X-ray polarization as a tool to understand coronae in accreting sources

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An extremely brief introduction

Accretion alone produce a MTBB peaked at UV for SMBH and soft X–rays for galactic BH
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(from Gilfanov et al. 2000)
MoCA: a Monte Carlo code for Comptonization in Astrophysics

MoCA in a nutshell

• single-photon source-to-observer class (Fortran2003)

• complete special relativistic and quantum treatment of Comptonization (Maxwell–Juttner distribution, KN cross-section & scattering angle distribution)

• complete GR description of the process (N–T disk, ray-tracing (M.Bursa routine), parallel transport of P vector)

• parallelisation & interoperability with C

• modular and easily customisable
Geometries in this talk

SLAB

SPHERE
source parameters

MBH = 10 Msun
mdot = 0.1 (Edd)

a = 0 / 0.998
limb darkening ON/OFF

corona parameters

kT = 100 keV

geometry SLAB/SPHERE
tau = 0.5/1/2
**source parameters**

MBH = 10 Msun  
midot = 0.1 (Edd)

a = 0 / 0.998  
limb darkening ON/OFF

| photons BH | 0.0000000000000000 |
| photons disc | 40.07992217797634 |
| photons escaped | 59.92007782202366 |

- photons escaped without scatterings = 45.70373016562983 |
- photons escaped 1 scattering = 21.81158453636724 |
- photons escaped 2 scattering = 13.13295245387409 |
- photons escaped 3 scattering = 7.9157220790942784 |
- photons escaped 4 scattering = 4.7218875253756295 |
- photons escaped 5 scattering = 2.7920075188119504 |
- photons escaped >5 scattering = 3.9221157804371583 |

**corona parameters**

kT = 100 keV  
geometry SLAB/SPHERE  
tau = 0.5/1/2
a0 limb / SLAB tau1

Pol Degree (a00, mdo01, MBH10 ) 10-1000 tau1 kT100 - limb

Pol Angle (a00, mdo01, MBH10 ) 10-1000 tau1 kT100 - limb
a0 limb / SLAB tau1

Pol Degree (a00, mdot01, MBH10) 10-1000 tau1 kT100 - limb

Polarization Degree [%]

Pol Angle (a00, mdot01, MBH10) 10-1000 tau1 kT100 - limb

Polarization angle [deg]

Energy [keV]
Polarization angle [deg]  
Energy [keV]  

Pol Angle (a00, mdot01, MBH10 ) 10-100 tau1 kT100 - limb

Polarization Degree [%]  
Energy [keV]  

Pol Degree (a00, mdot01, MBH10 ) 1000-1000 tau1 kT100 - limb

Polarization angle [deg]  
Energy [keV]  

a0 limb / SLAB tau1

Polarization degree [%]  
Energy [keV]  

Pol Angle (a00, mdot01, MBH10 ) 10-100 tau1 kT100 - limb

Polarization angle [deg]  
Energy [keV]  

a0 limb / SPHERE tau1
Stephen O’Dell talk on IXPE
Pol Degree (a0, mdot01, MBH10) \(\tau_1 kT_{100}\)

Polarization Degree [%]

Pol Angle (a0, mdot01, MBH10) \(\tau_1 kT_{100}\)

Polarization angle [deg]
Conclusions & Future Developments

X-ray polarization has the potential to discriminate (certain) geometries even w/o exploiting the spectral capabilities of future polarimeters (IXPE, eXTP)

If the data will be very good it has the potential to constrain even more parameters such as the spin of the BH, for example

Waiting for 2021…

- Develop more realistic models and explore more of the parameters space (e.g. reflection from the disc, compact corona, double corona, non-thermal electrons,..)

- Apply MoCA to different interesting astrophysical case of study (magnetic-field induced polarization, i.e. GRB, jets)