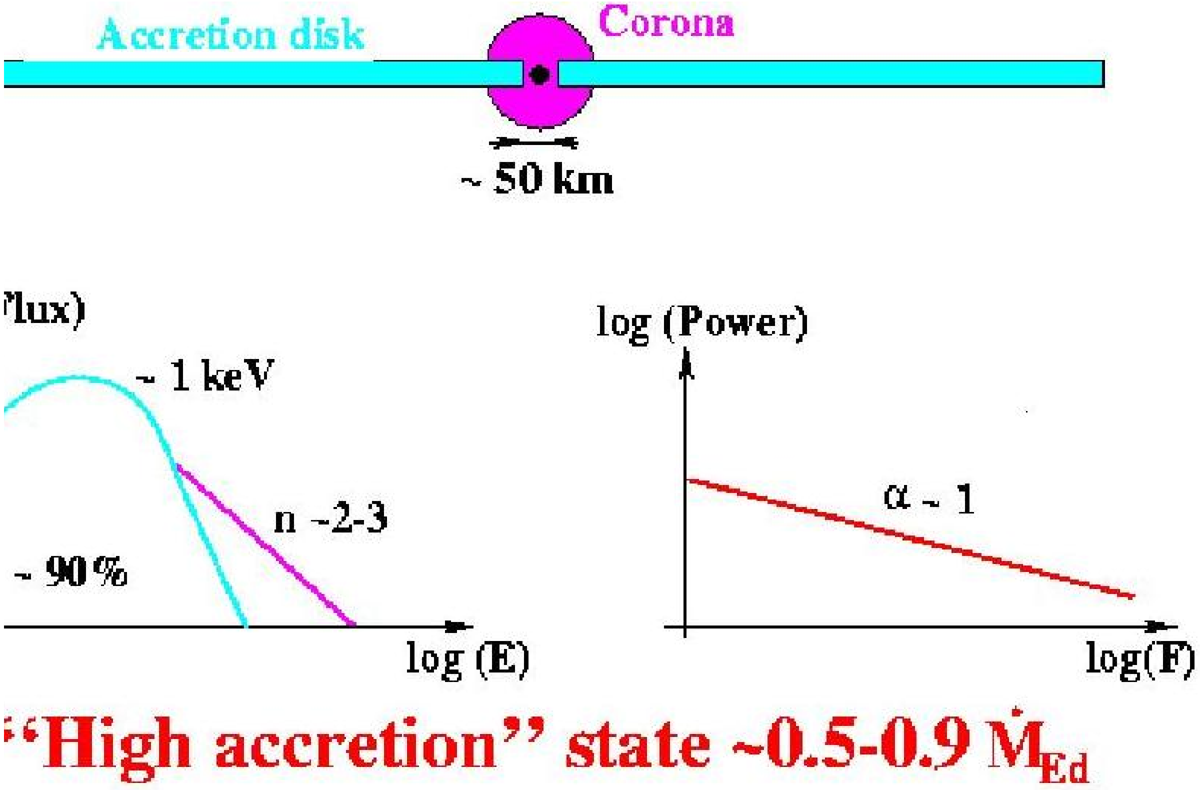
# Accretion #3

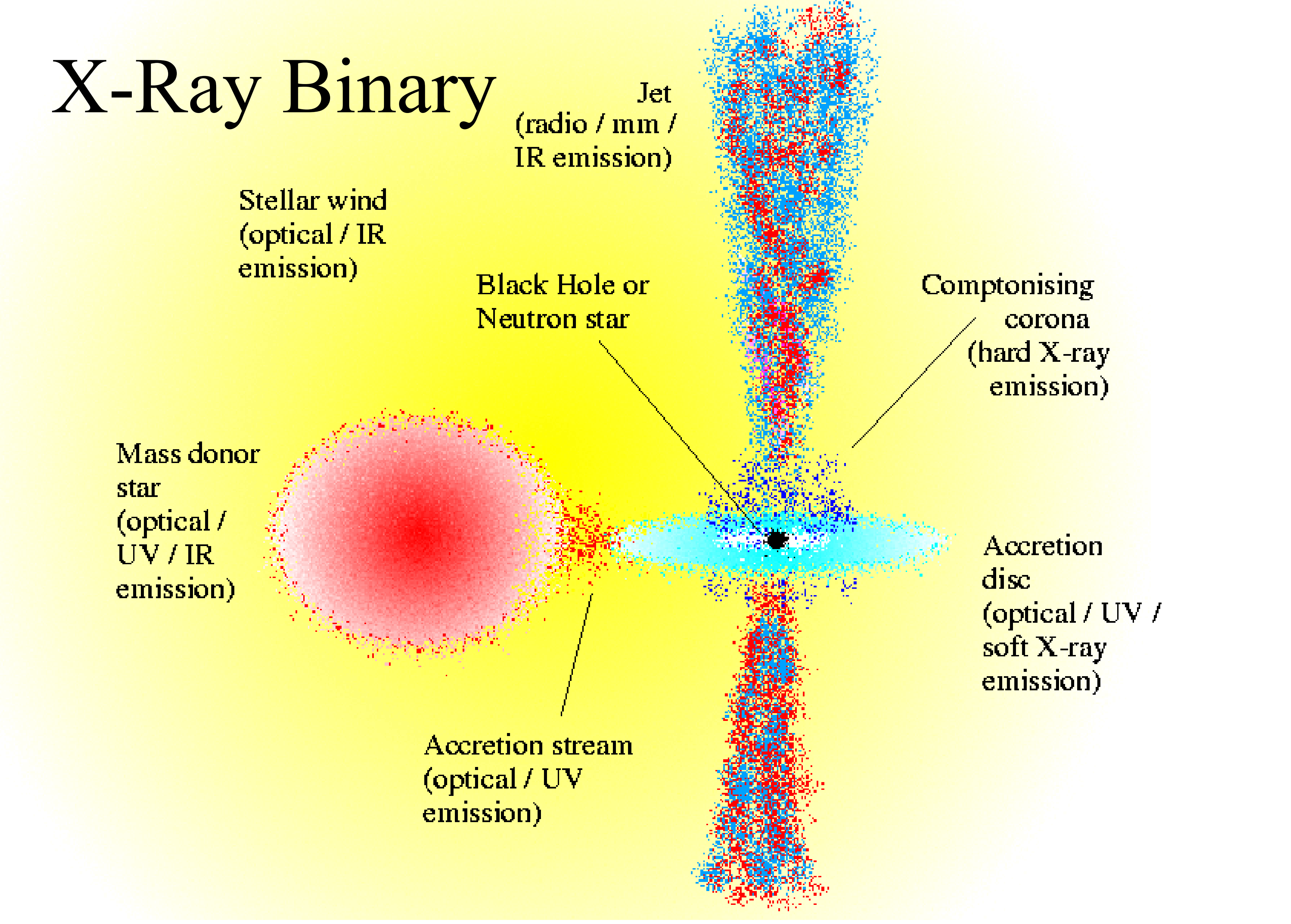
- When is the thin disk model valid?
- Reynolds number, viscosity
- Time scales in disk
- BH spectra
- Using X-ray spectra to determine BH mass and spin
- Using emission lines to determine BH spin

# X-Ray Spectrum

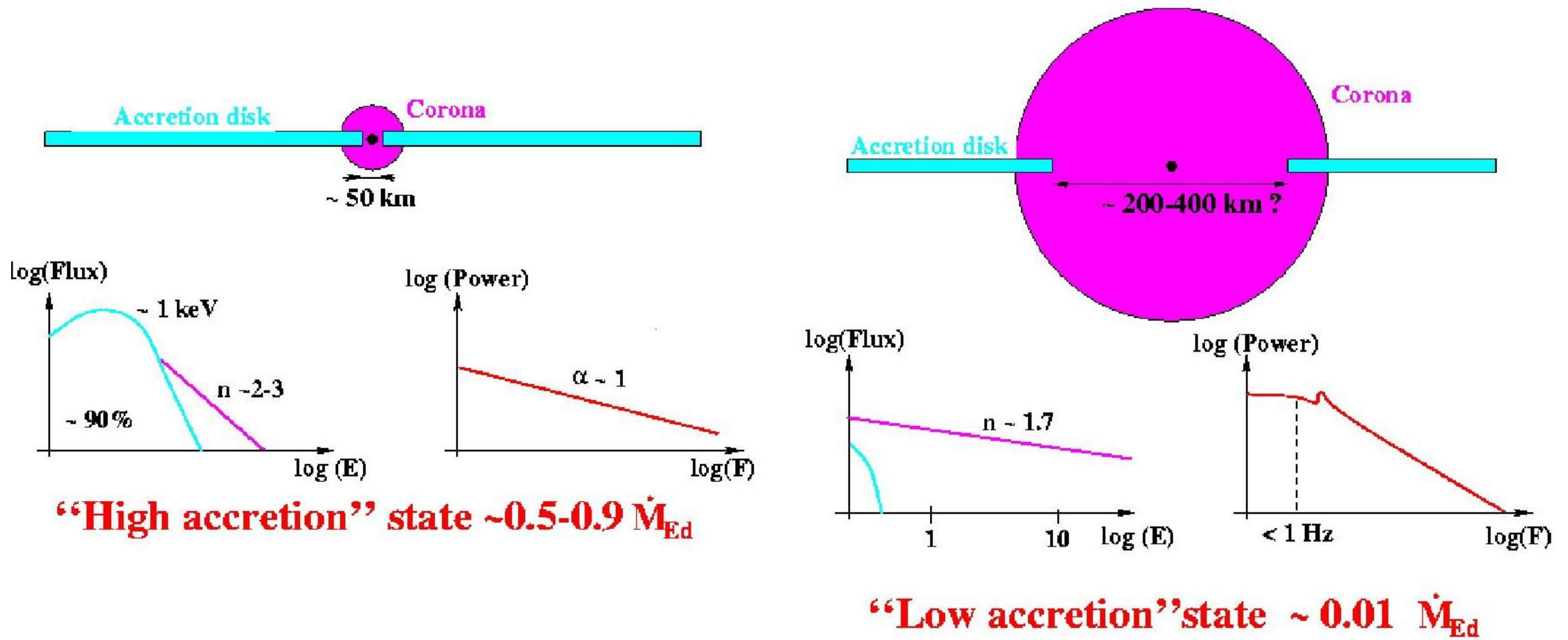



- Thermal emission from disk - multicolor blackbody
- Emission from corona - powerlaw or Comptonization

# X-Ray Binary


Jet
(radio / mm /
IR emission)
Stellar wind
(optical / IR
emission)
Black Hole or
Neutron star
Comptonising
corona
(hard X-ray
emission)
Mass donor
star
(optical /
UV / IR
emission)
Accretion
disc
(optical / UV /
soft X-ray
emission)
Accretion stream
(optical / UV
emission)

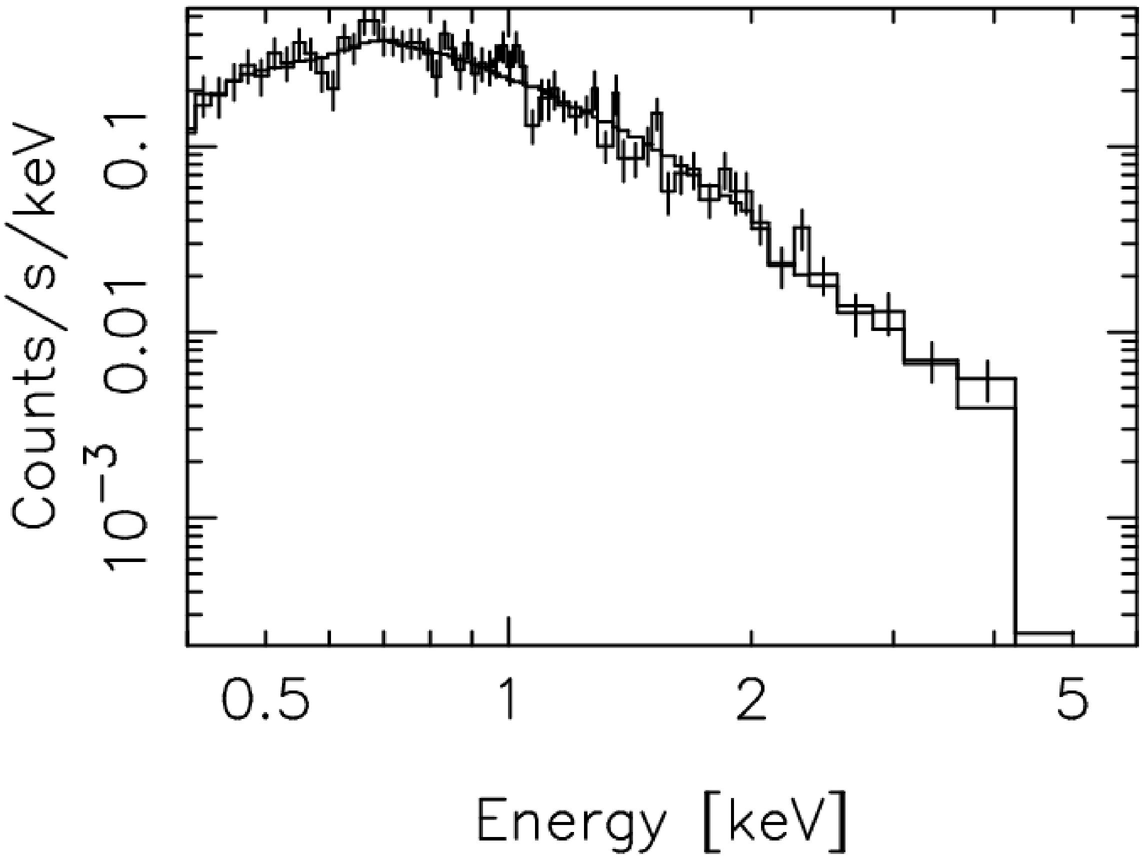
# X-Ray Spectral States




**Emission consists of two components:**

- Thermal emission from disk - multicolor blackbody
- Emission from corona - powerlaw or Comptonization

# X-Ray Spectrum of NGC 5408 X-1




Disk temperature of 0.13 keV is possible evidence for 1000 solar mass black hole (Kaaret et al. 2003).

# Can we find the BH spin from the X-ray spectrum?

- $T_{in}$ = temperature at inner disk radius (keV)
- $K = (R_{in}/D)^2 \cdot \cos\theta$, where $R_{in}$ is the inner disk radius, D is the distance to the source, and $\theta$ is the angle of the disk

- $R_{in}$ depends on spin of BH. Can attempt to use X-ray spectrum to constrain spin.

# Emission lines

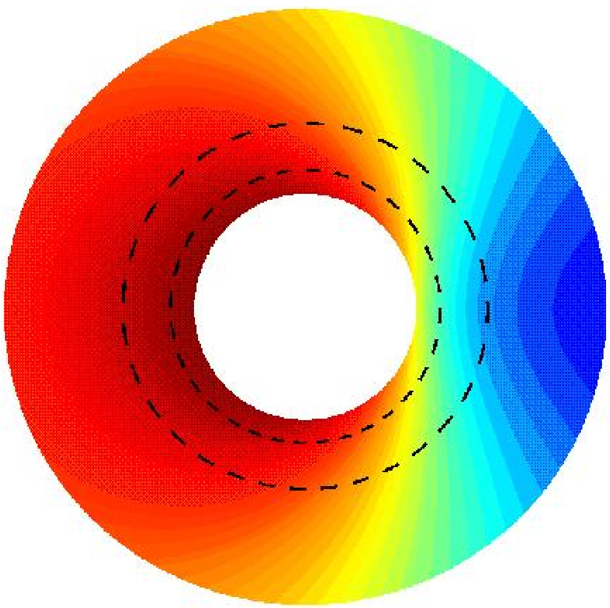
In addition to continuum components (blackbody and Comptonization), X-ray spectra sometimes exhibit emission and/or absorption lines.

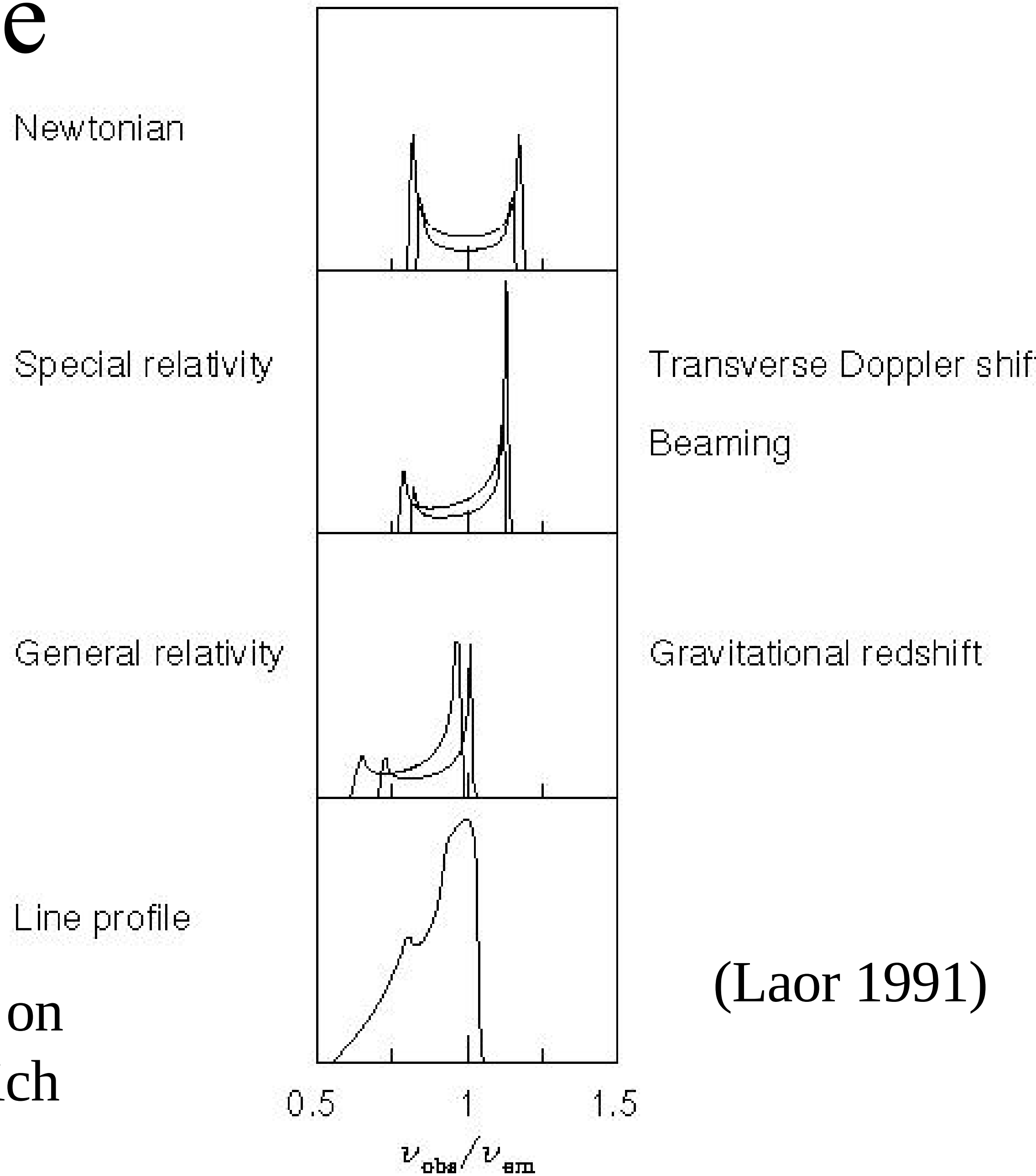
Emission lines can be produced by hot gas or by cold gas that is illuminated by continuum radiation (fluorescence).

Absorption lines are produced by warm, cool, or cold gas lying between the emission source and the observer.

The lines produced depend on the ionization state of the material.  Lines can be used as diagnostics of the physical state of the gas.

# Relativistic line profiles






(Laor 1991)

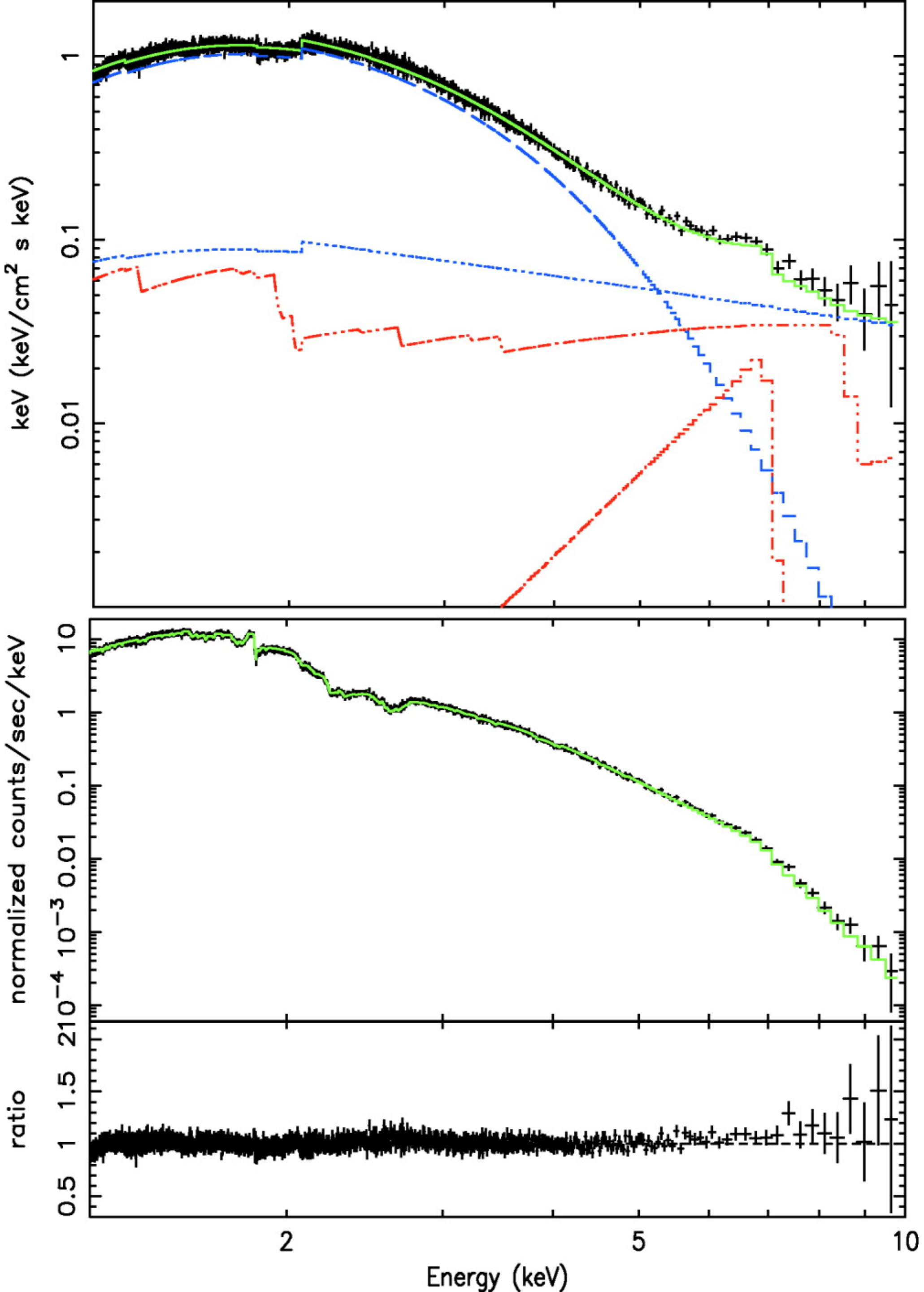
Red edge of line depends on gravitational redshift, which depends on BH spin

# Reflection

Reflection of X-rays, e.g. produced in the corona and reflected off the disk, can produce another continuum component.

Reflection is closely related to fluorescent line emission and the reflection component has strong line and edge features.

# X-Ray Spectrum of GX 339-4




Disk and power-law components in blue.

Reflection and line emission in red.

Total in green.

Data in black.

(Miller et al. 2003)