X-ray polarization and radio-quiet AGN

Giorgio Matt

(Università Roma Tre, Italy)

Preliminary remark

Despite its widely recognized importance, X-ray polarimetry is so far a virtually unexplored field due to technical limitations.

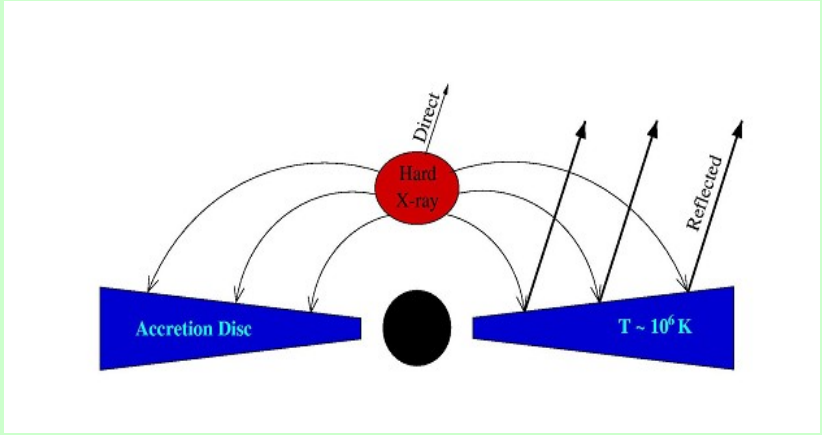
Technological developments in recent years have made now AGN accessible to X-ray polarimetry.

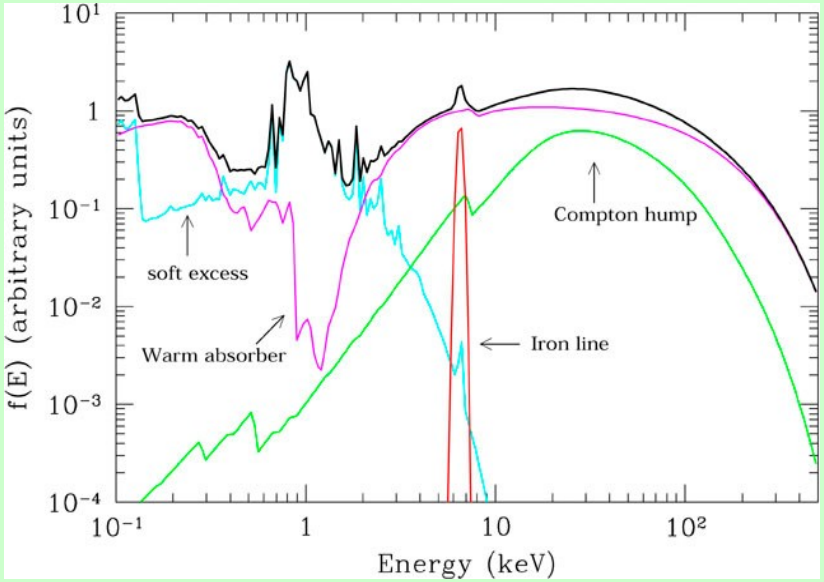
Plan of the talk

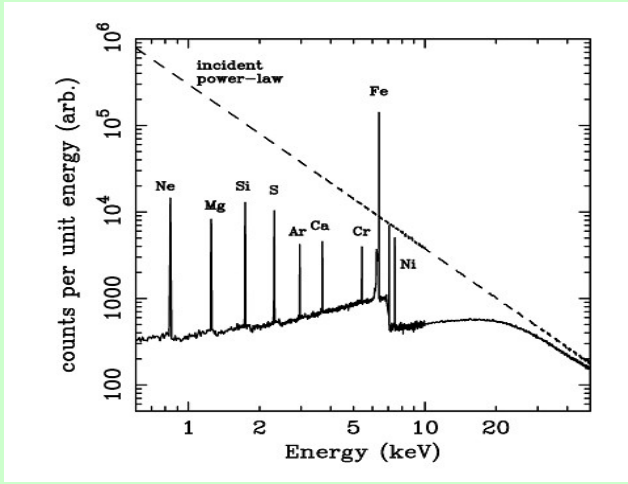
- **The geometry of the hot X-ray corona**
- **Strong gravity and the BH spin**
- **Is the torus really a torus?**

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).



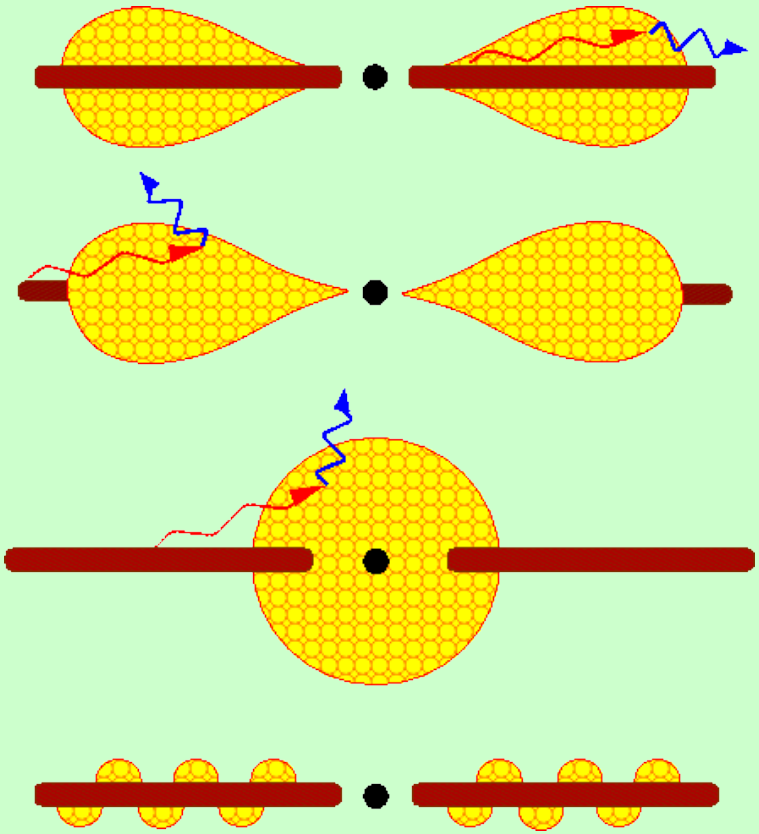




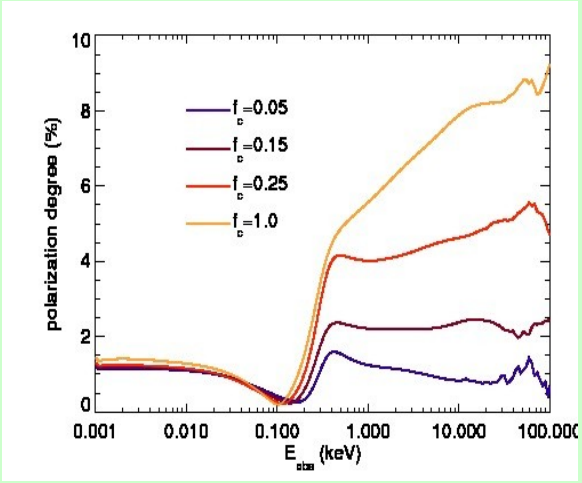
Part of the primary emission illuminates the disc and is reflected (and polarized) via Compton Scattering

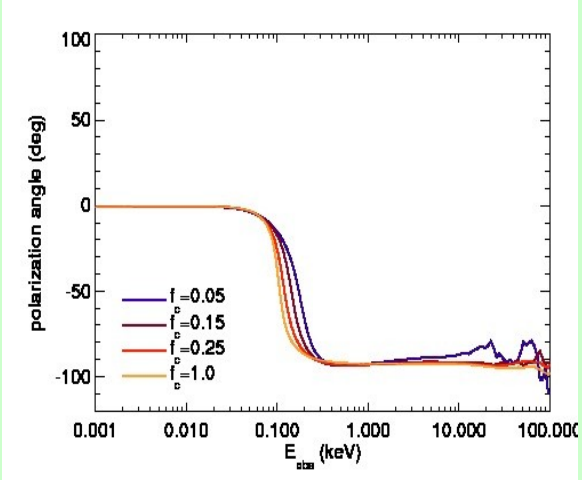
The geometry of the hot corona

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



Schnittman & Krolik (2010)

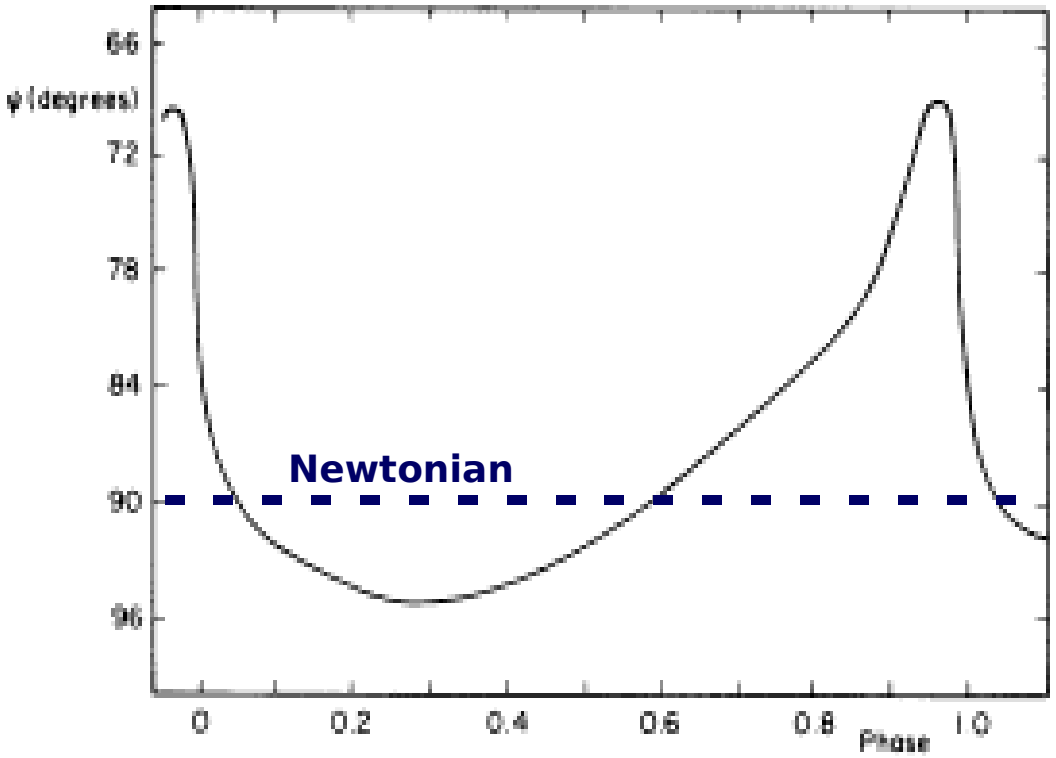


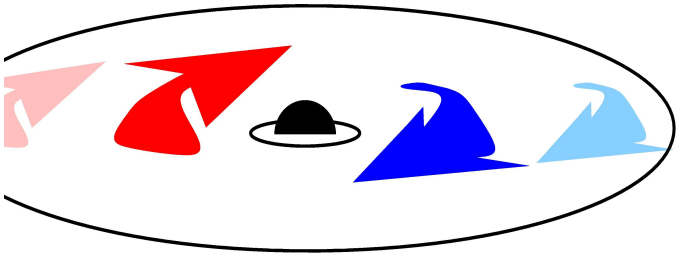


More in Francesco Tamborra's talk

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



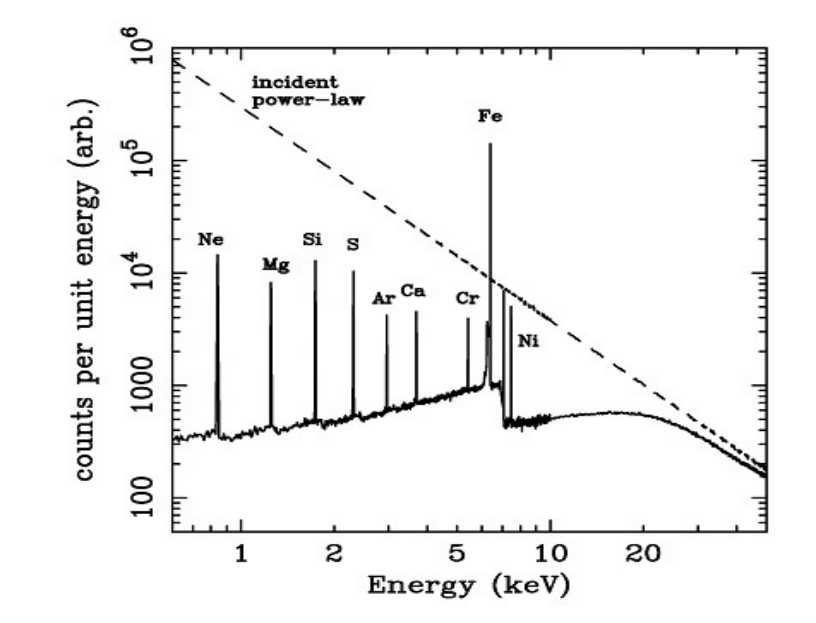


Orbiting spot with:
a=0.998; R=11.1 Rg
i=75.5 deg

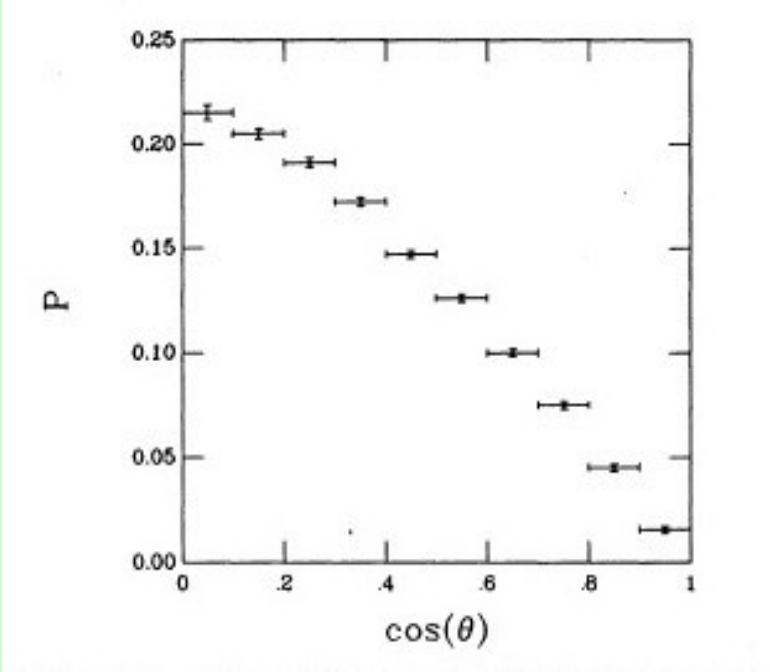
(Phase=0 when the spot is behind the BH).

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

Polarization of reflected flux

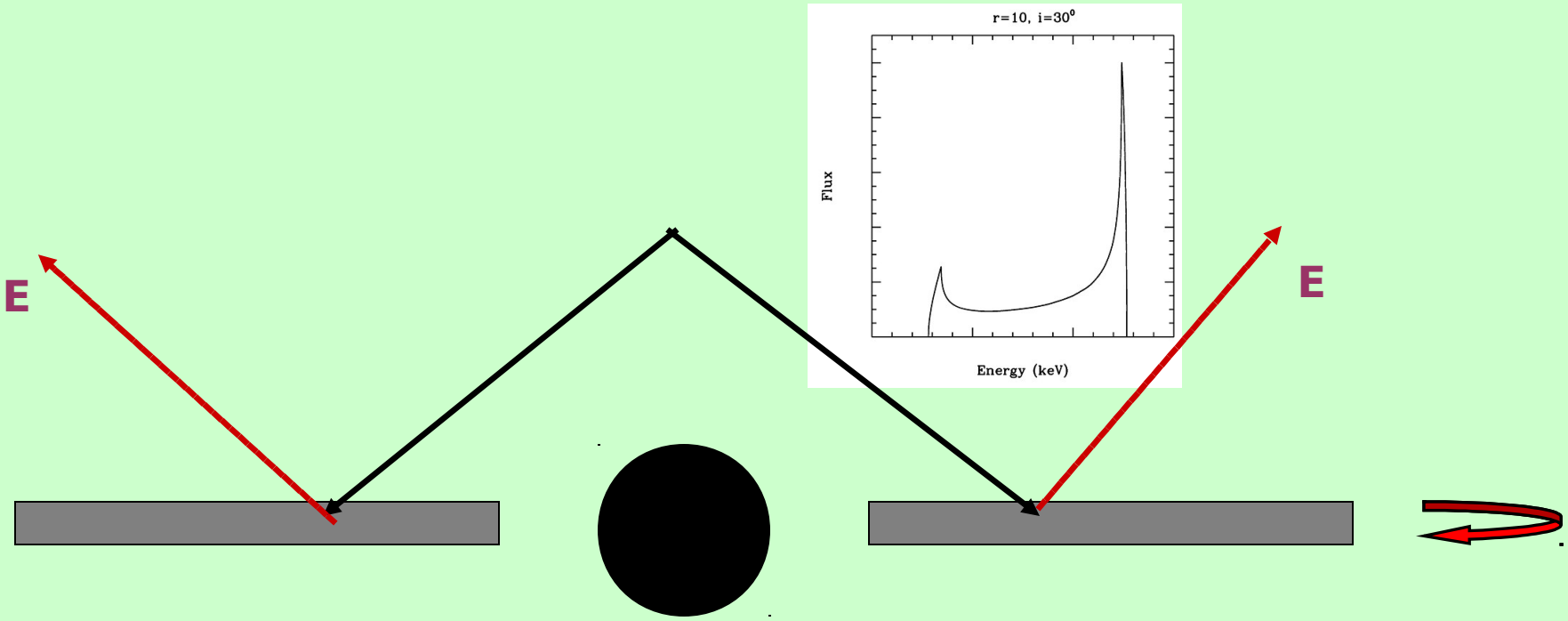


Polarization of reflected (continuum) radiation is large, up to 20% (Matt et al. 1989) assuming isotropic illumination, a plane-parallel reflecting slab and unpolarized illuminating radiation.



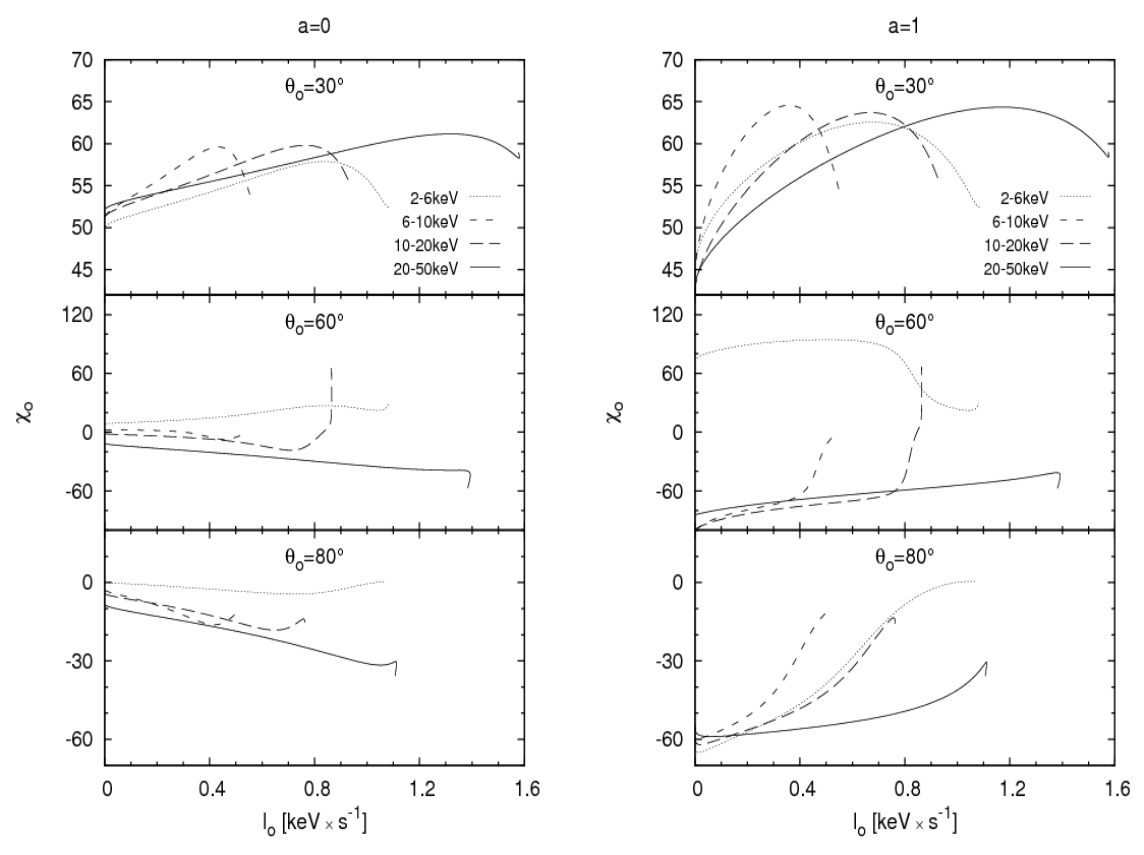
The exact values depend on the actual geometry of the system and on the polarization degree of the primary radiation.

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)

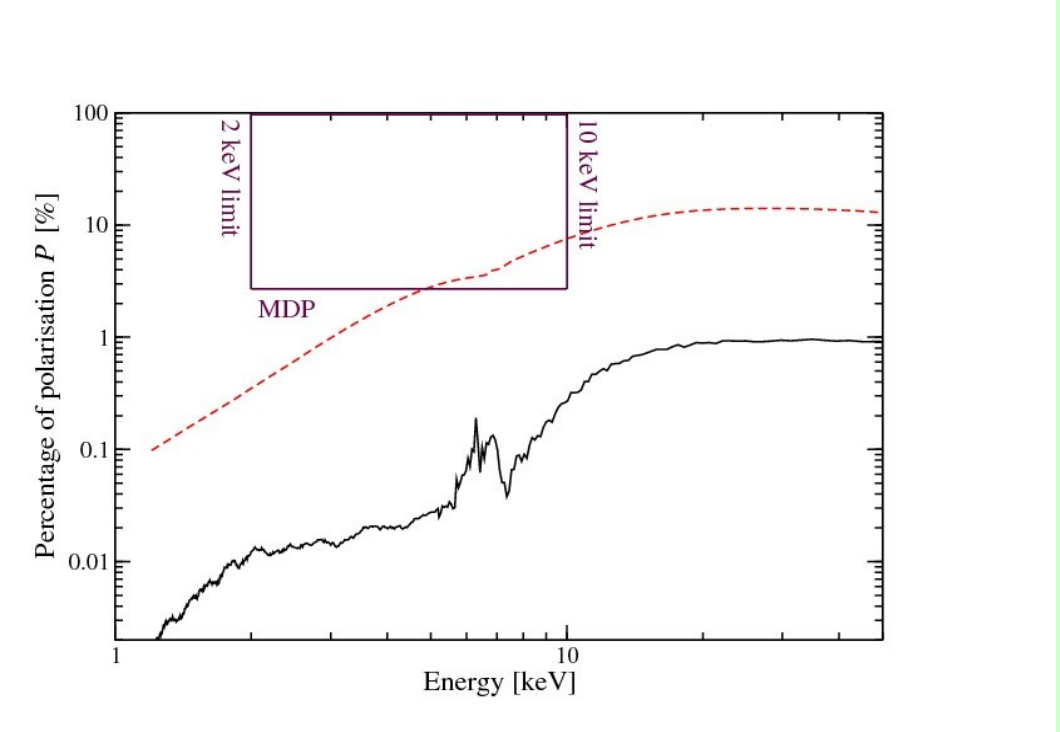
Variation of h with time implies a time and flux variation of the degree and angle of polarization.

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 easily distinguish between the two models!



Marin et al. (2012)

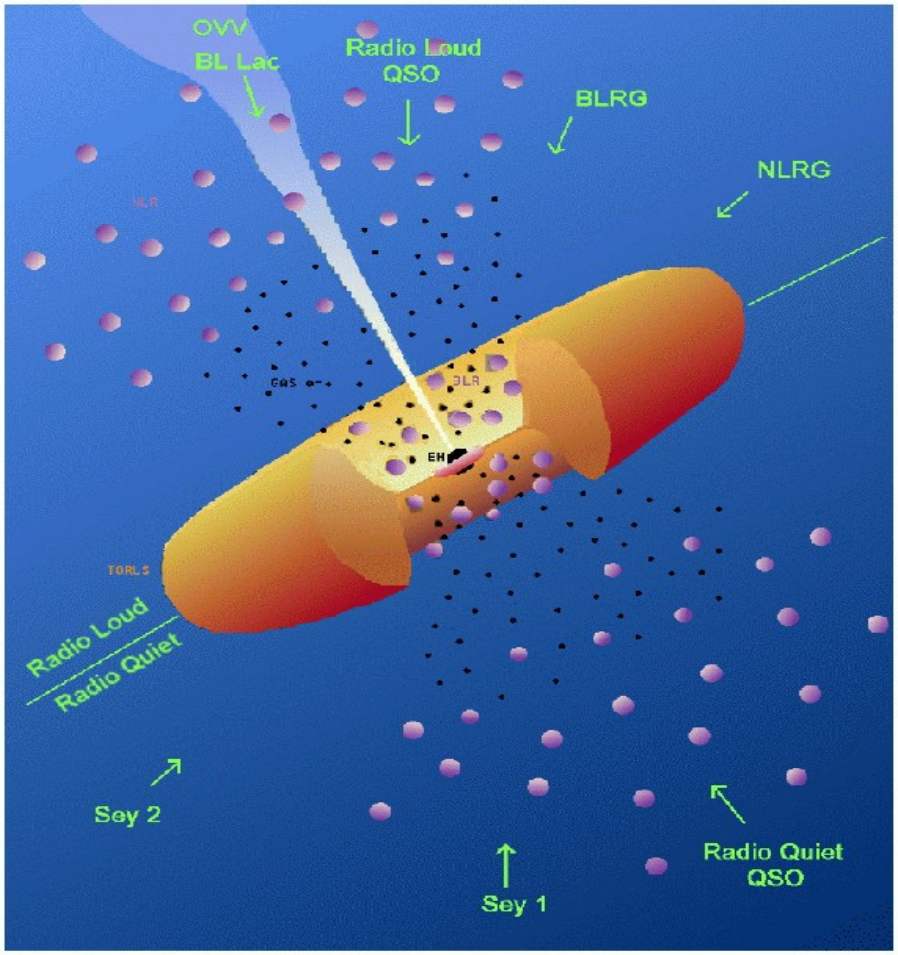
Reflection from the torus

Is the torus really a torus?

The actual geometry of the obscuring matter is not well known.

X-ray polarimetry can help:

the polarization degree is a measure of the asphericity,
the polarization angle will tell us the orientation of the "torus".

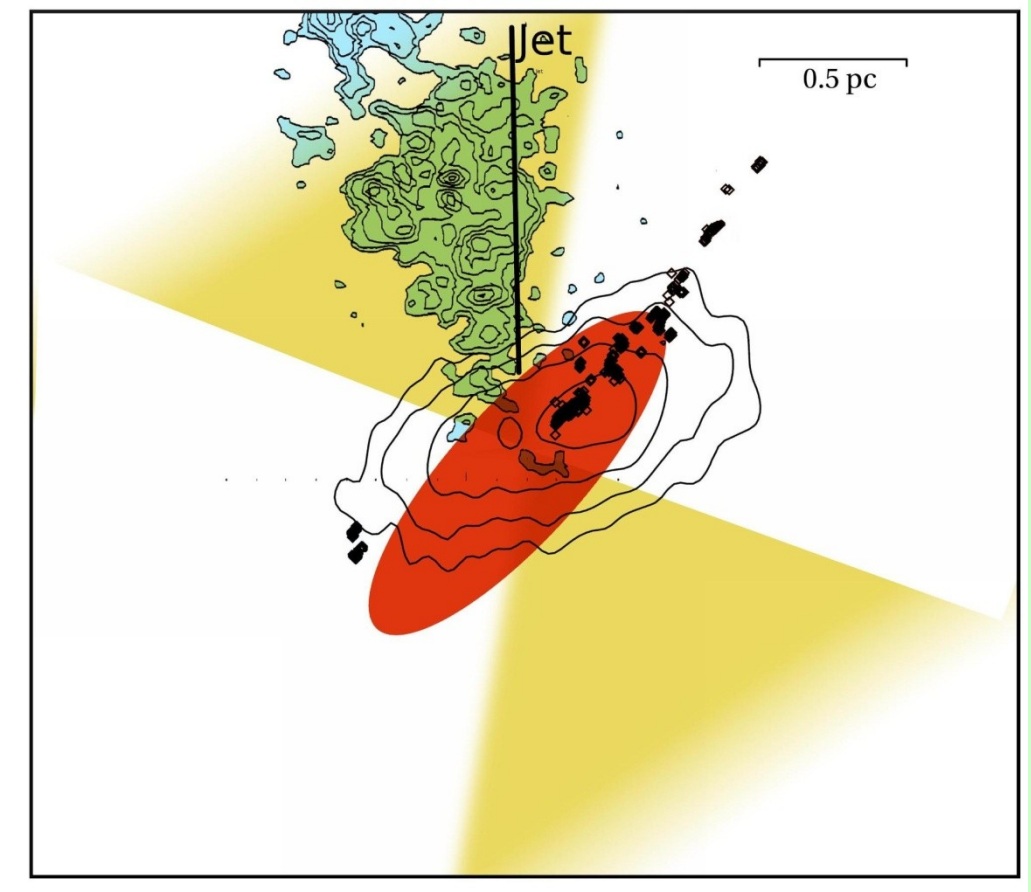


Urry & Padovani (1995)

The orientation of the torus

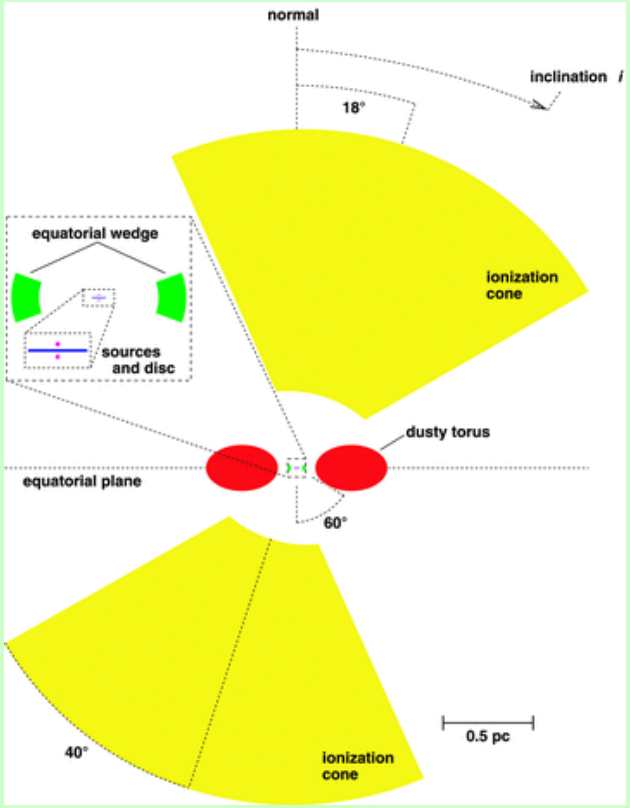
Geometry of the torus:

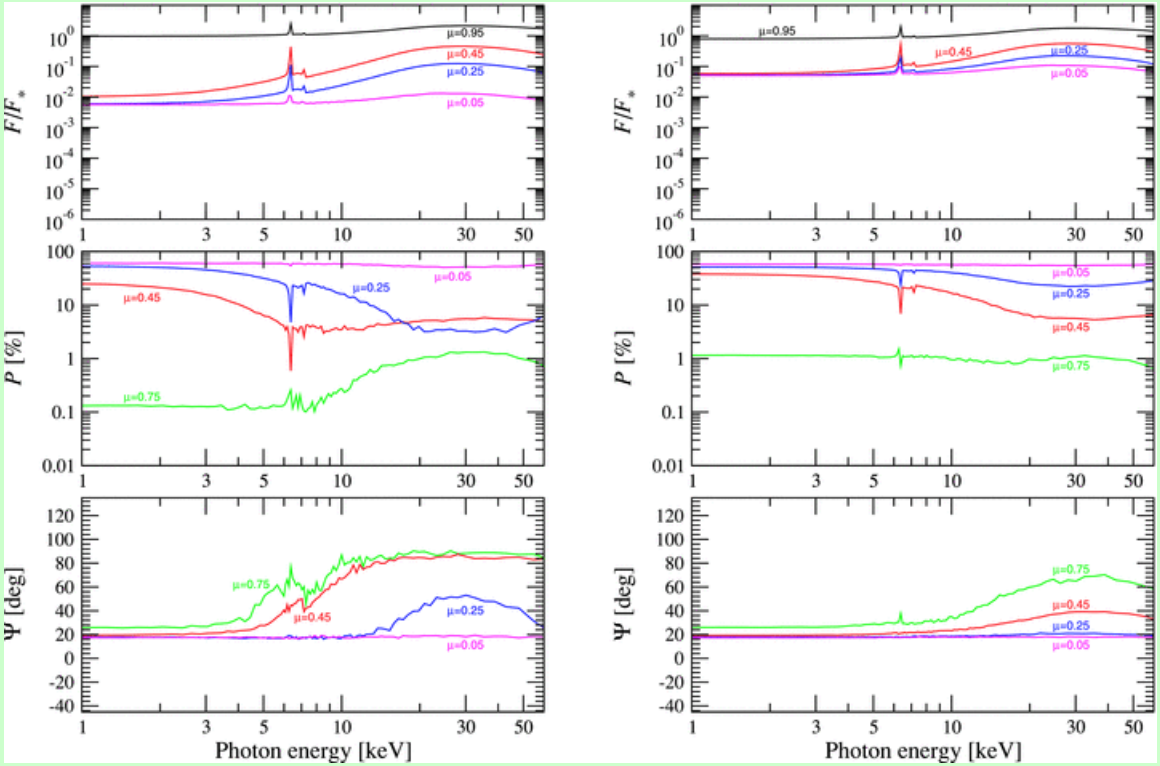
the polarization angle will give us the orientation of the torus, to be compared with IR results, and with the ionization cones (Goosmann & Matt 2011)



Raban et al. (2009)

The orientation of the torus





Goosmann & Matt (2011)

Observational perspectives

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

XIPE (X-ray Imaging Polarimetry Explorer). Submitted to ESA in response to the M4 call (PI: Paolo Soffitta).

Several X-ray polarimetric missions also submitted to NASA in response to the call for a Small Mission Explorer (including IXPE, PI: Martin Weisskopf)

More in Paolo Soffitta's talk

X-ray polarimetry will help determining the geometry of the inner regions of AGN

Observational perspectives may become bright soon!!!