Compton X-ray Polarization Signatures in High Energy Astrophysical Systems

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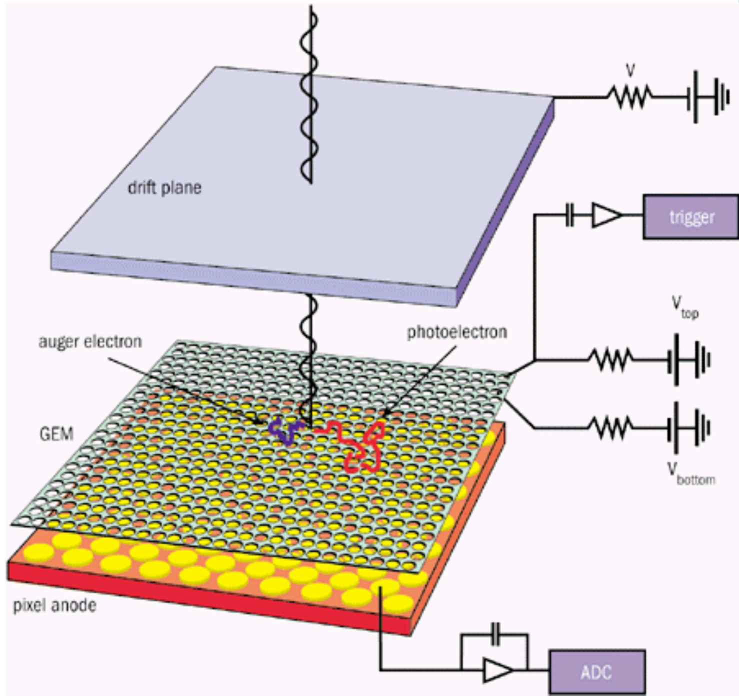
X-ray Polarimetry - History and Developments

Weisskopf et al. 2006



Cerncourier.com/cws/article/cern/28488

Polarization in cosmic sources

- Emission processes: synchrotron emission, non-thermal bremsstahlung
- Scattering in non-spherical distributions of accreting material e.g. accretion disks, columns
- Reflection e.g. from WD surfaces

Importance of Polarimetry

- Emission mechanisms and scattering/reflection impart unique polarization signatures on photons.
- Polarization probes scattering region geometries and determines physical parameters of emission sites (e.g. magnetic field strength)
- Current timing/spectral data can be ambiguous, polarimetry can constrain models e.g. accretion disk structure around BHs, NS gap models

Polarized Compton Scattering - Mathematics (Briefly)

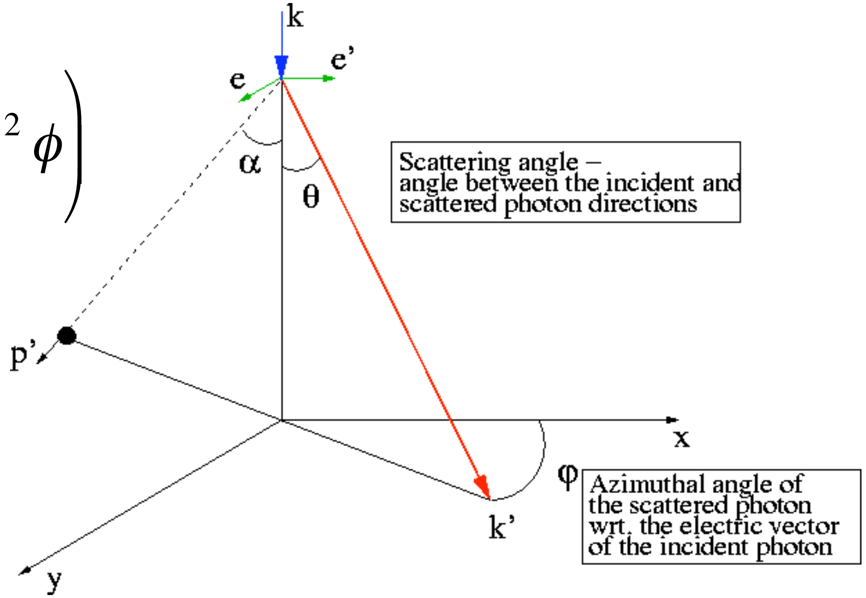
Differential Klein-Nishina cross-section

Polarized:

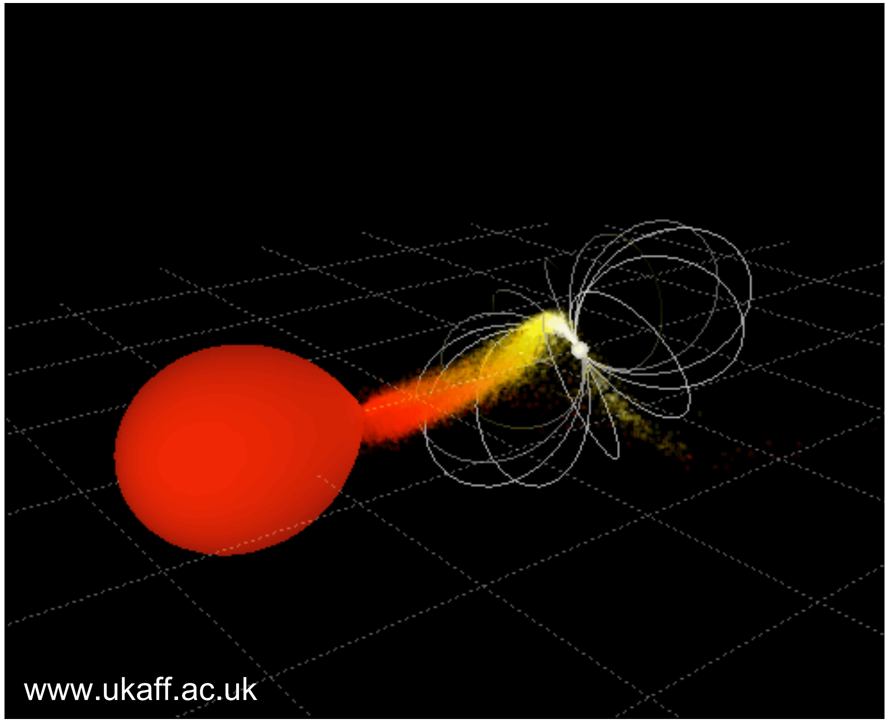
$$\frac{d\sigma}{d\Omega} = \frac{r_e^2}{2}\left(\frac{\nu'}{\nu}\right)^2\left(\frac{\nu'}{\nu} + \frac{\nu}{\nu'} - 2\sin^2\theta\cos^2\phi\right)$$

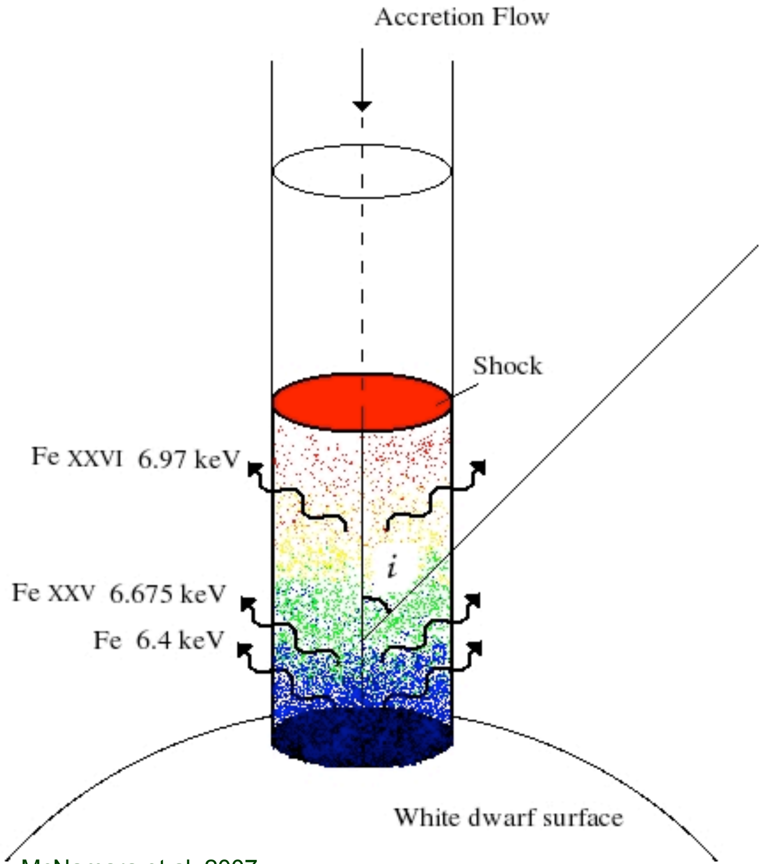
Non-polarized:

$$\frac{d\sigma}{d\Omega} = \frac{r_e^2}{2}\left(\frac{\nu'}{\nu}\right)^2\left(\frac{\nu'}{\nu} + \frac{\nu}{\nu'} - \sin^2\theta\right)$$



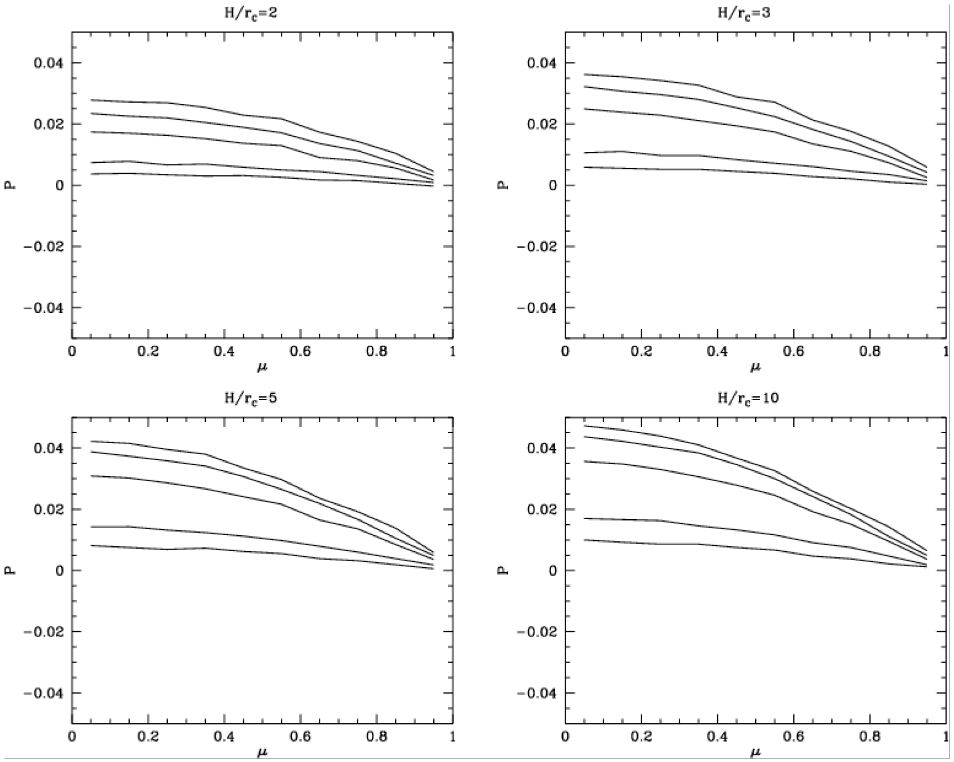
MCV Accretion Column Model





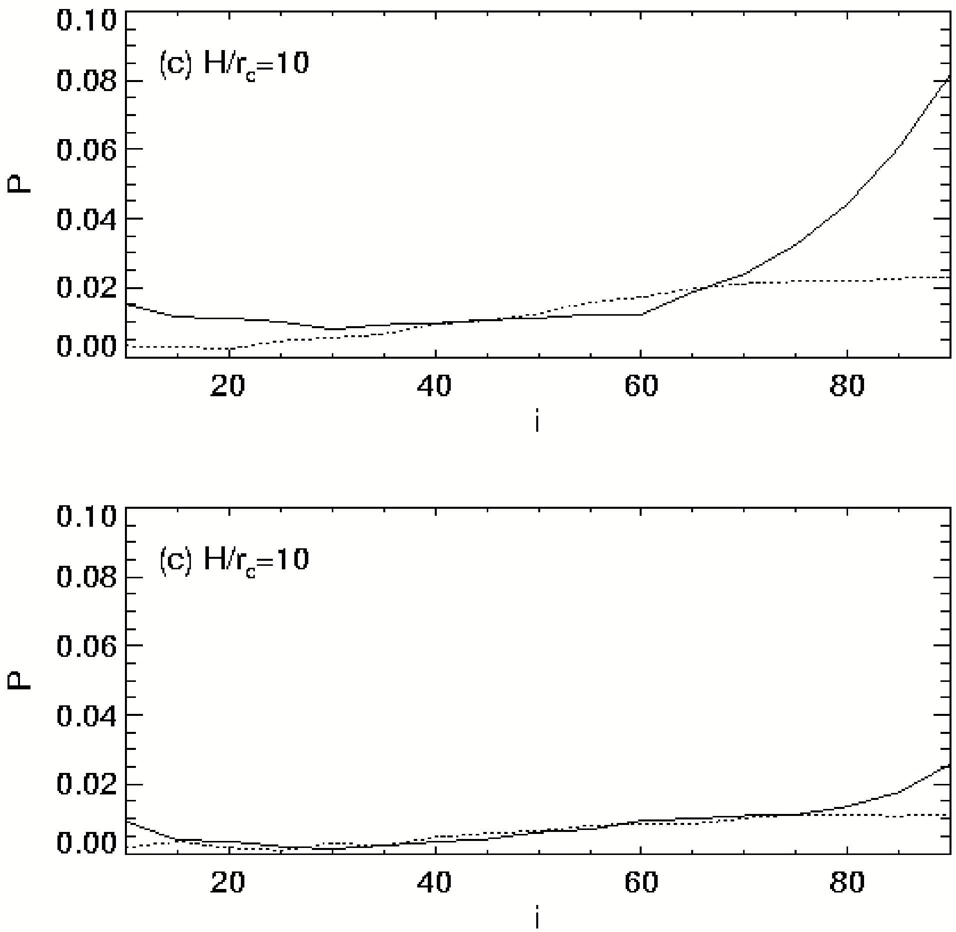
McNamara et al. 2007

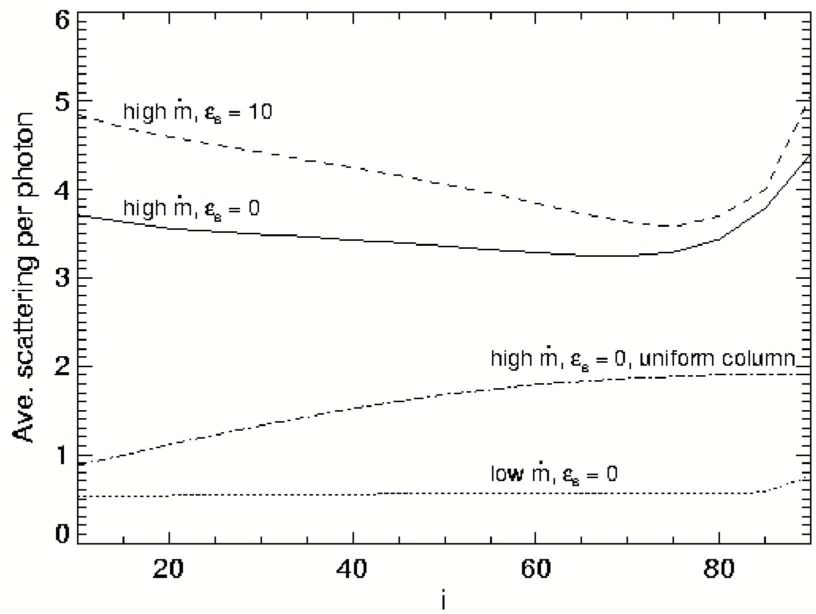
Polarization Signatures - Simple Model (Matt 2004)



- No shock
- Uniform density and hence emissivity

Results

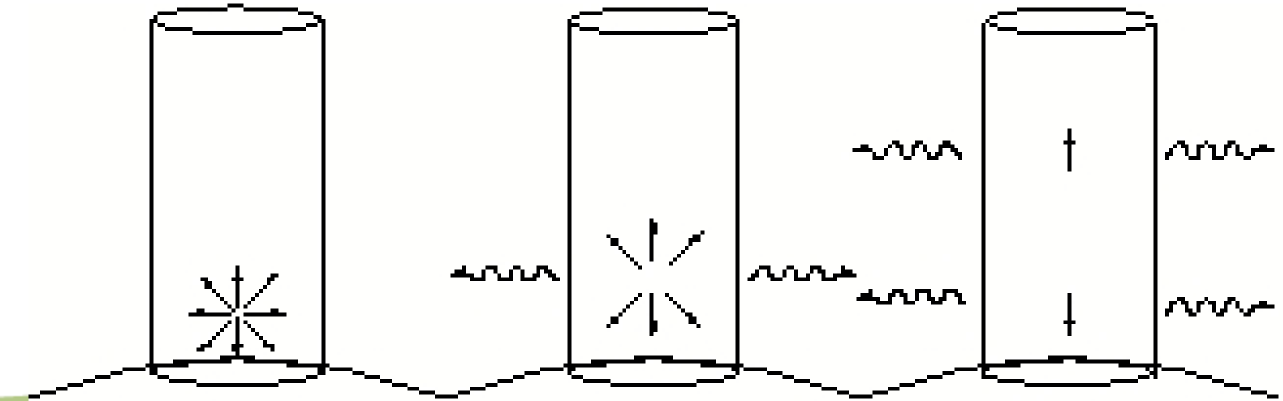




McNamara et al. (2007)

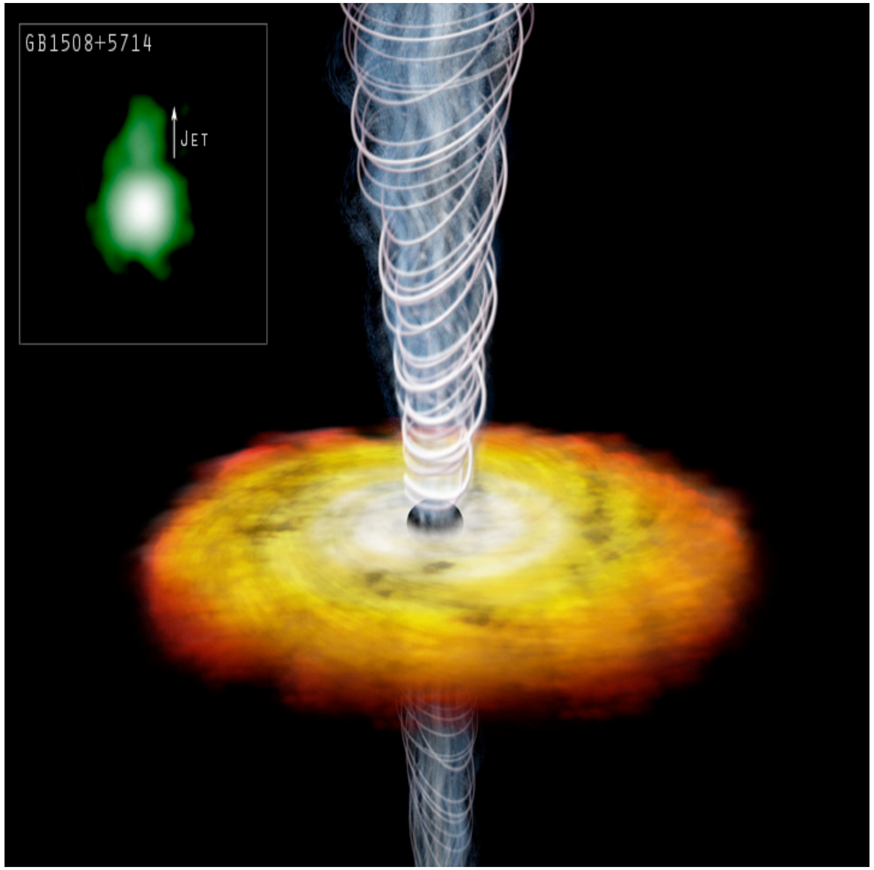
Why do the results differ so dramatically for the different models?

- Non-uniform density structure has a significant effect on photon distribution and ave number of scatterings.
- Enhanced emissivity at column base causes photon distributions to become increasingly anisotropic => results in highly polarized photons at large angles.



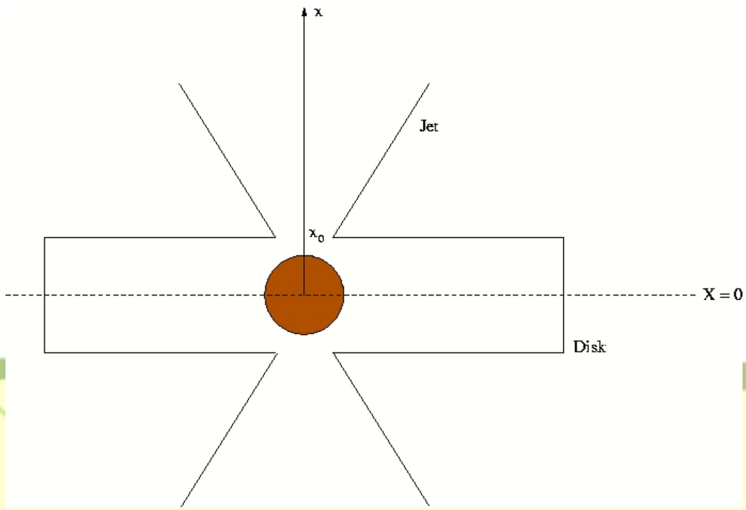
Jet Model

- Model scattering of synchrotron radiation emitted in the jet and soft emission from the disk - polarization signatures should differ.

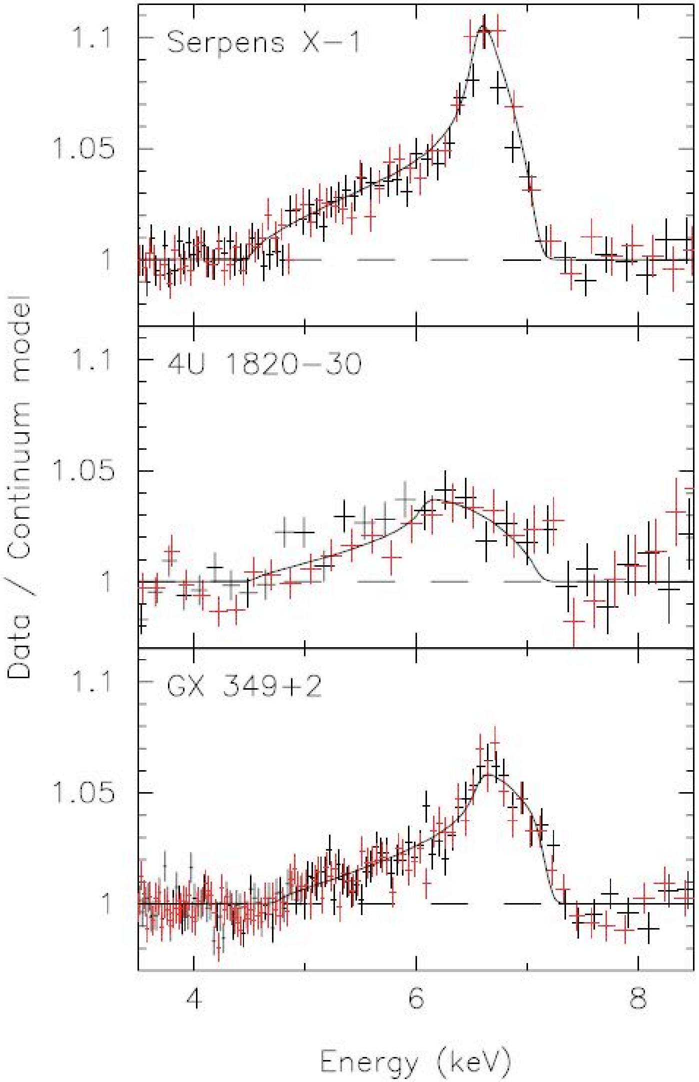


Jet Model (AGN parameters)

- Conical shaped jet, $\Gamma >> 1$
- Electron number density falls off as $N_e(x) = N_0\left(\frac{x}{x_0}\right)^{-2}$
- Jet electrons are non-thermal with powerlaw distribution, $N_e(\gamma) = K\gamma^{-p}$
- Three ref frames, electron rest frame, co-moving plasma frame and observer frame.



Future Work



Cackett et al., 2008, ApJ, 674, 415

- Modelling Fe emission lines from near BH, investigate whether broadening effects are due to scattering or gravitational redshift.
- Investigate polarization of the emission lines.