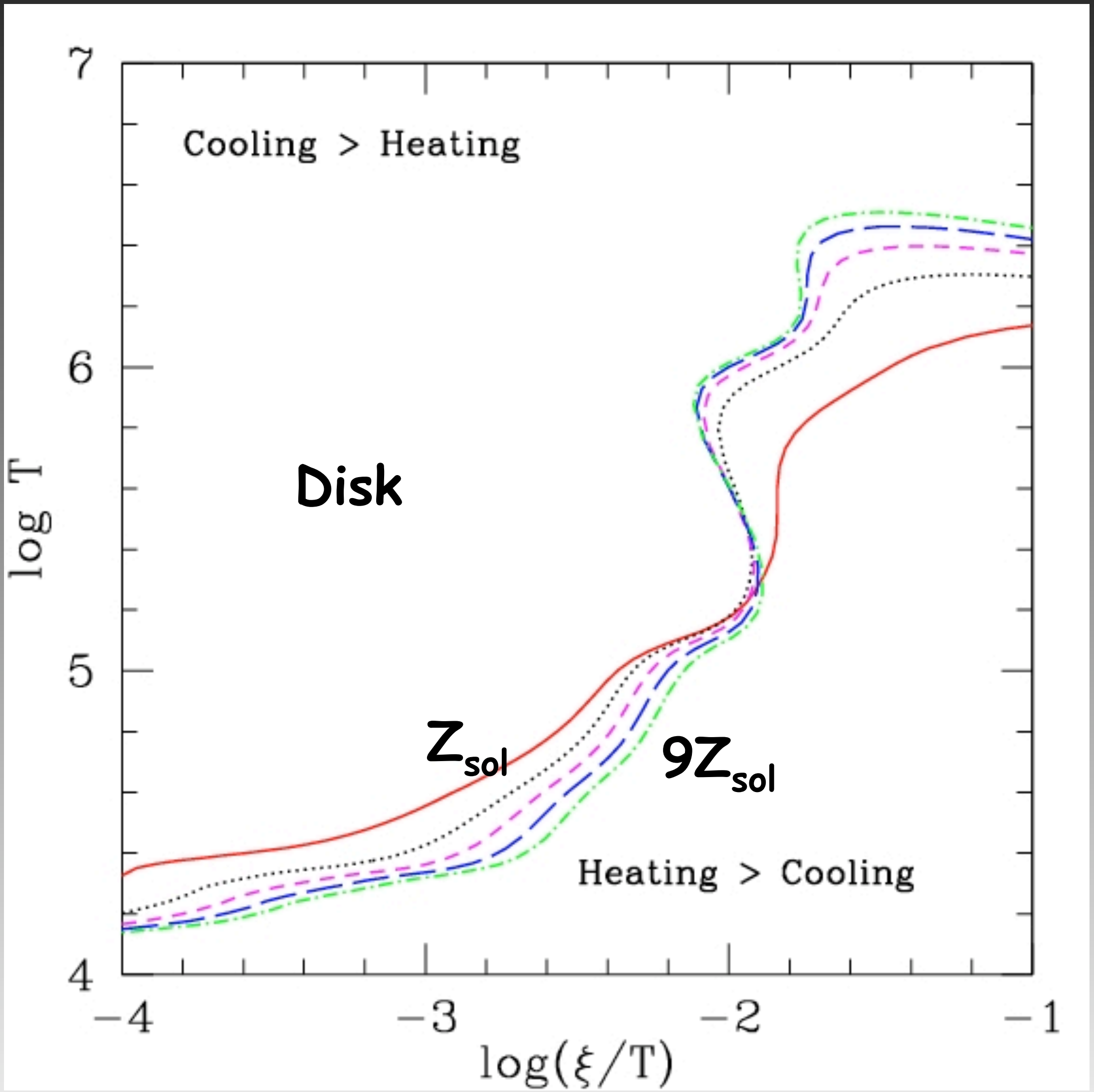




Multiple phases in pressure equilibrium



Summary

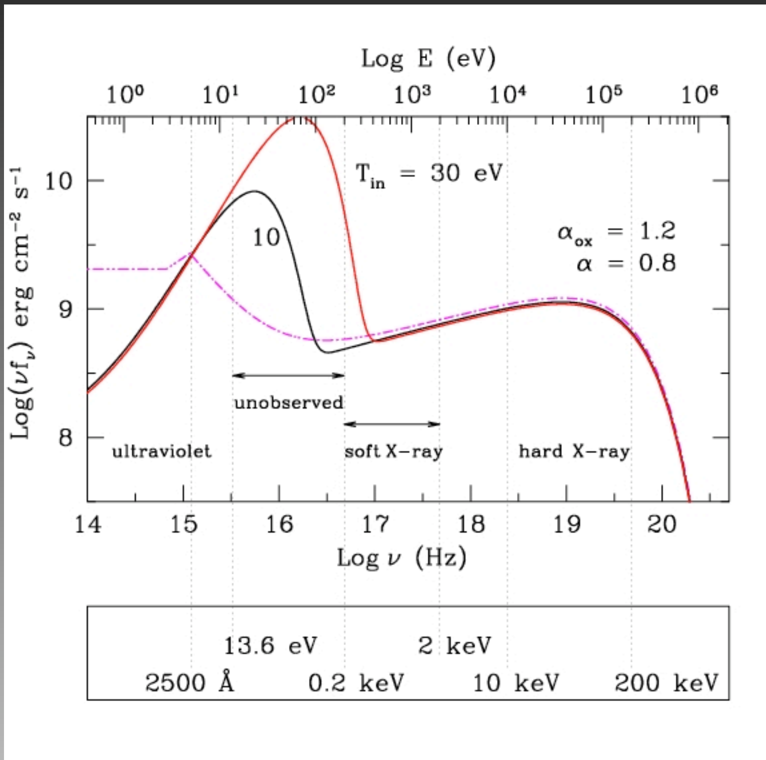
- Careful reconstruction of the accretion disk component can give valuable constraints on the mass and accretion rate of the black hole at the centre of the AGN.
  - Astrosat may be very helpful in this area in future.

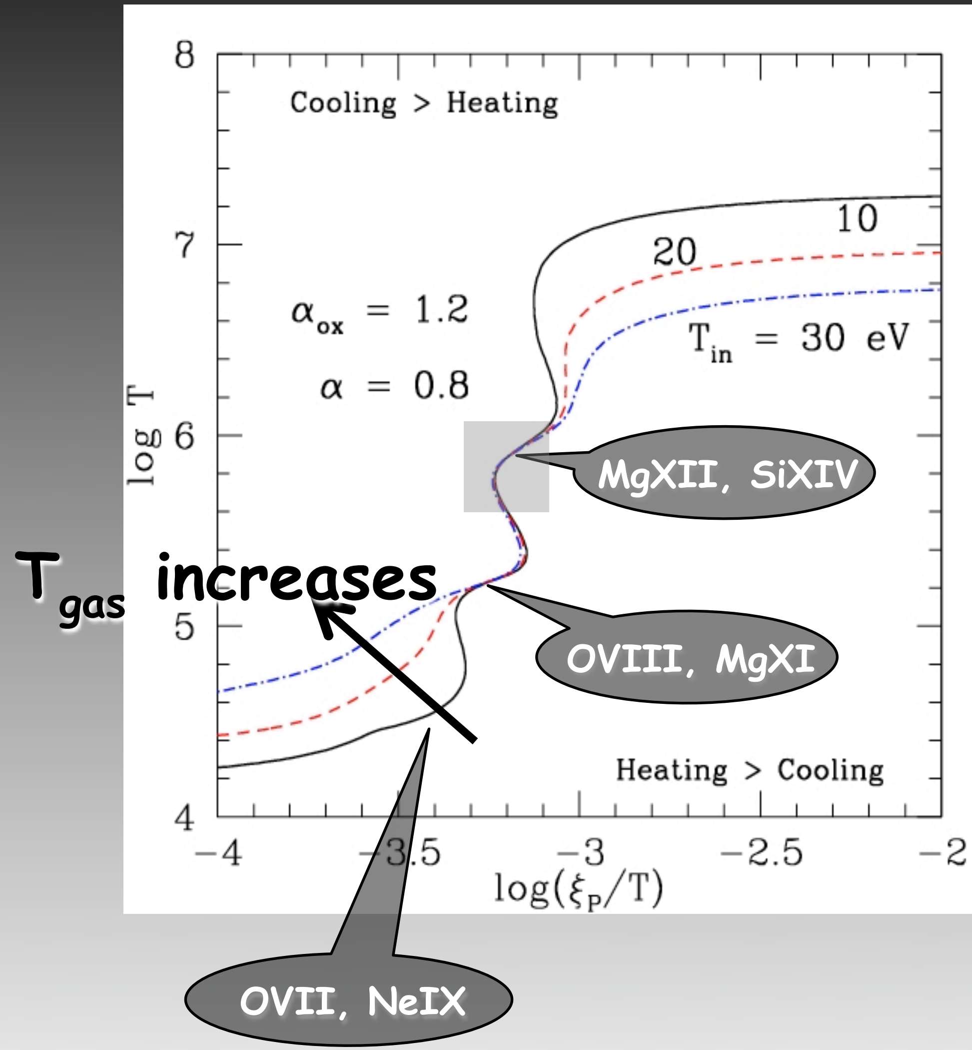
- The accretion disk has significant effect on warm absorber, especially ions with IP ≤ 740 eV (OVII).

- The UV - X-ray absorber connection is better explained if the disk component is included in the analysis.

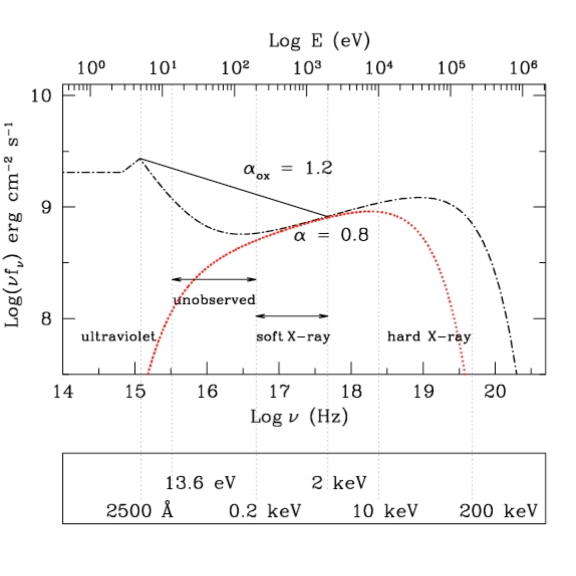
- Warm absorber becomes thermodynamically more stable with the inclusion of the disk component
  - but multiple phases at different temperatures are not in pressure equilibrium
  - need super-Solar warm absorber for multi-phase.

Does the disk affect the warm absorber?

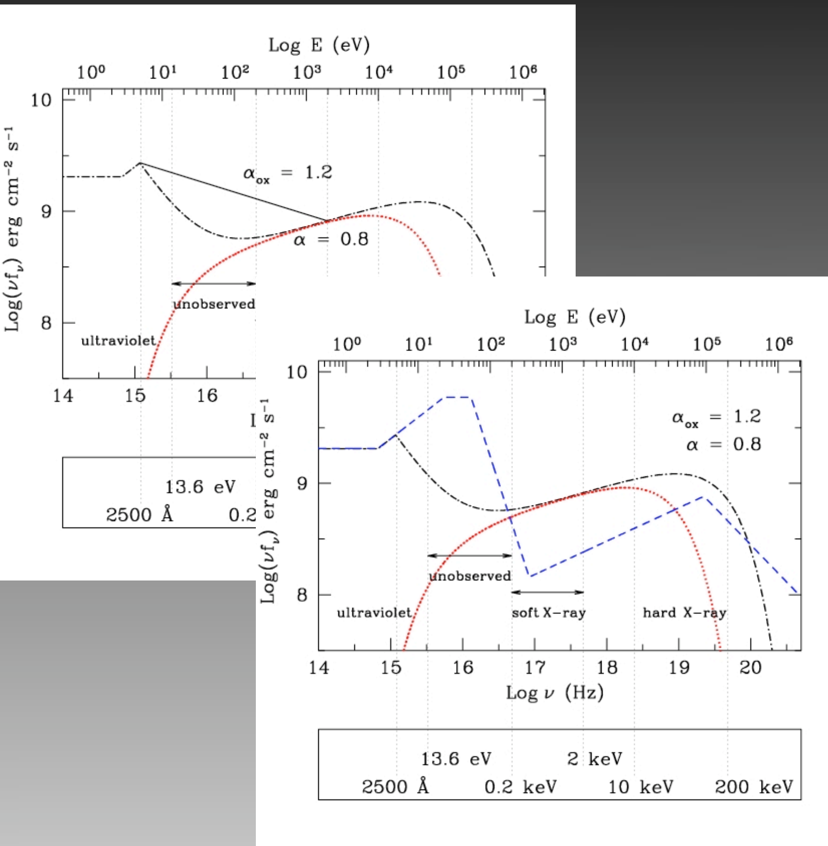




AGN Spectral Energy Distribution – an overview



AGN Spectral Energy Distribution – an overview



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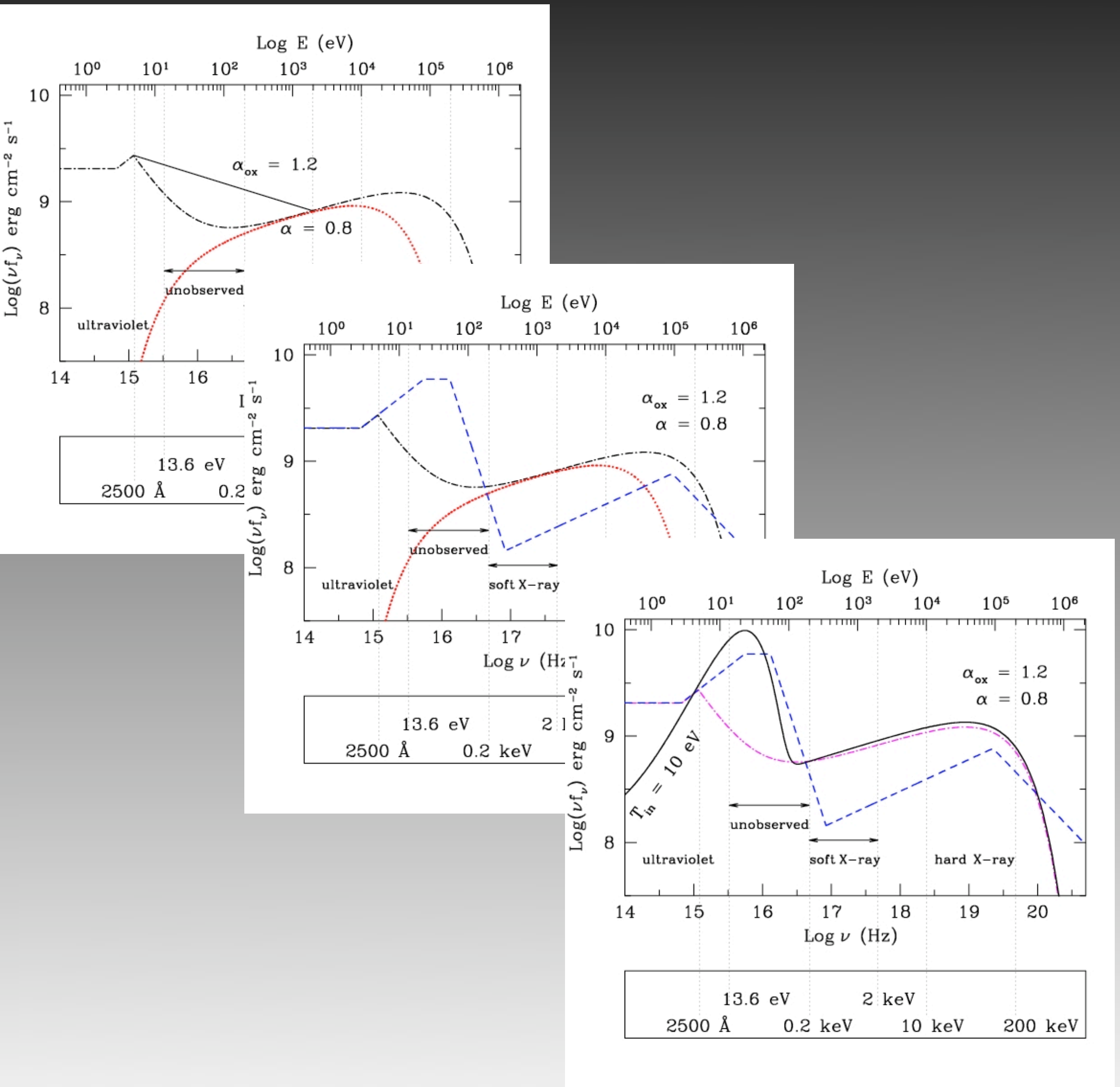
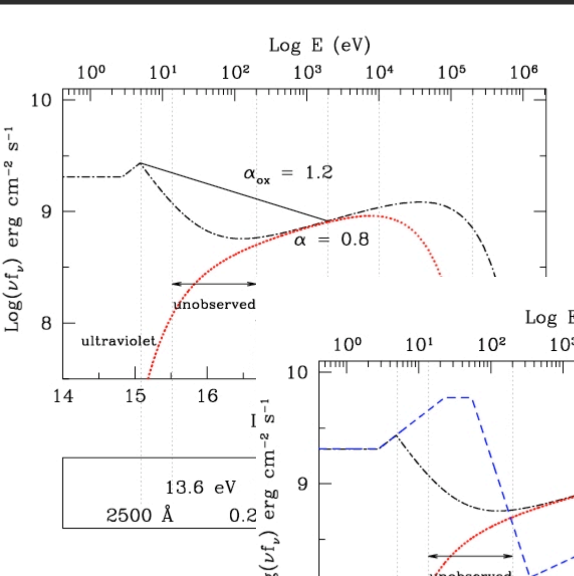
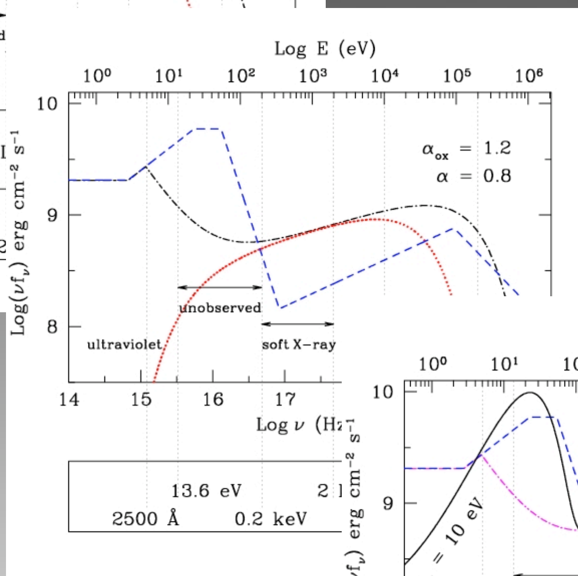
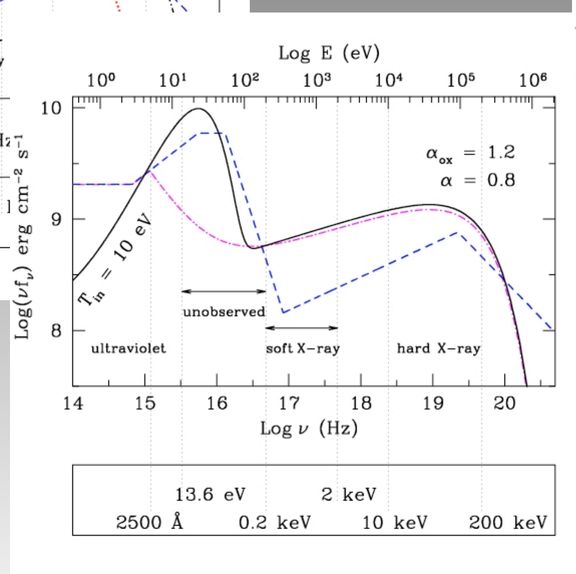


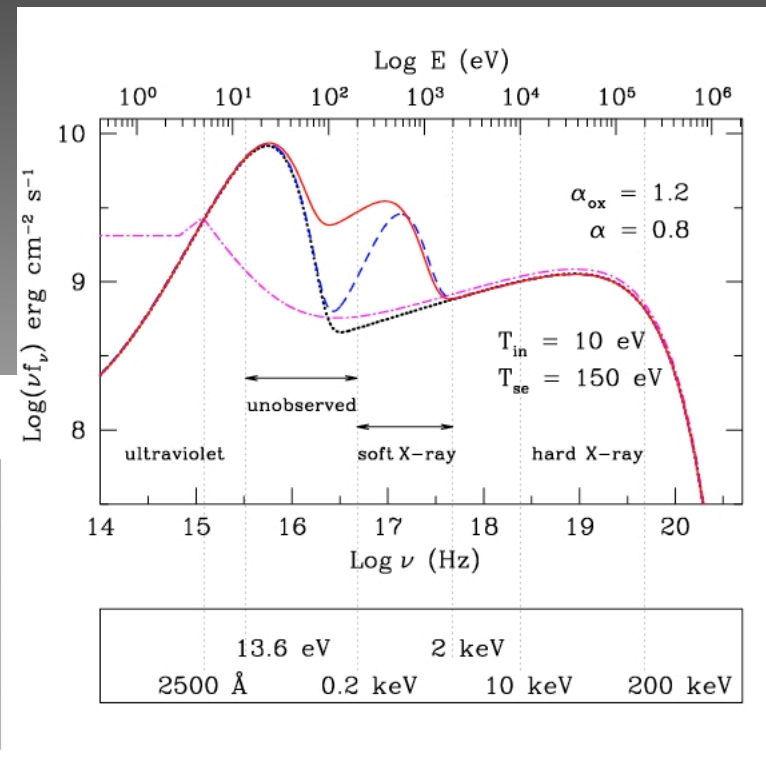
AGN Spectral Energy Distribution – an overview

$$f(\nu) \sim \left[\left\{\nu^{-\alpha} + \eta' \frac{2\pi h}{c^2} \frac{\nu^3}{\exp(h\nu / KT_{se}) - 1}\right\} + \eta'' f_{dbb}(\nu, T_{in})\right] e^{-\frac{\nu}{\nu_{max}}}$$

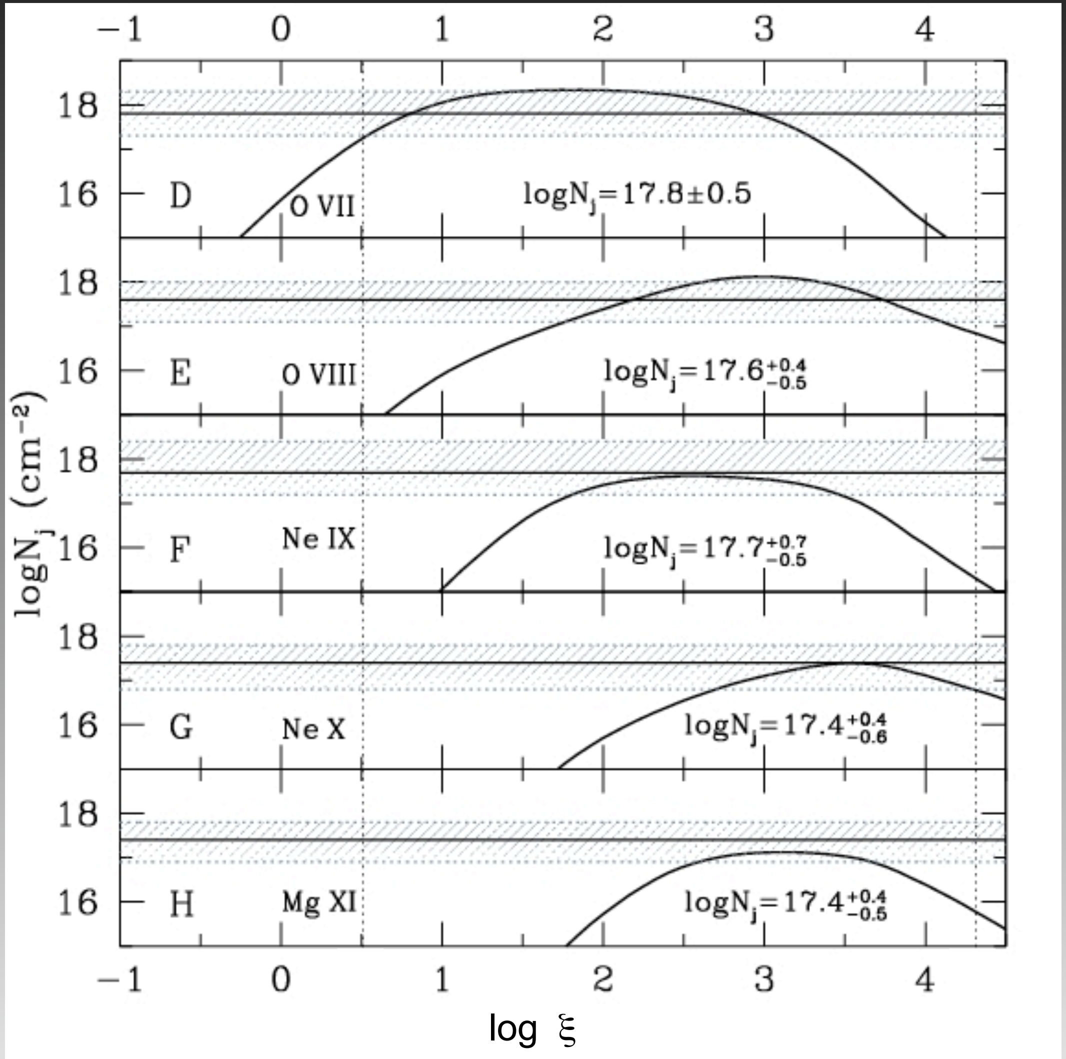


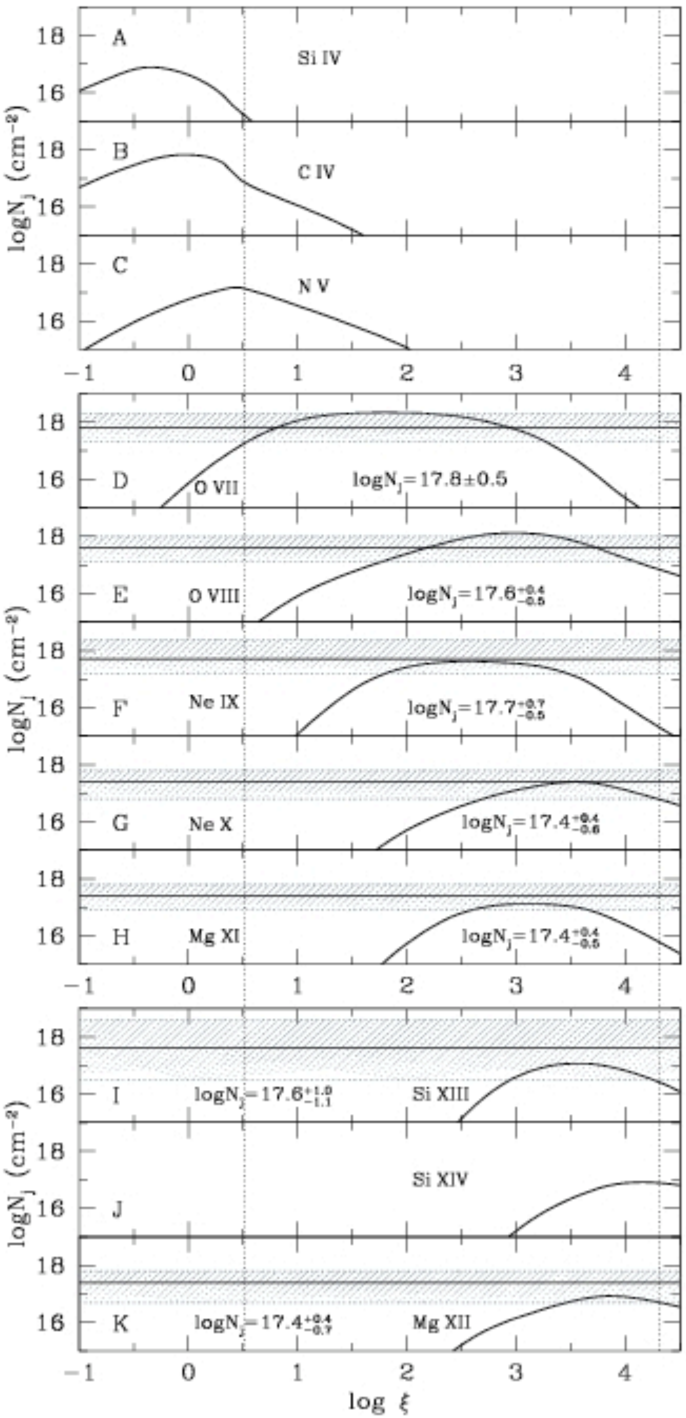






N_j – matching theory and observations





X-ray and UV ions coexist?

- The 3 ions from UV having similar velocity components – SiIV, CIV, NV
- UV analysis puts constraint on $N_j > 10^{16}$ cm^{-2} for these ions
- The lower end ξ values from X-rays reproduce UV ions
- Concern about SiIV?
- Need to check if Rin = 10 does a better job

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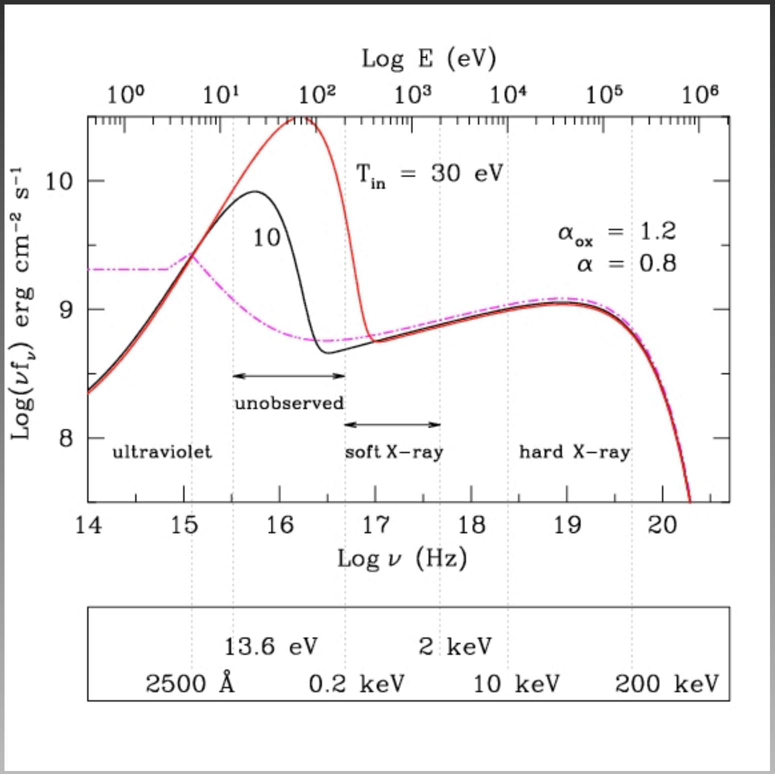

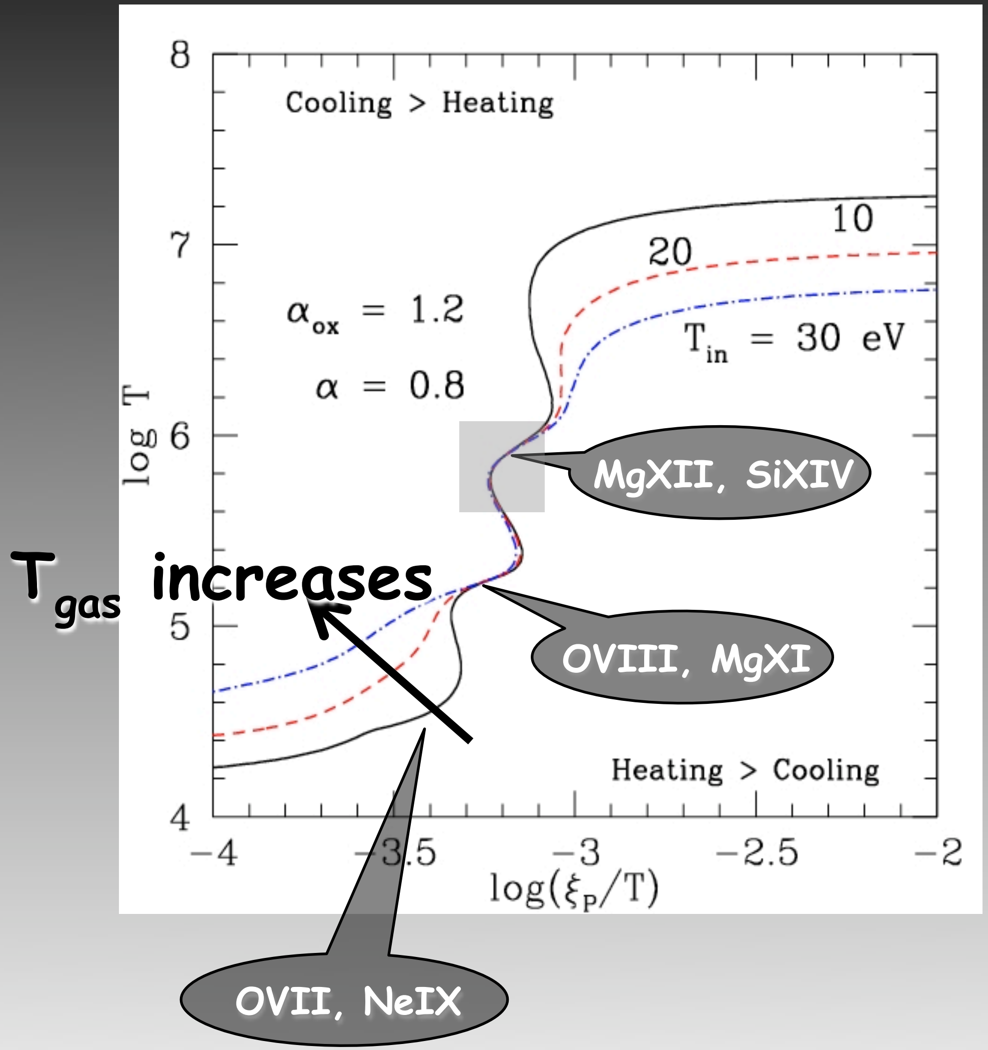

Chakravorty et.al. 2011