The X-ray polarimetric view of the AGN central engine

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STRONGGRAVITY
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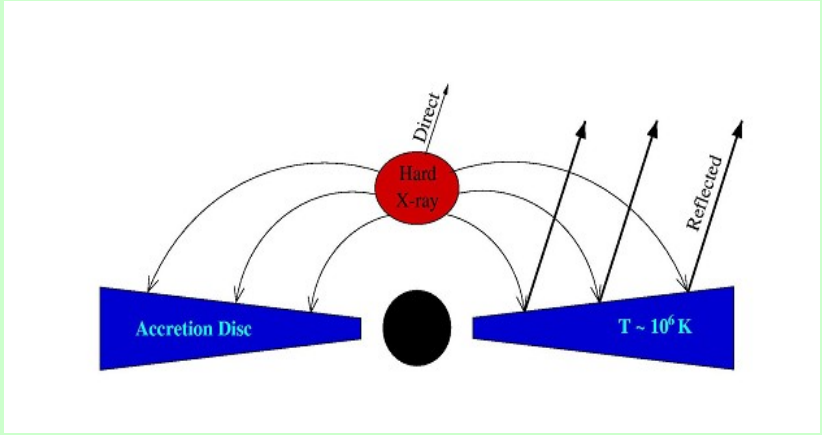
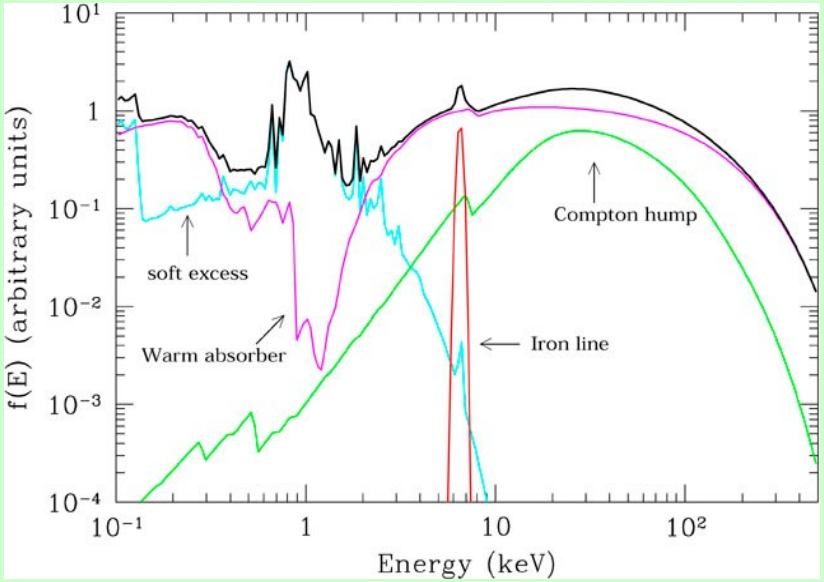
Plan of the talk

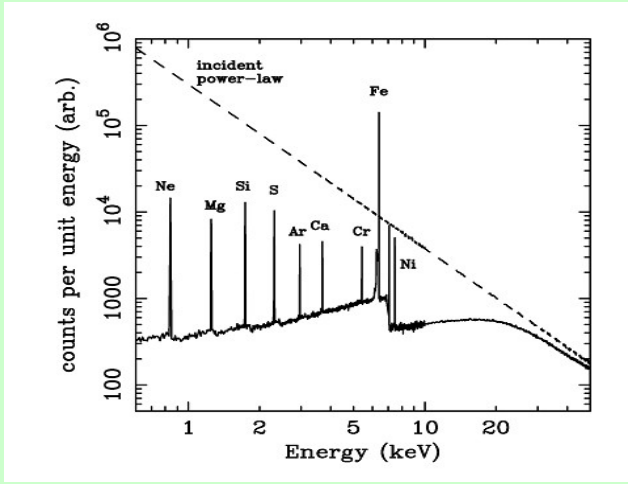
- The geometry of the hot X-ray corona
- Strong gravity and the BH spin
- The orientation of the torus
- The GC as a low luminosity AGN
- Observational perspectives

Active Galactic Nuclei in X-rays

In AGN the primary X-ray emission is due to Inverse Compton by electrons in a hot corona of the UV/soft X-ray disc photons. It is likely to be significantly polarized (e.g. Haardt & Matt 1993, Poutanen & Vilhu 1993).



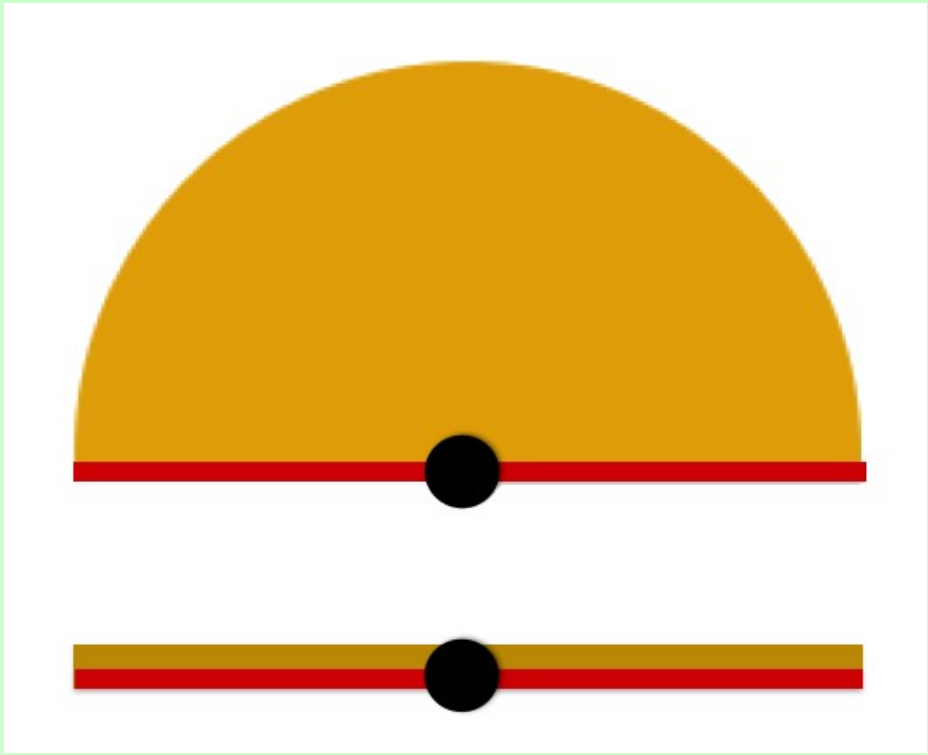


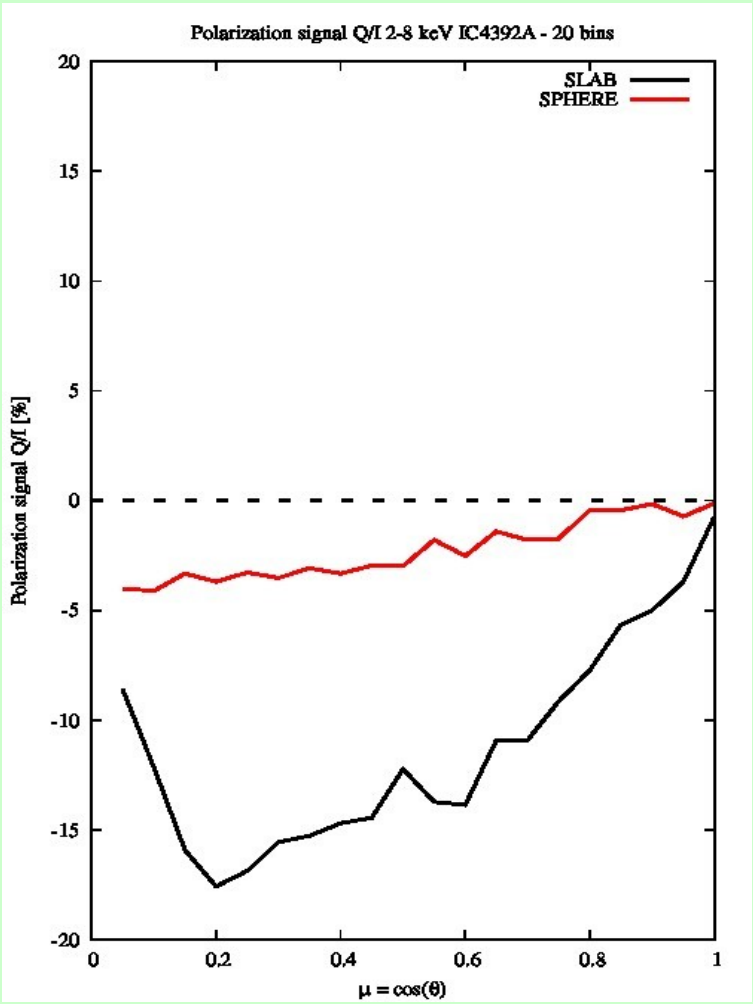


Part of the primary emission illuminates the disc and is reflected (and polarized) via Compton Scattering

The geometry of the hot corona

The geometry of the hot corona is unknown. Emission is expected to be polarized if the corona OR the radiation field are not spherical





Slab and sphere geometries, temperature and τ as per IC4229A (Brenneman et al. 2014)

Tamborra et al., in prep.

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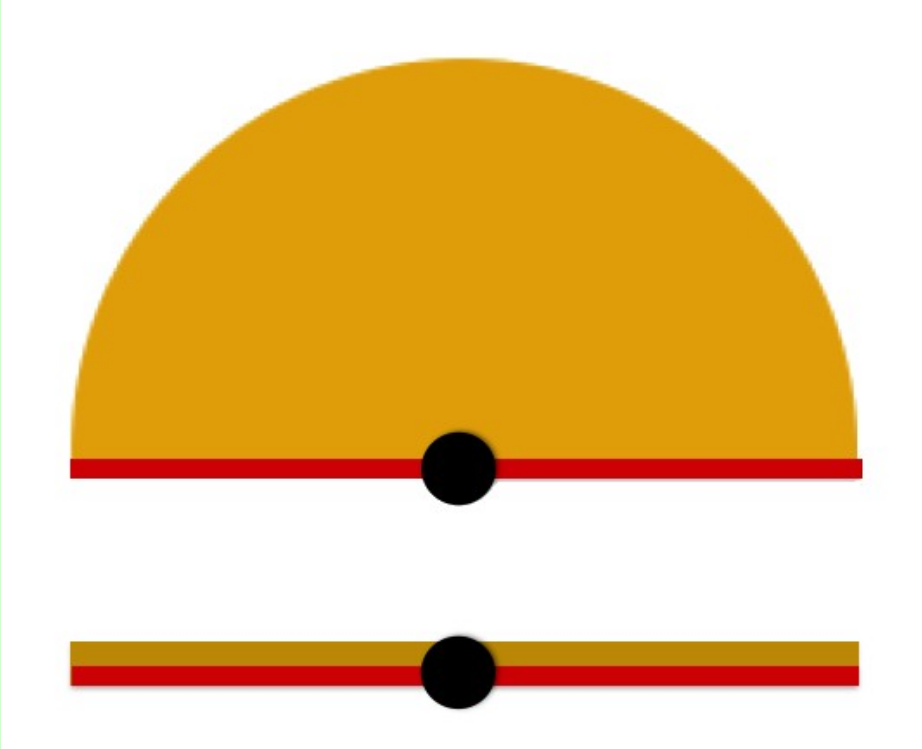
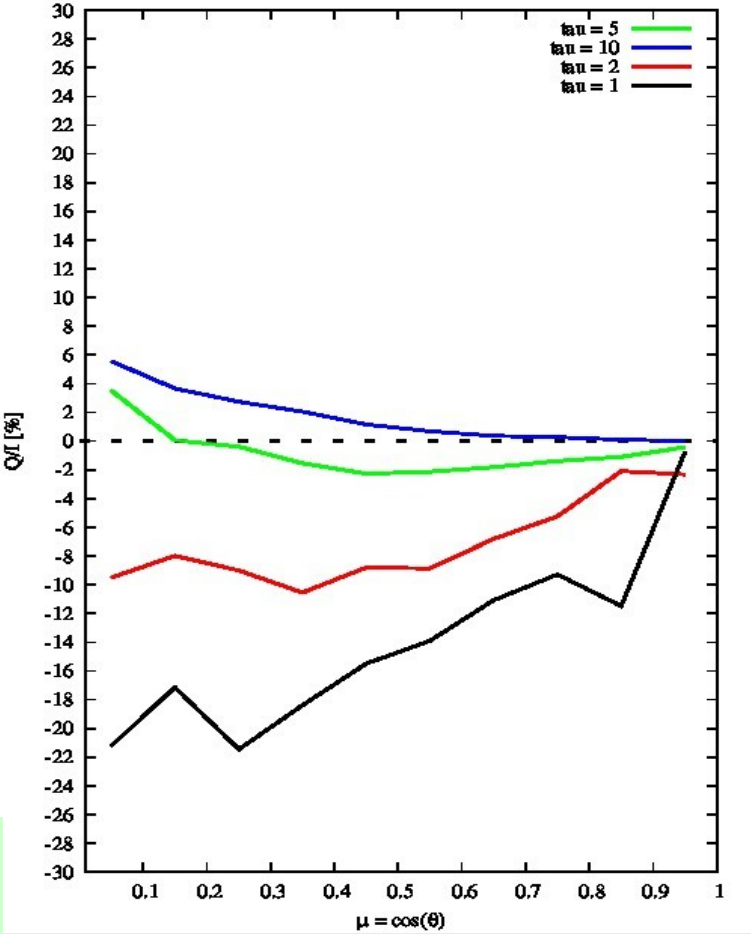


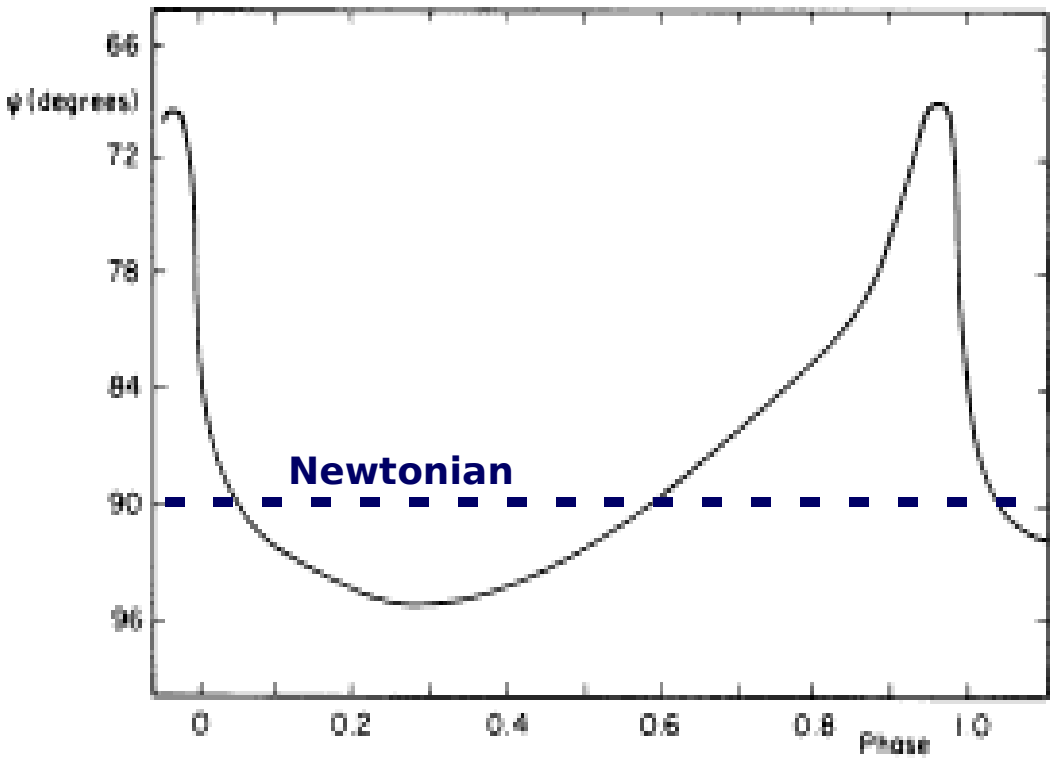


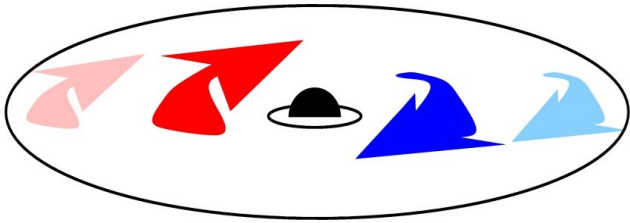
Slab geometry, temperature as per IC4229A, different values of tau

Tamborra et al., in prep.

Probing strong gravity effects

General and Special Relativity effects around a compact object ("strong gravity effects") significantly modifies the polarization properties of the radiation. In particular, the Polarization Angle (PA) as seen at infinity is rotated due to aberration (SR) and light bending (GR) effects (e.g. Connors & Stark 1977; Pineault 1977).
The rotation is larger for smaller radii and higher inclination angles



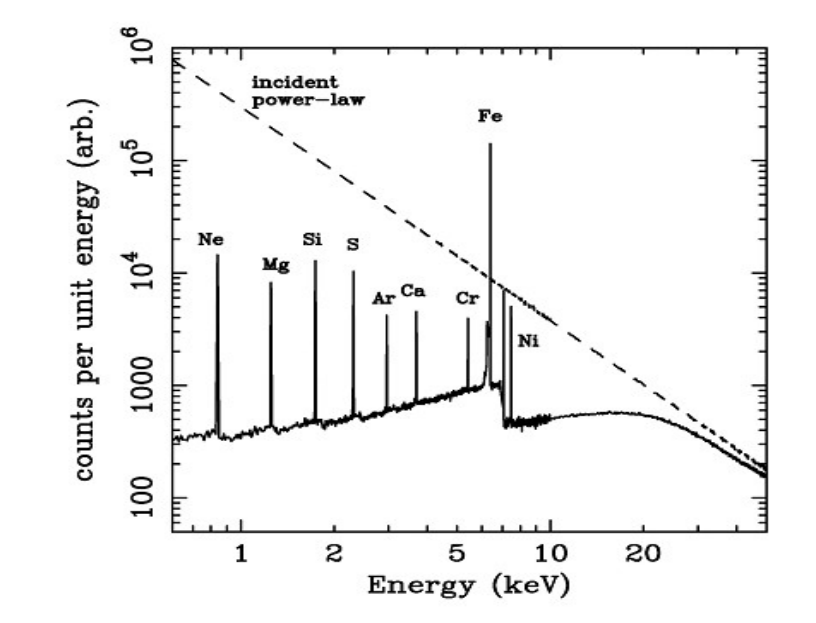


Orbiting spot with:
a=0.998; R=11.1 Rg
i=75.5 deg

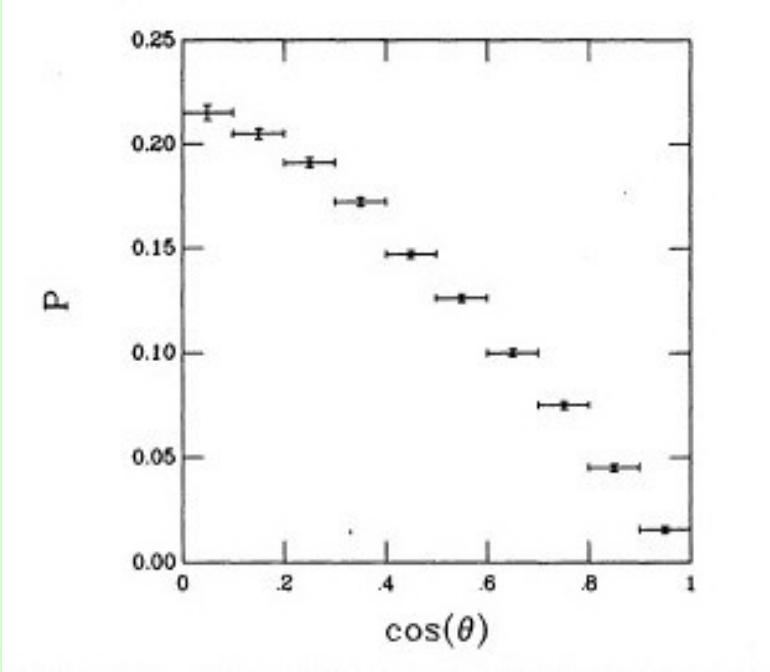
(Phase=0 when the spot is behind the BH).

The PA of the net (i.e. phase-averaged) radiation is also rotated!

Polarization of reflected flux

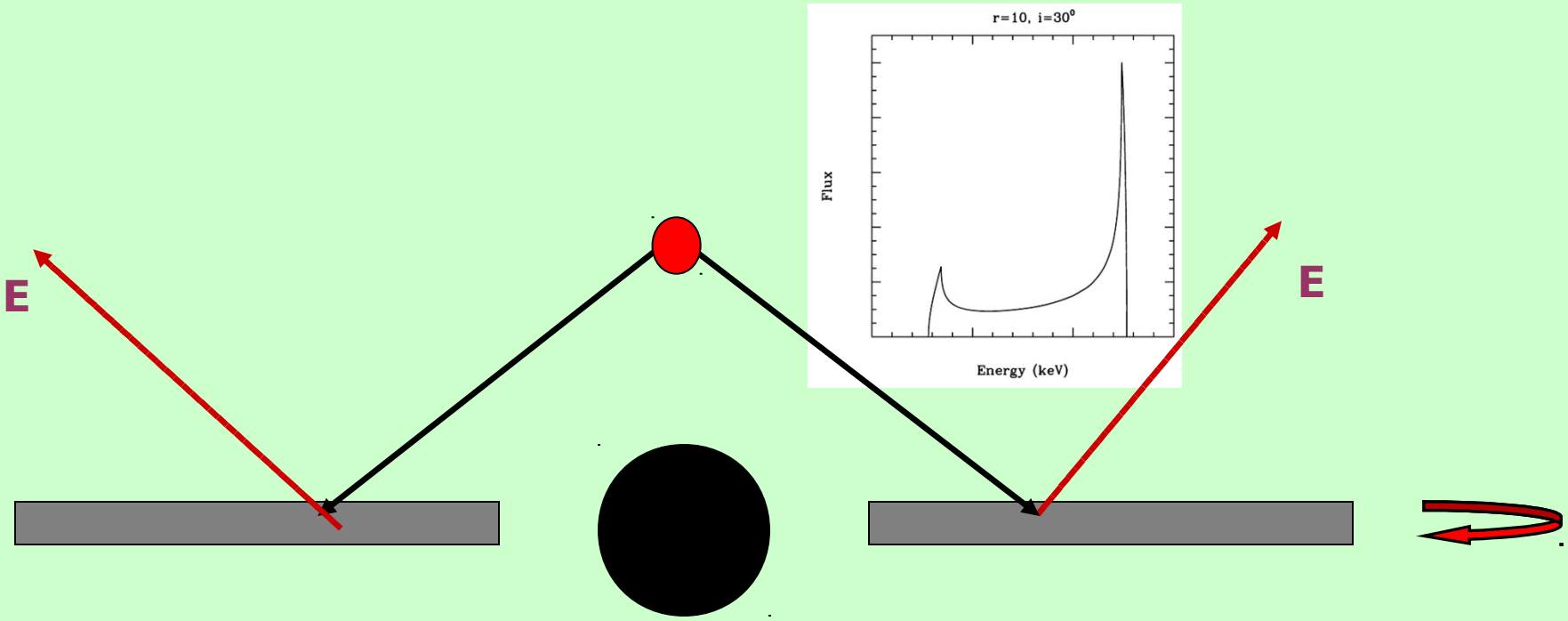


Polarization of reflected (continuum) radiation is large, up to 20% (Matt et al. 1989) assuming isotropic illumination, a plane-parallel reflecting slab and unpolarized illuminating radiation.



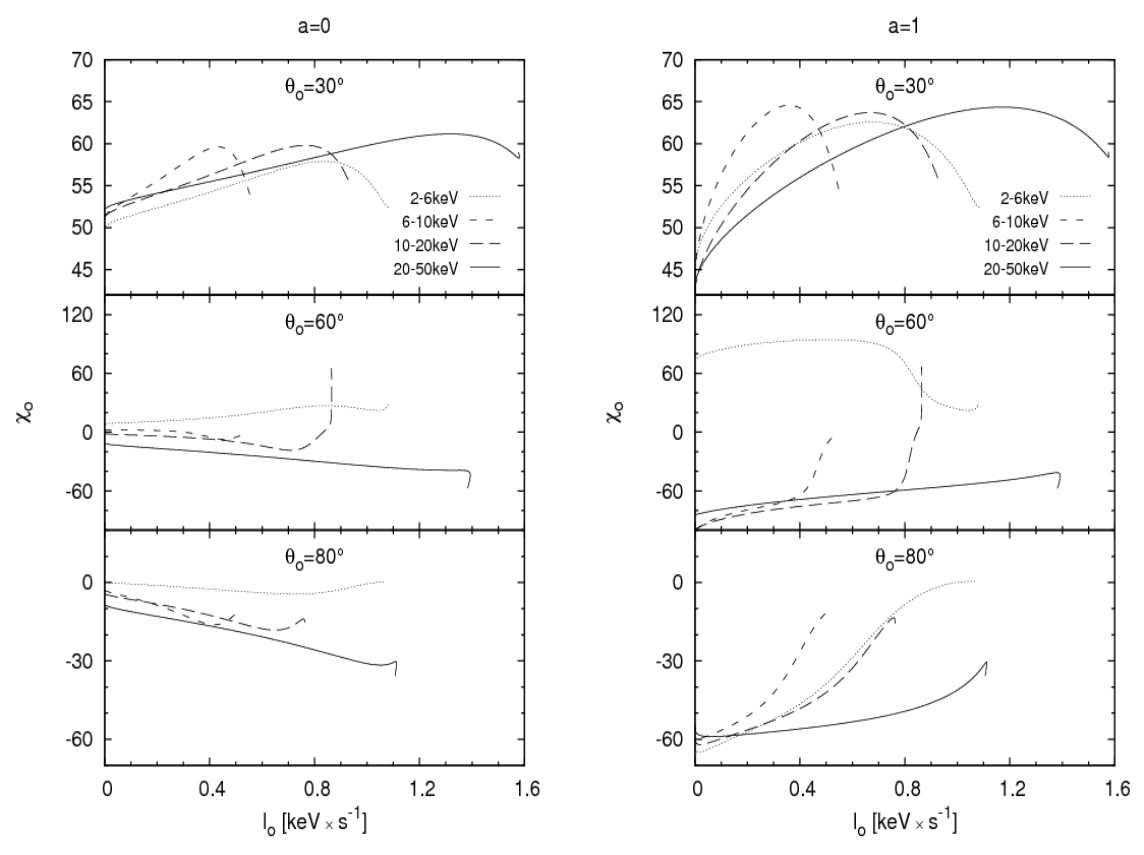
The exact values depend on the actual geometry of the system and on the polarization degree of the primary radiation.

Reflection in Relativistic discs



Breaking of the symmetry due to SR (Doppler boosting) also causes a rotation of the PA with respect to the Newtonian case. Changes in the illumination properties (e.g. in the height of the lamp-post) will cause changes in the total PA, which is therefore likely to be time- (and flux-) dependent. Variations of the height have been claimed in several AGN (e.g. Miniutti et al. 2003, Parker et al. 2014).

Reflection in Relativistic discs



Dovciak et al. (2011)

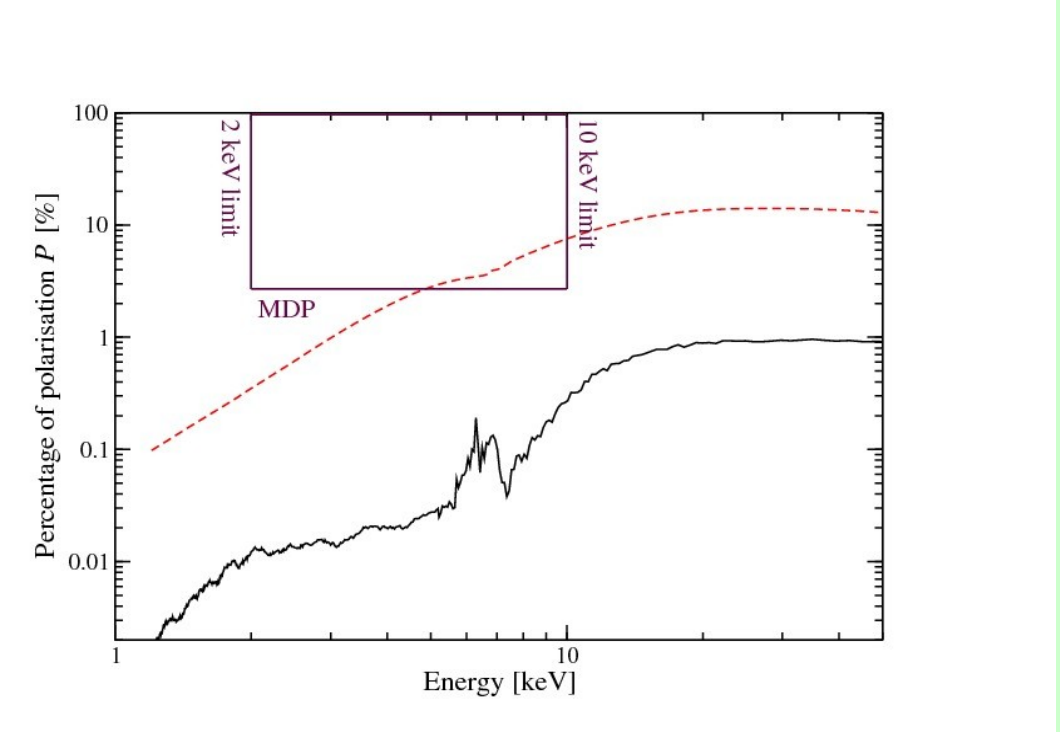
Variation of h with time implies a time and flux variation of the degree and angle of polarization.

The effect depends also on the BH spin.

Reflection or absorption?

The relativistic reflection interpretation of the broad feature often seen in Seyfert galaxies has been challenged: complex absorption?

Polarimety can distinguish between the two models!

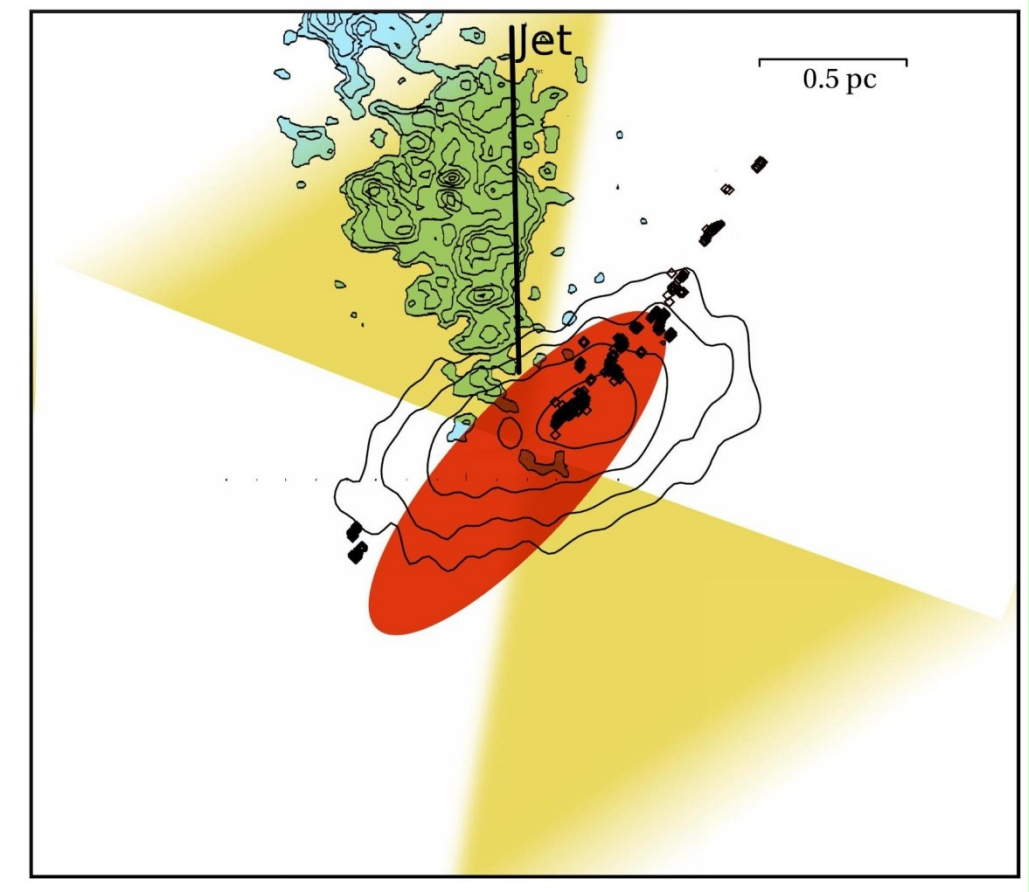


Marin et al. (2012)

The orientation of the torus

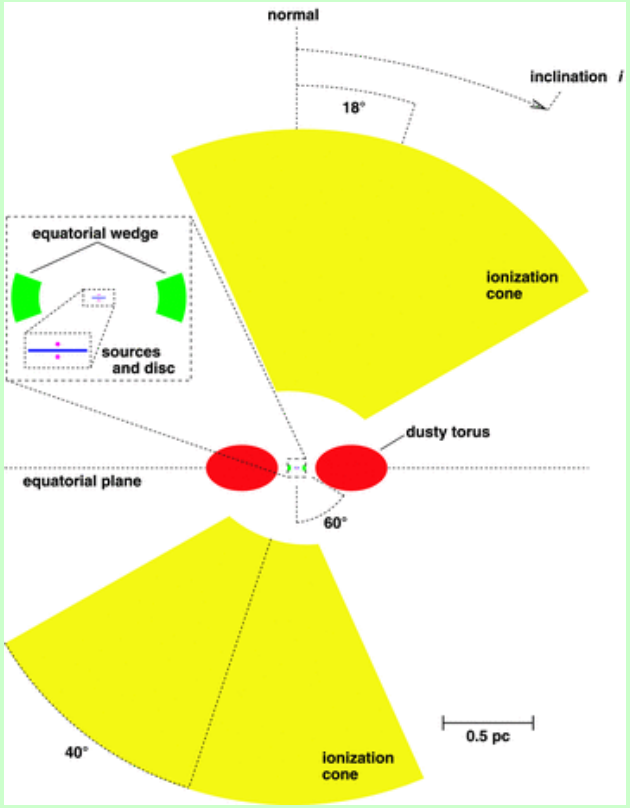
Geometry of the torus:

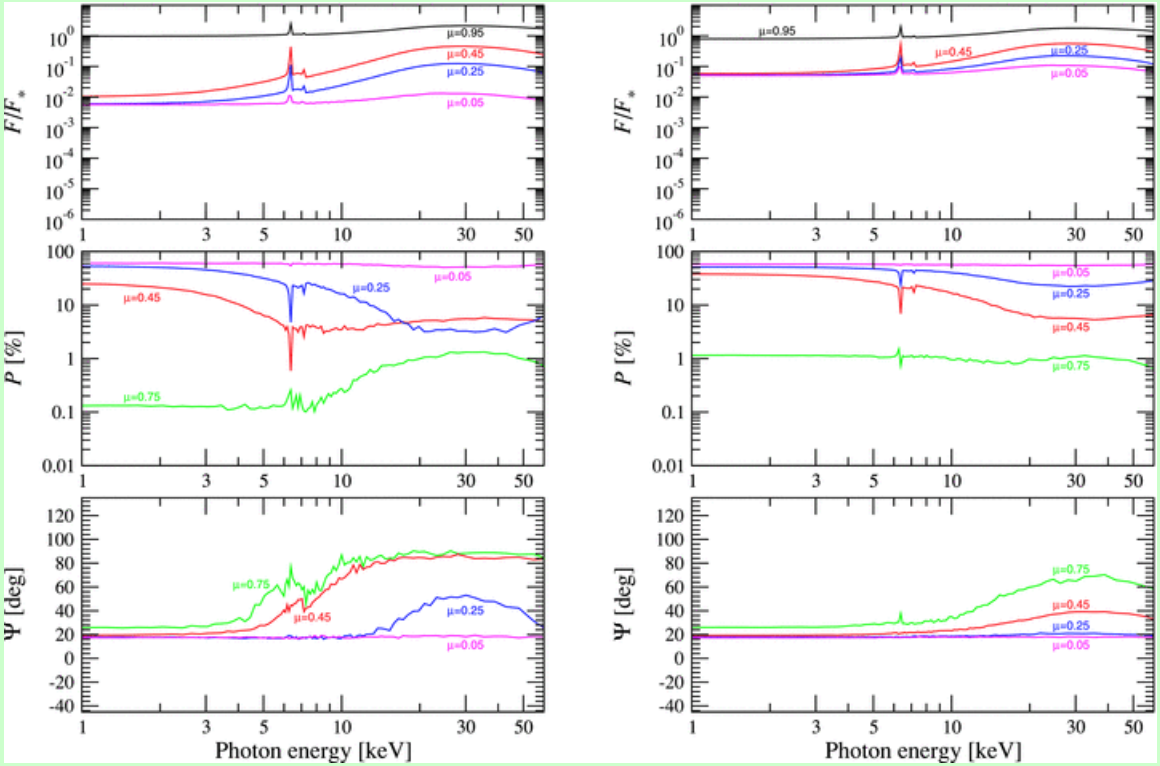
the polarization angle will give us the orientation of the torus, to be compared with IR results, and with the ionization cones (Goosmann & Matt 2011)



Raban et al. (2009)

The orientation of the torus



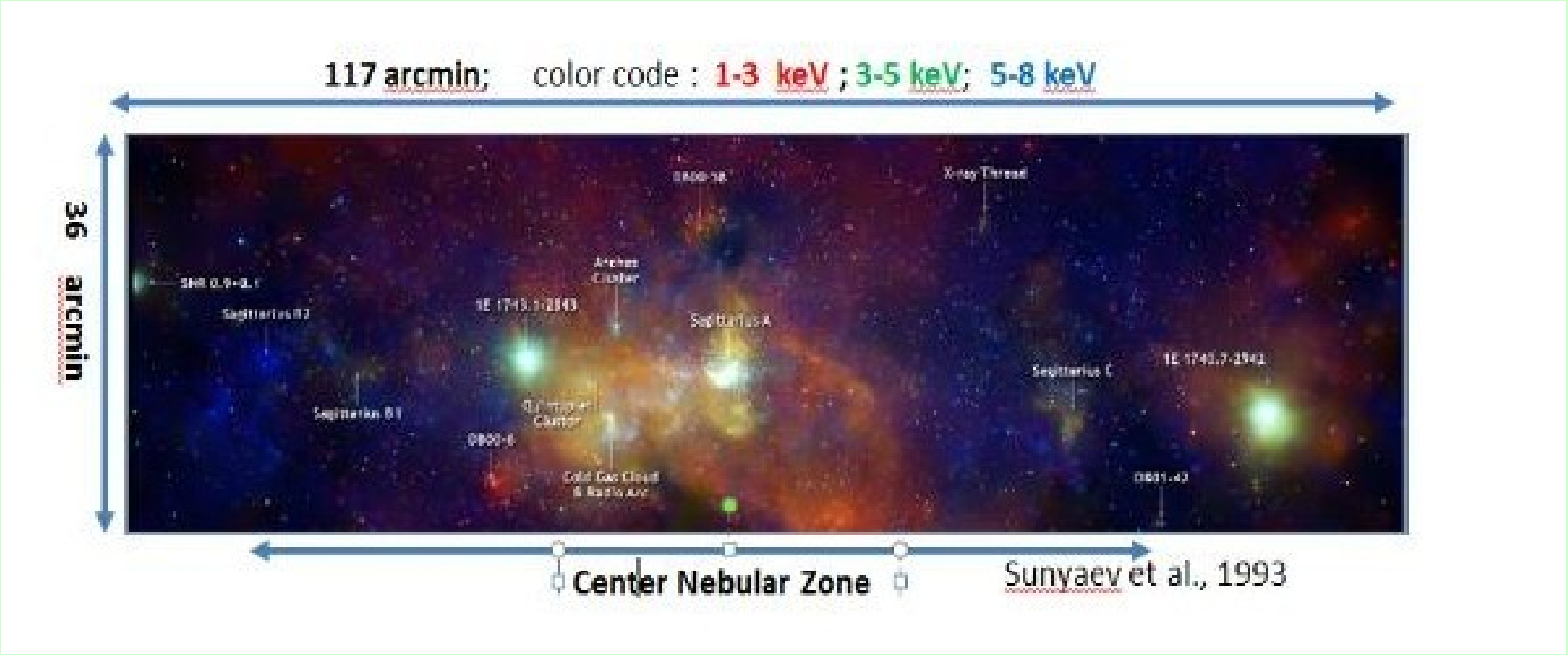


Goosmann & Matt (2011)

GC as a low luminosity AGN

Cold molecular clouds around Sgr A* (i.e. the supermassive black hole at the centre of our own Galaxy) show a neutral iron line and a Compton bump → Reflection from an external source!?!

No bright enough sources are in the surroundings. Are they reflecting X-rays from Sgr A*? so, was it one million times brighter a few hundreds years ago? Polarimetry can tell! (Churazov et al. 2002)



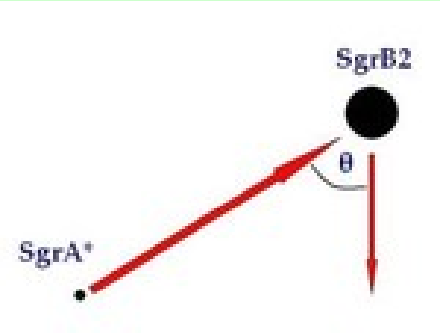
GC as a low luminosity AGN

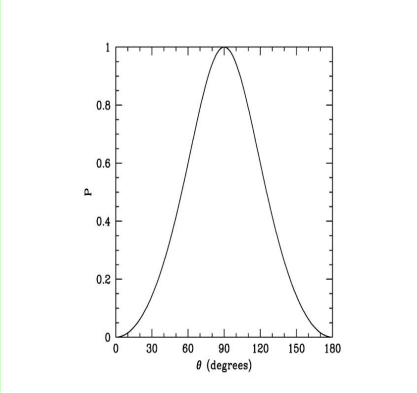
Polarization by scattering from Sgr B complex, Sgr C complex

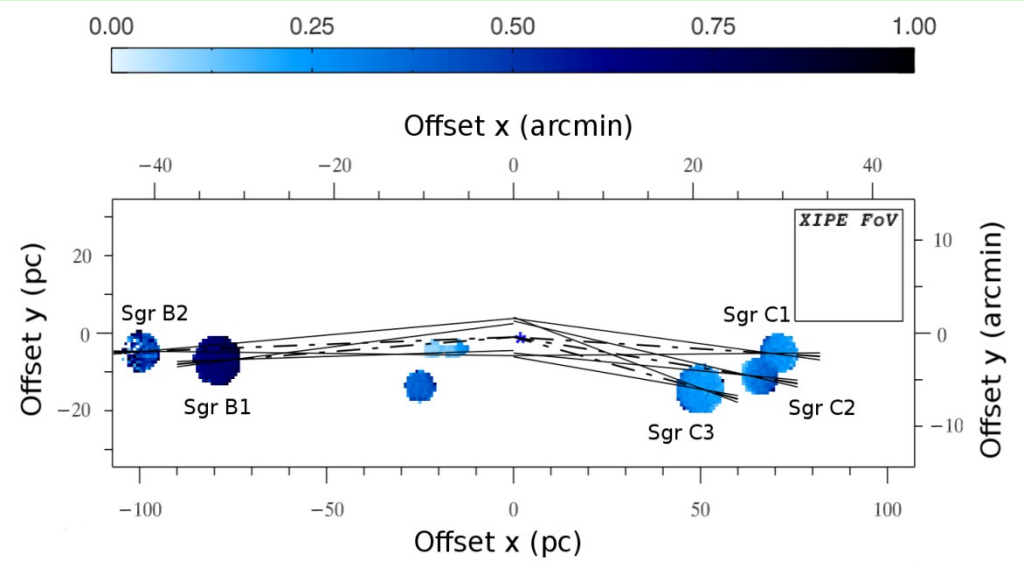
The angle of polarization pinpoints the source of X-rays

The degree of polarization measures the scattering angle and determines the true distance of the clouds from Sgr A*.

Marin et al. 2014







Observational perspectives

The illustrated cases can be addressed by small/medium-size X-ray polarimetric missions.

***XIPE** (X-ray Imaging Polarimetry Explorer). Selected by ESA (M4) for phase A study. Final selection: May 2017*

***IXPE** (Imaging X-ray Polarimetry Explorer). Selected by NASA (SMEX) for phase A study. Final selection: Early 2017*

***PRAXyS** (Polarimeter for Relativistic Astrophysical X-ray sources). Selected by NASA (SMEX) for phase A study. Final selection: Early 2017*

Observational perspectives

Example: **MDP=2% in 2-8 keV with XIPE**

Source	Type	Texp (ks)
IC 4329A	Sy1	230
GRS1734-292	Sy1	400
MCG+8-11-11	Sy1	410
NGC 2110	Sy2	220
MCG+5-23-16	Sy2	260
NGC 5506	Sy2	550
	Total	~2000

Summary

X-rays probes the central engine of AGN

Spectroscopy probes dynamics

Timing probes scales

Polarimetry probes geometry