Relativistic Fe line emission and photoionized absorption in GRO J1655-40 during its 2005 outburst

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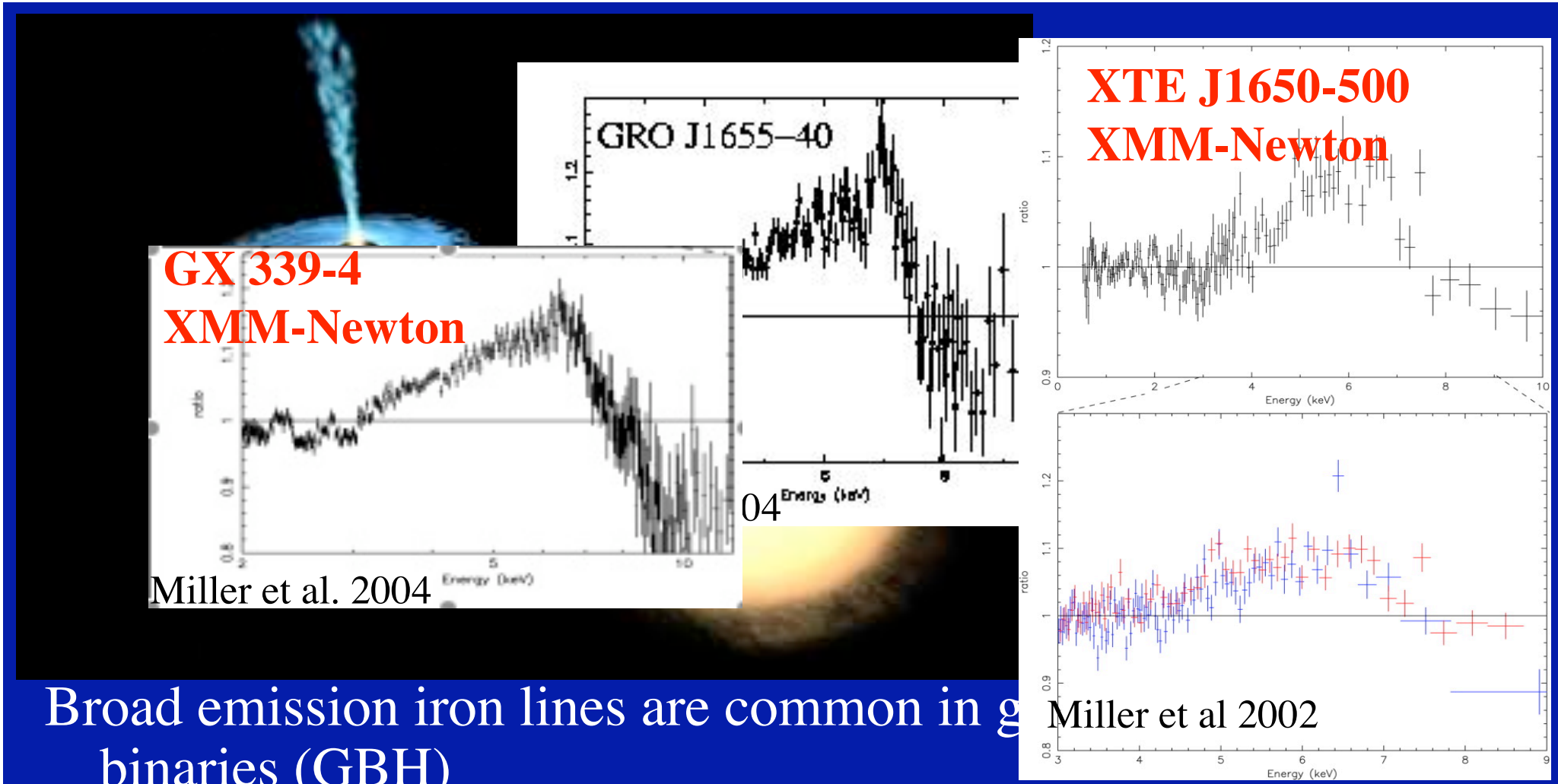
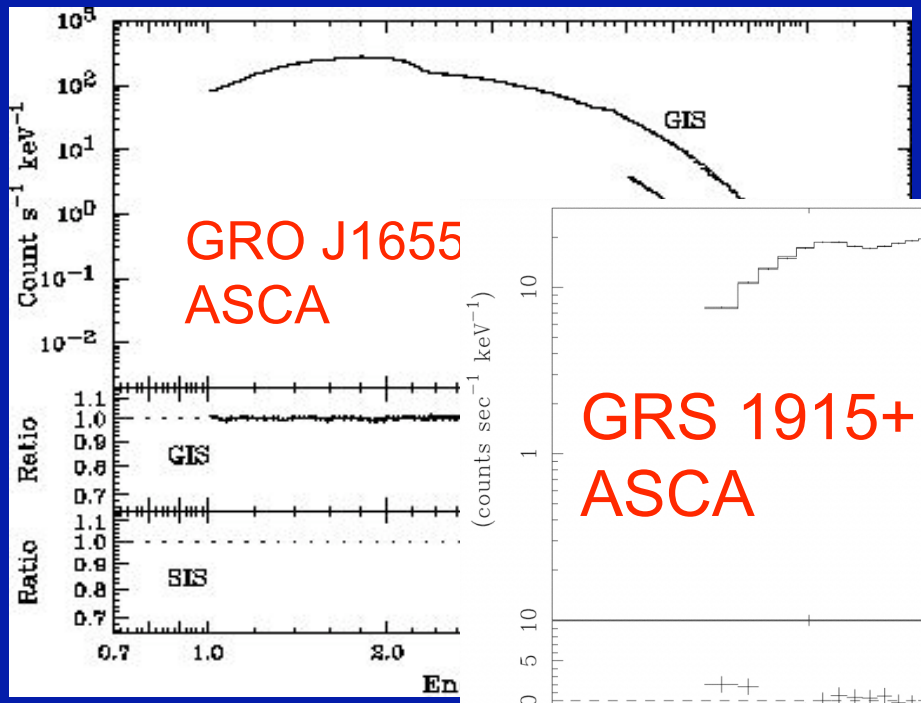


Broad emission iron lines are common in g binaries (GBH)

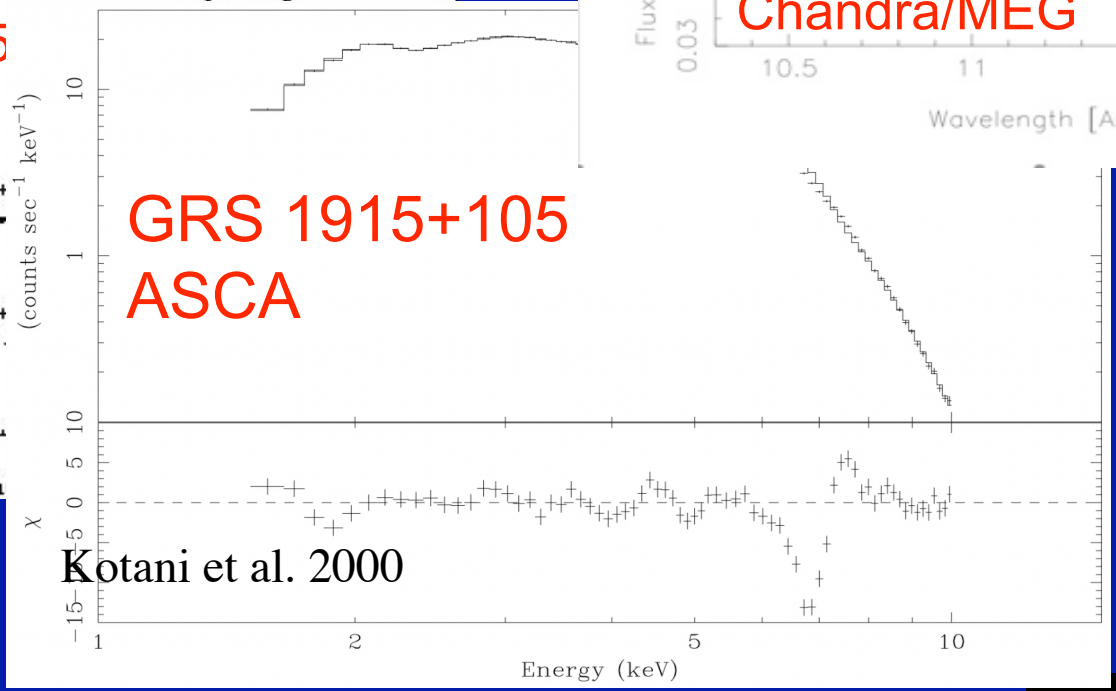
Some Fe lines are extremely broad indicating high spin (if disk to ISO) and extreme emissivity (Miller et al 2002, 2003, 2004; Miniutti et al 2004)

Absorption lines seen in galactic black hole binaries

Ueda et al. 1998/Yamaoka et al. 2001

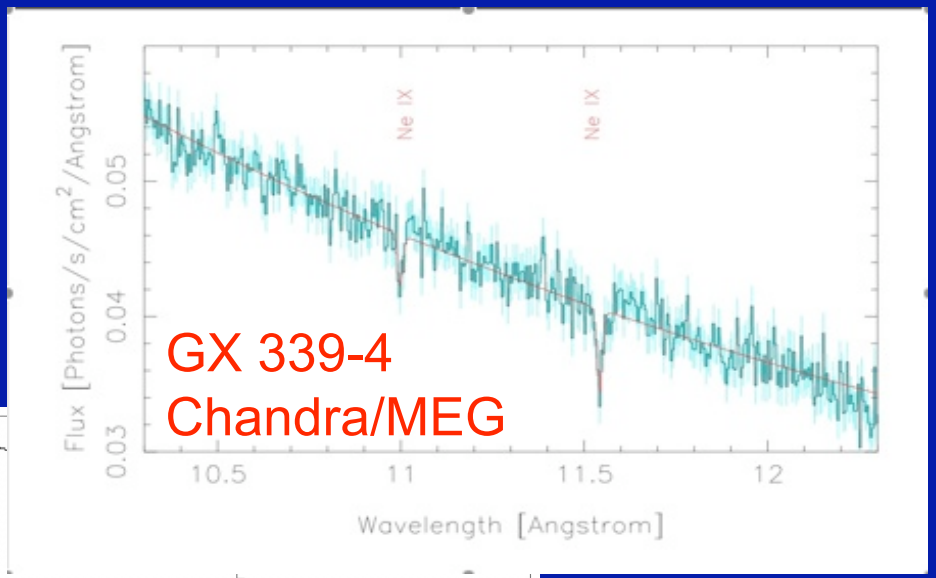


GRO J1655
ASCA



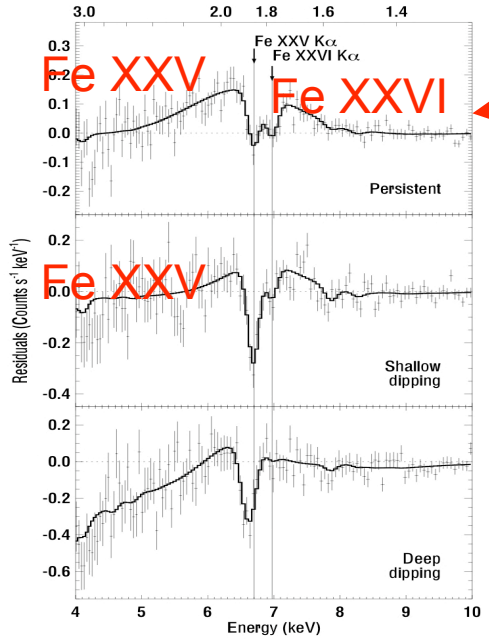
GRS 1915+105
ASCA

Kotani et al. 2000



GX 339-4
Chandra/MEG

Miller et al. 2004

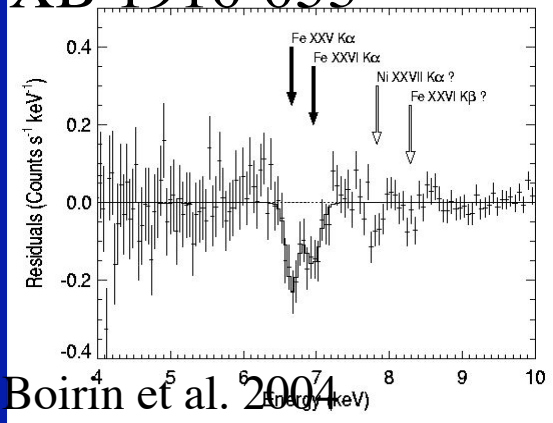


4U 1323-62 Boirin et al. 2005

Absorption lines are also often seen in dipping LMXBs

(4U 1323-62, XB 1254-690, XB 1916-053, X 1624-490, MXB 1659-298 …)

XB 1916-053



Boirin et al. 2004

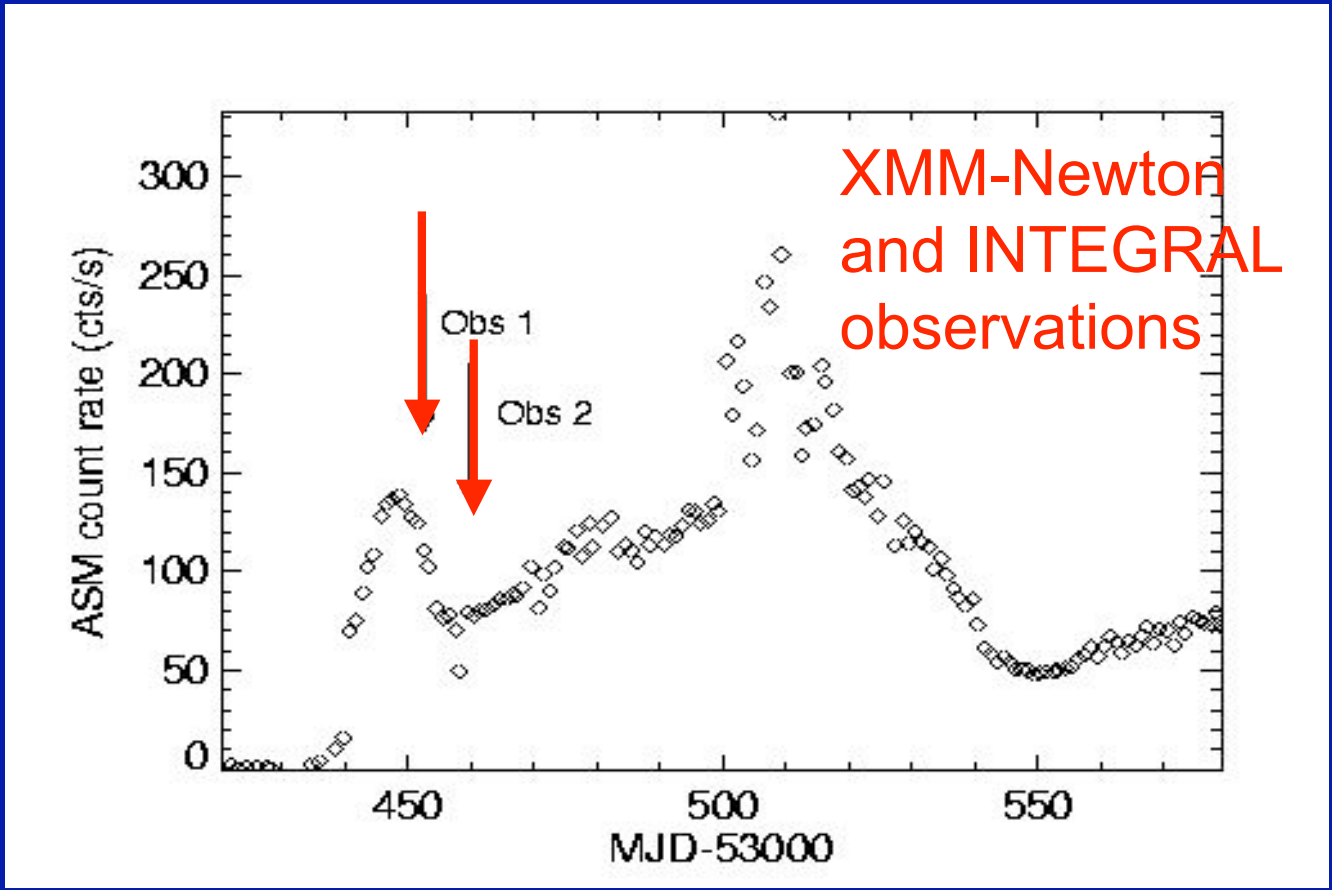
Attributed to a highly photoionized plasma above the accretion disk and mostly equatorial.

(Boirin et al. 2005, Diaz Trigo et al. 2006).

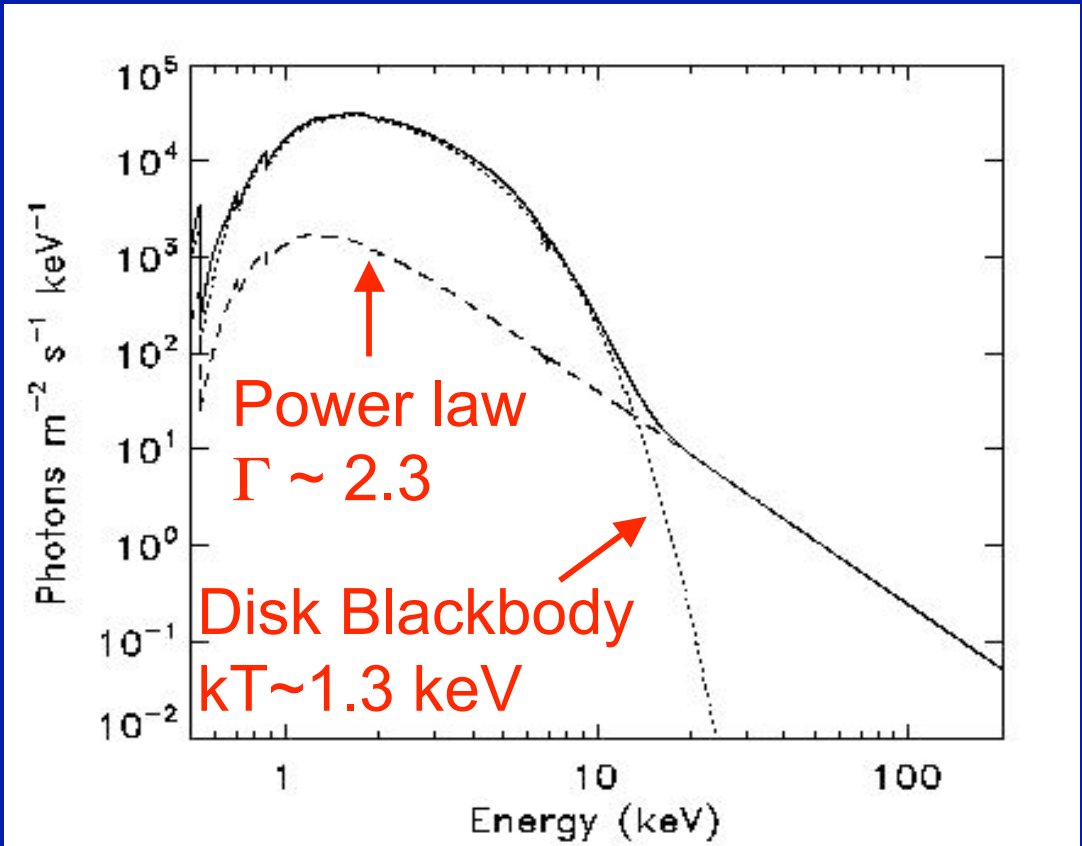
Are both absorption and relativistic emission needed?

Recently, it has been argued that relativistic smearing can be significantly reduced if there is also Fe K line absorption from an outflowing disk wind (e.g. Done & Gierlinski, 2006 on XTE J1650-500 - BeppoSAX data).

ASM 0.5-12 keV Light Curve



Continuum model

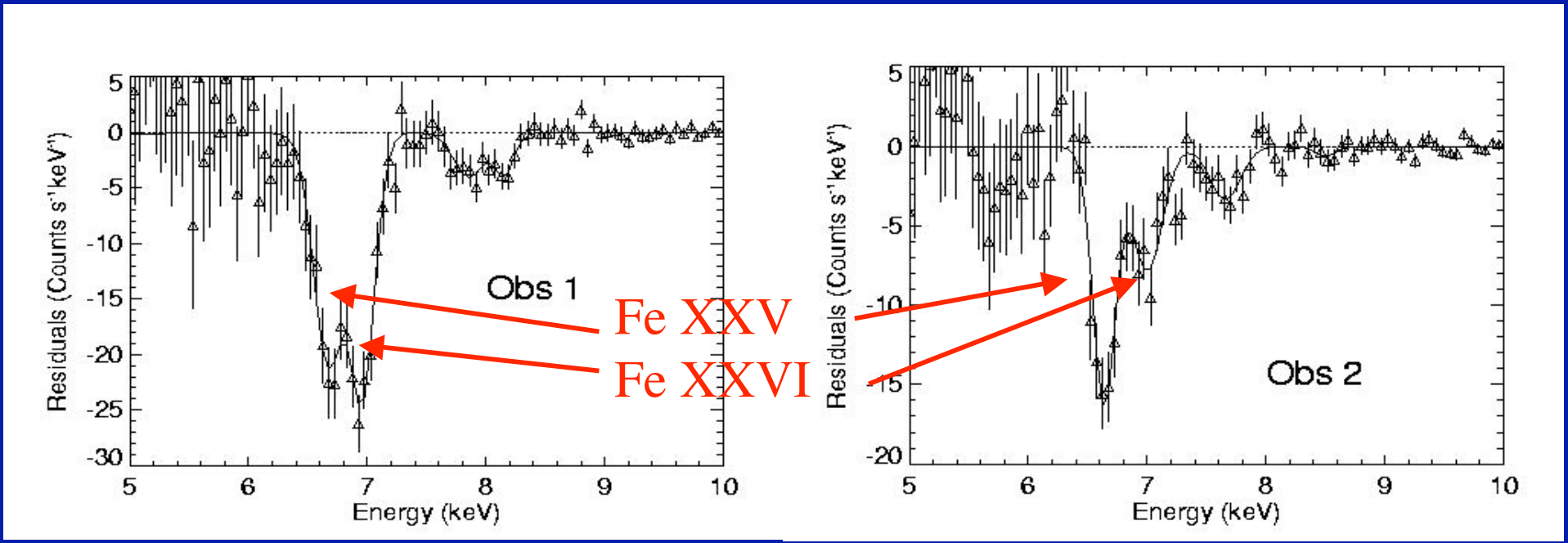


- Model: abs*(diskbb+power-law)
- dbb dominates the emission (>95% of total 0.5-10 keV luminosity)

High-soft (HS) state

GRO J1655-40 in the HS state

Highly-ionized absorption - less ionized in Obs 2



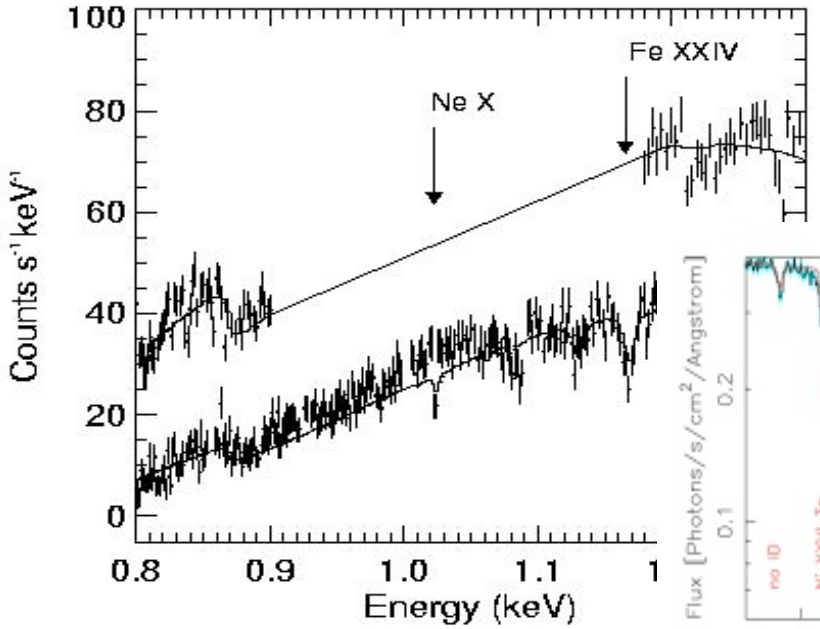
$N_H = 6 * 10^{22}$ cm^{-2}
Log $\xi = 3.73$

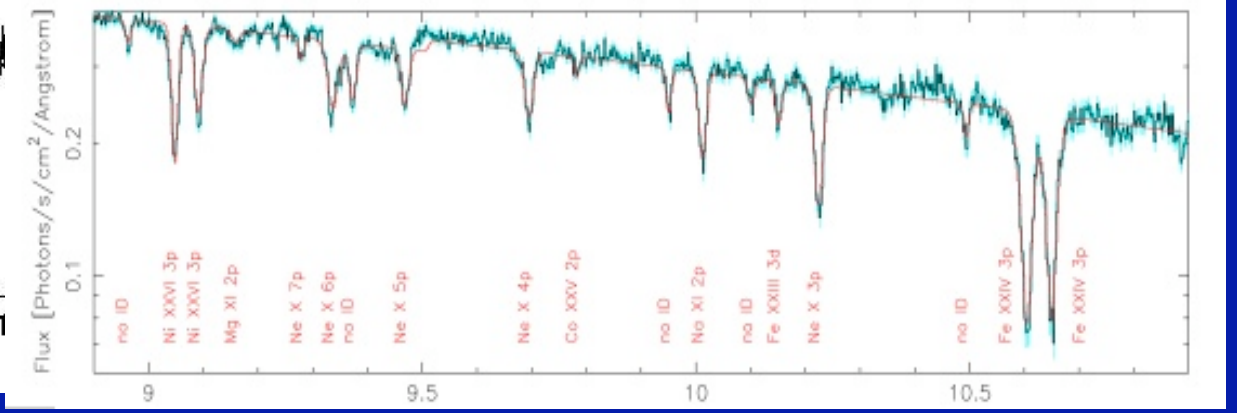
$N_H = 3 * 10^{22}$ cm^{-2}
Log $\xi = 3.30$

GRO J1655-40 in the HS state

Obs 2 - Blueshifted absorption lines in the RGS

Outflow into our line of sight -> v ~ 490 +/- 130 km/s

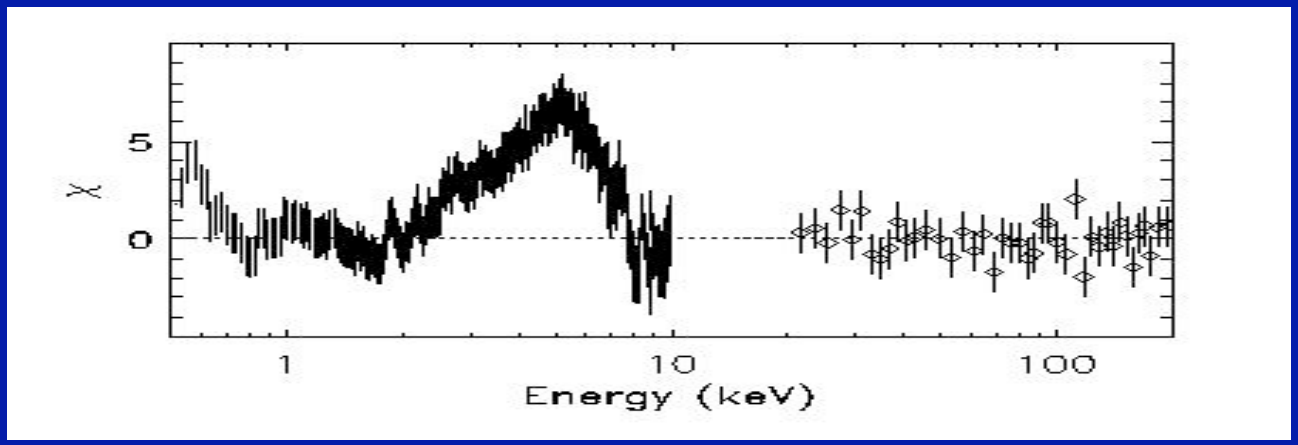




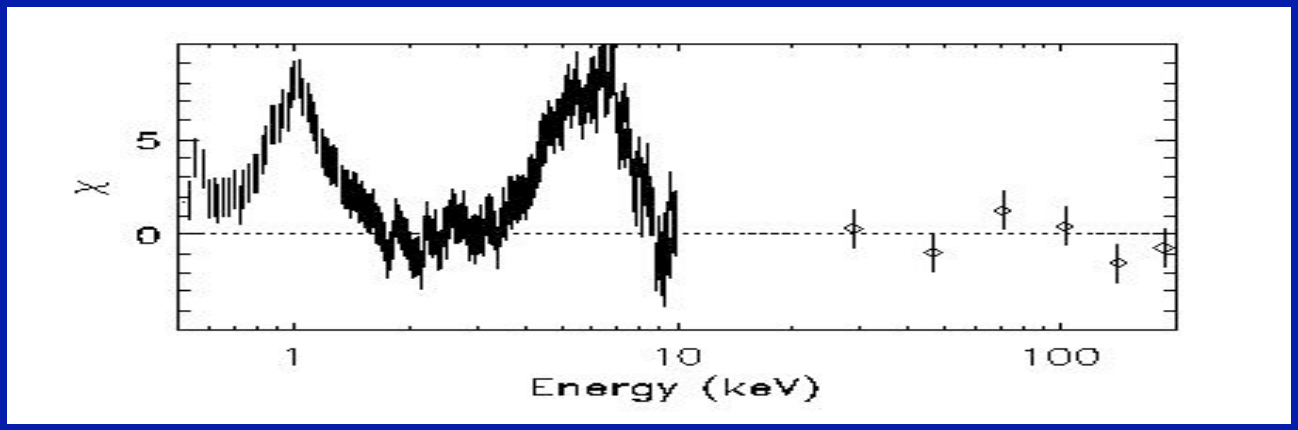
In agreement with HETGs
Observation taken 4 days later than XMM Obs 2
(Miller et al. 2006)

GRO J1655-40 in the HS state

Relativistic emission from Fe



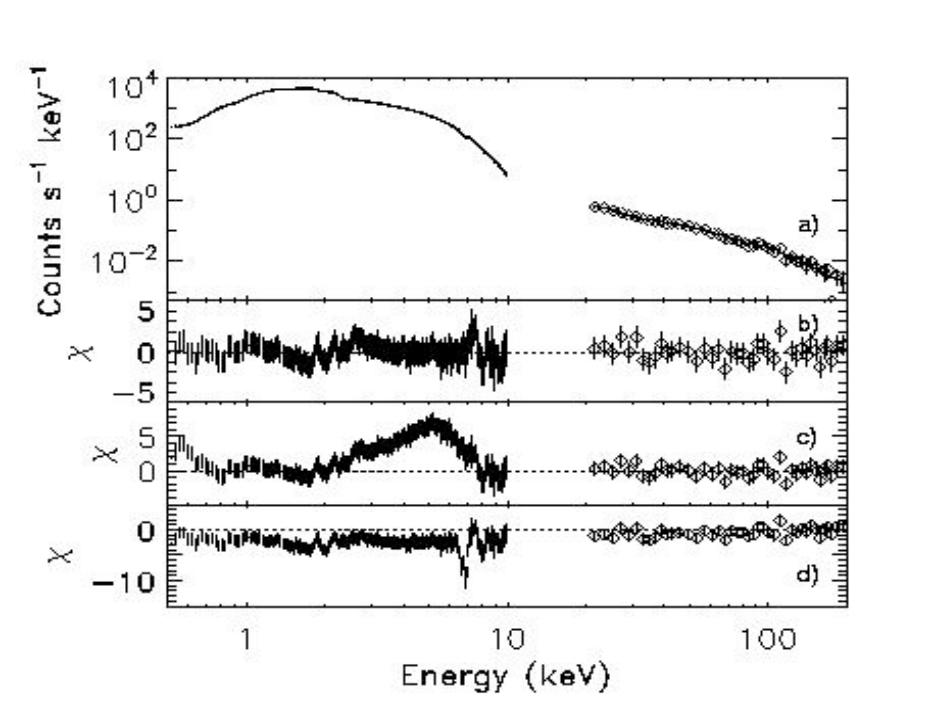
E ~ 6.74 keV
R_{in} ~ 1.31r_g
Inclination ~ 51 deg

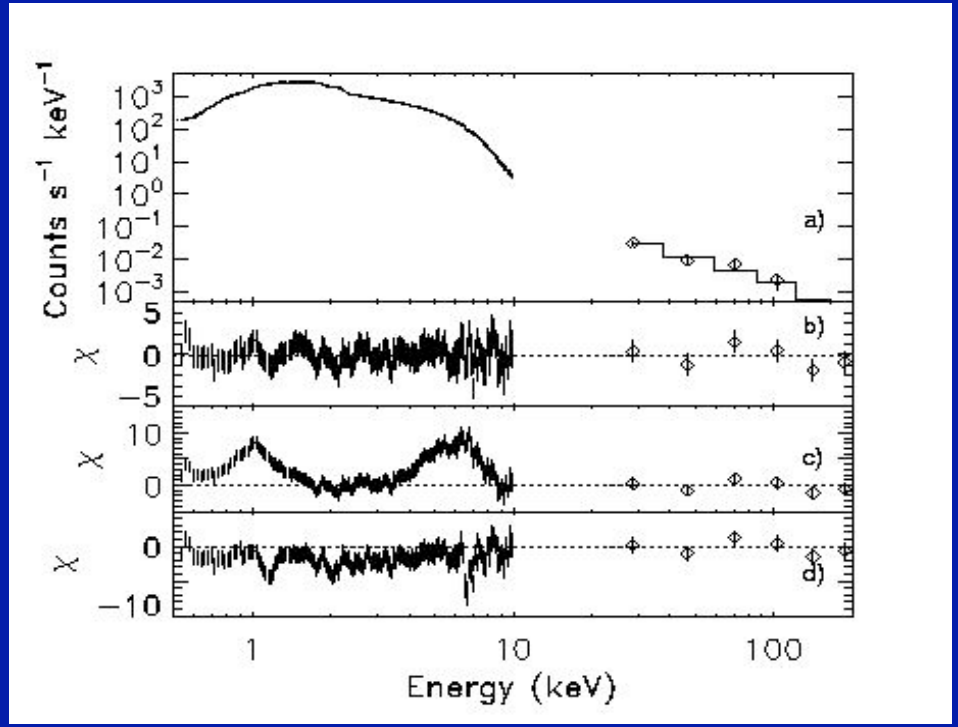


E ~ 6.97 keV
R_{in} ~ 1.42r_g
Inclination ~ 61 deg

GRO J1655-40 in the HS state

0.5-200 keV best-fit to EPIC pn and ISGRI





but….

Emissivity of the Fe line is extremely high

Some questions:

Where is the line produced?

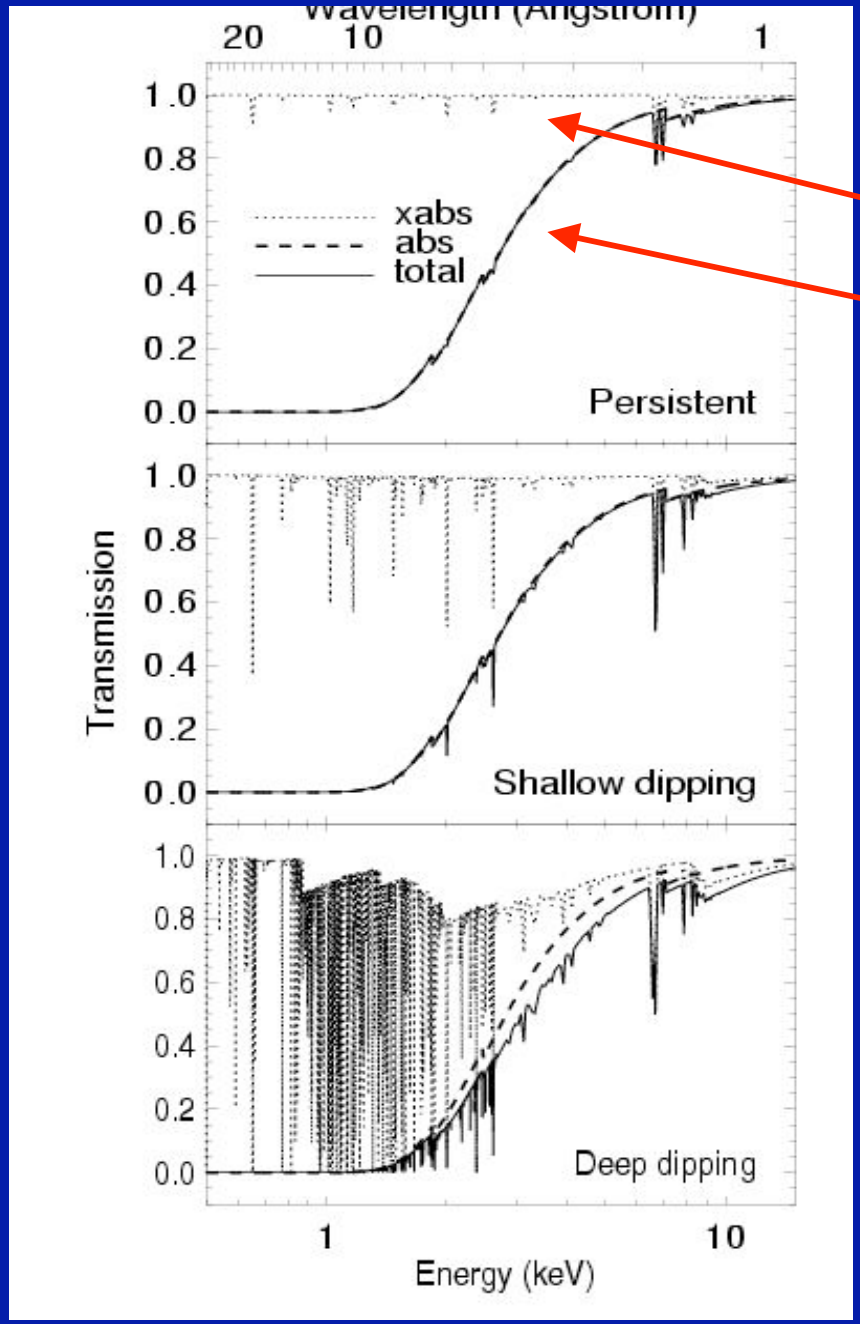
Are the reflection models good for BH binaries?

Is other continuum needed?

Or do we “simply” need a better model of the relativistic Fe K line?

Conclusions

- *Both* extreme relativistic emission from Fe and highly-ionized absorption are present in the HS state of GRO J1655-40 during its 2005 outburst.
- The photoionized absorber is less ionized in Obs 2 responding to the lower luminosity -> outflowing wind revealed by RGS observations.
- The broadness of the Fe line shows a radius close to the ISO, indicating a spinning black hole, in agreement with QPOs observations.
- A better model for the Fe K line is very likely needed…



Transmission of the:

ionized absorber

neutral absorber

Total transmission

broad Iron lines around black holes

GRO J1655-40 in the HS state

- Disk to minimum stable orbit (ISCO)
- Relativistic effects affect all emission
- Fe Kα line from irradiated disk -> broad and skewed
- Broadening gives an independent measure of R_{in} and spin
- Models predict increasing width as go from low-hard to high-soft states

GRO J1655-40 in the HS state

- High-soft state is disk-dominated
- For $M_{BH} \sim 10$ M -> $T_{disk} \sim 1$ keV
- Hot electrons Compton upscatter photons from outer cool disk -> Power-law component