



IXPE

Imaging
X-Ray
Polarimetry
Explorer



X-ray polarimetry as a tool to measure the black hole spin in microquasars: simulations of IXPE capabilities

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- **Imaging X-ray Polarimetry Explorer (IXPE)**
- **Launch: December 9, 2021**
- **NASA & ASI mission**
- **Accreting Stellar-Mass Black Hole Binaries among the target sources**

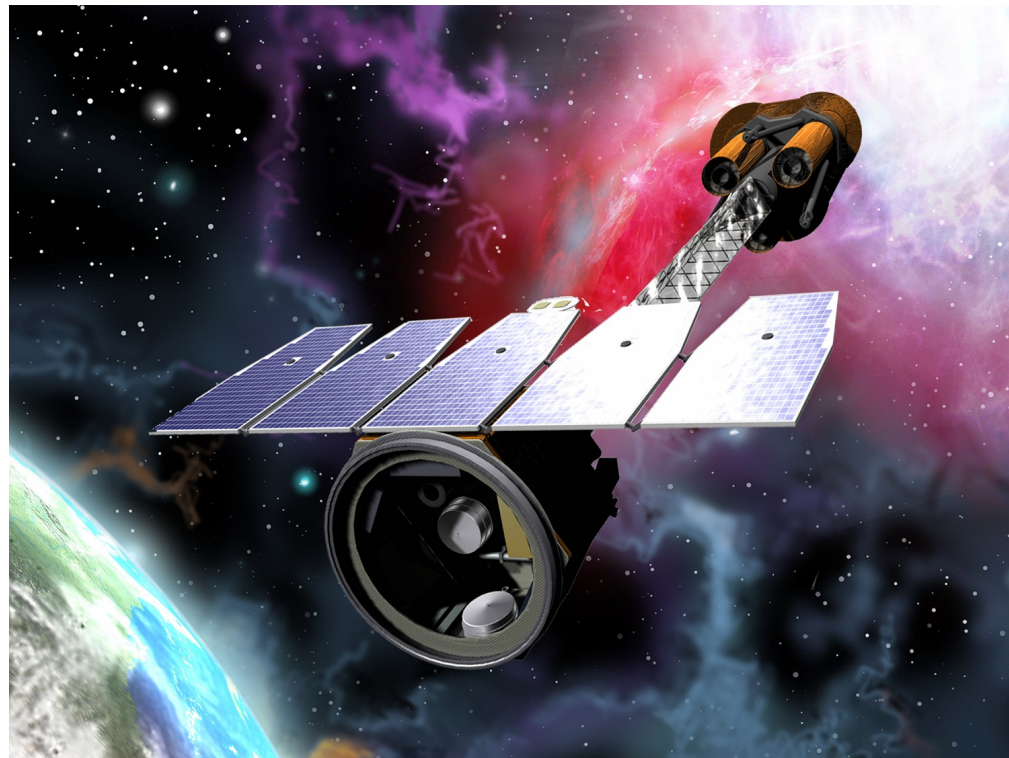
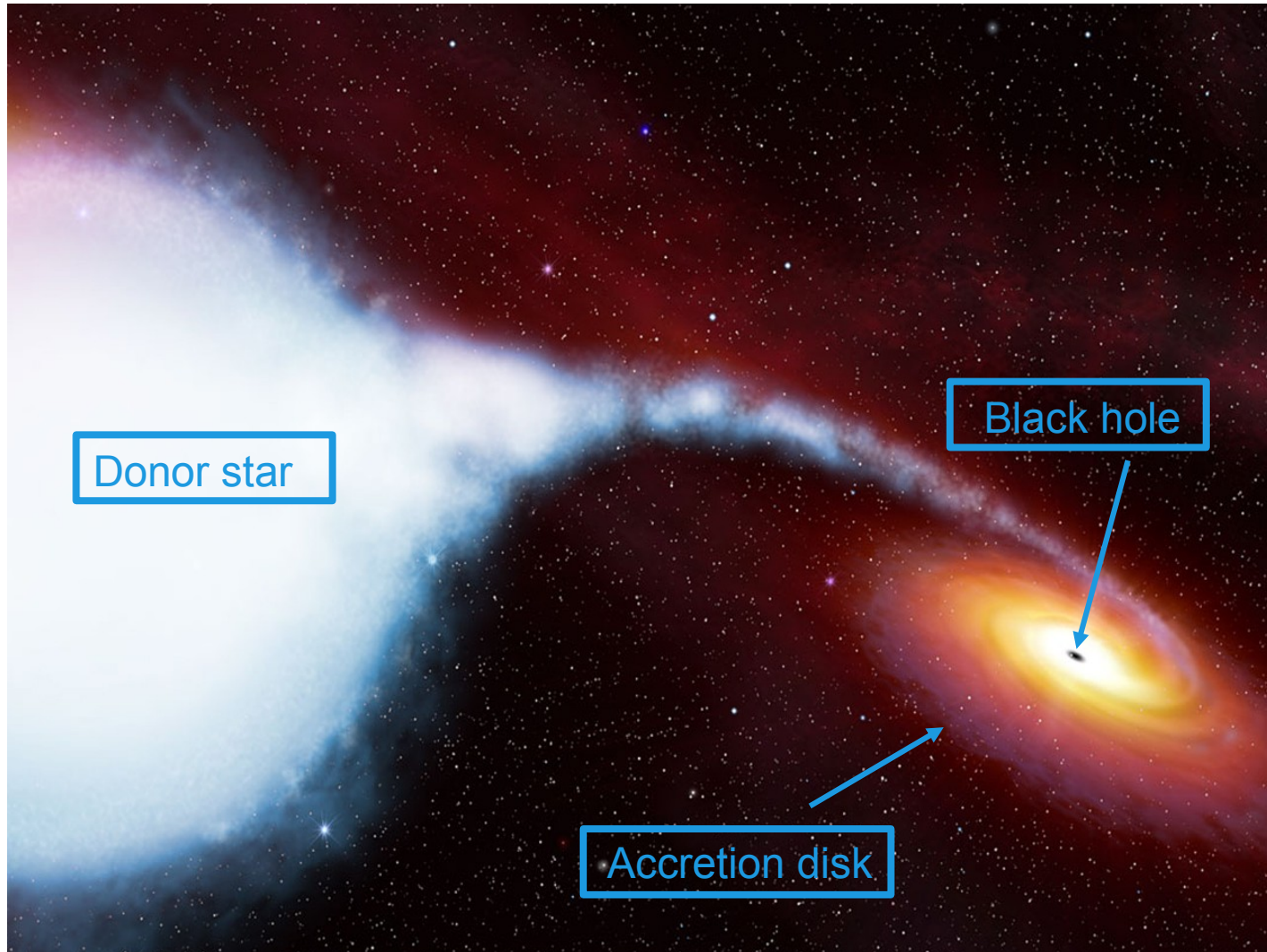


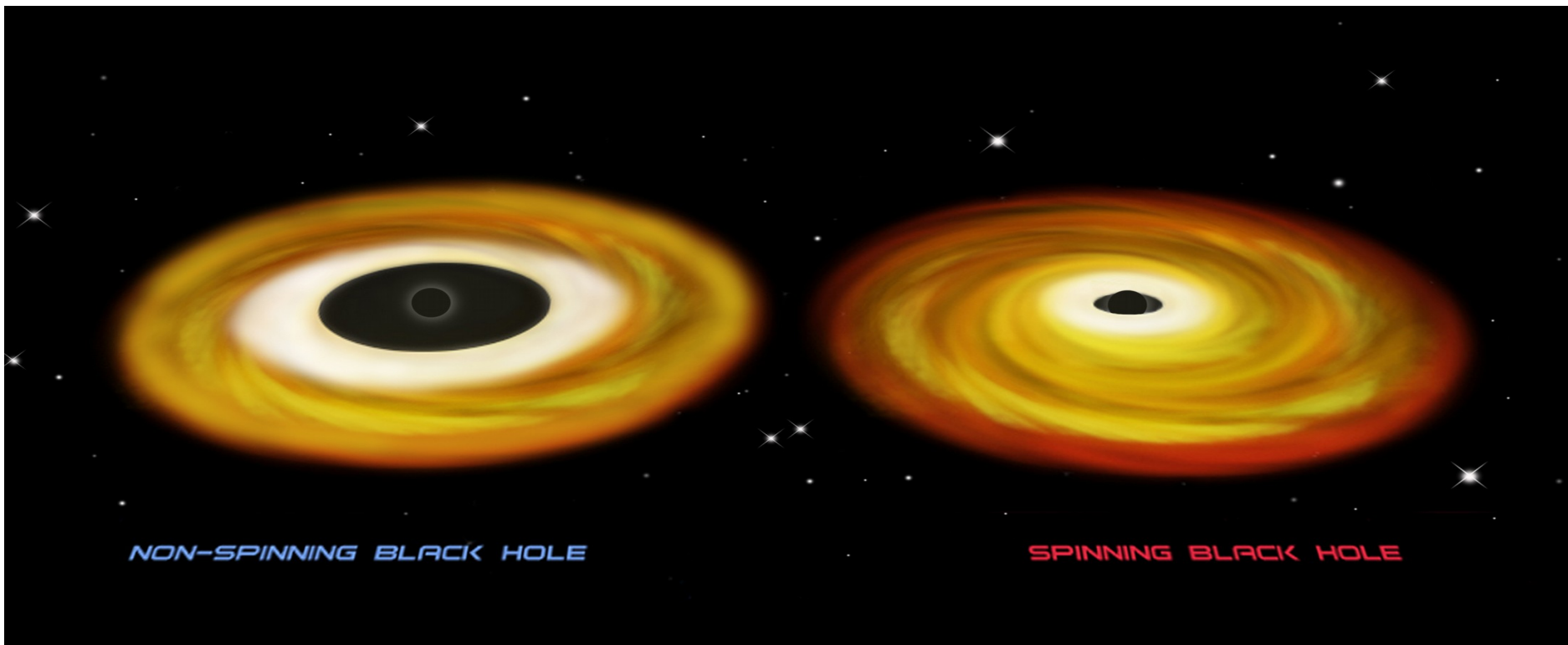
Image credit: <https://ixpe.msfc.nasa.gov/>

X-RAY BINARY SYSTEMS



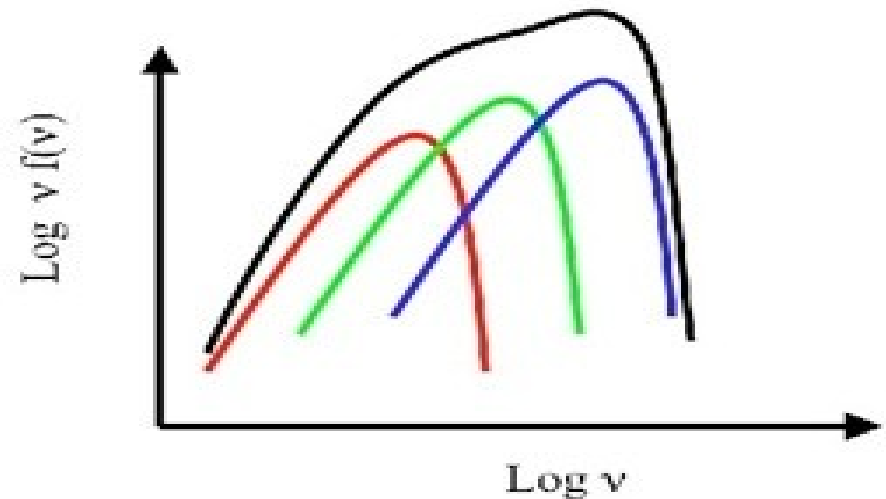
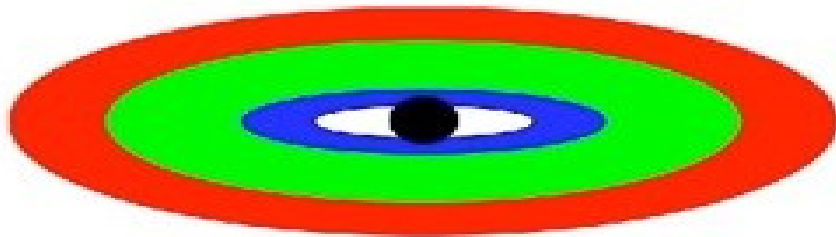
ACCRETING STELLAR MASS BLACK HOLES

- **Black hole spin measurement from thermal spectrum**



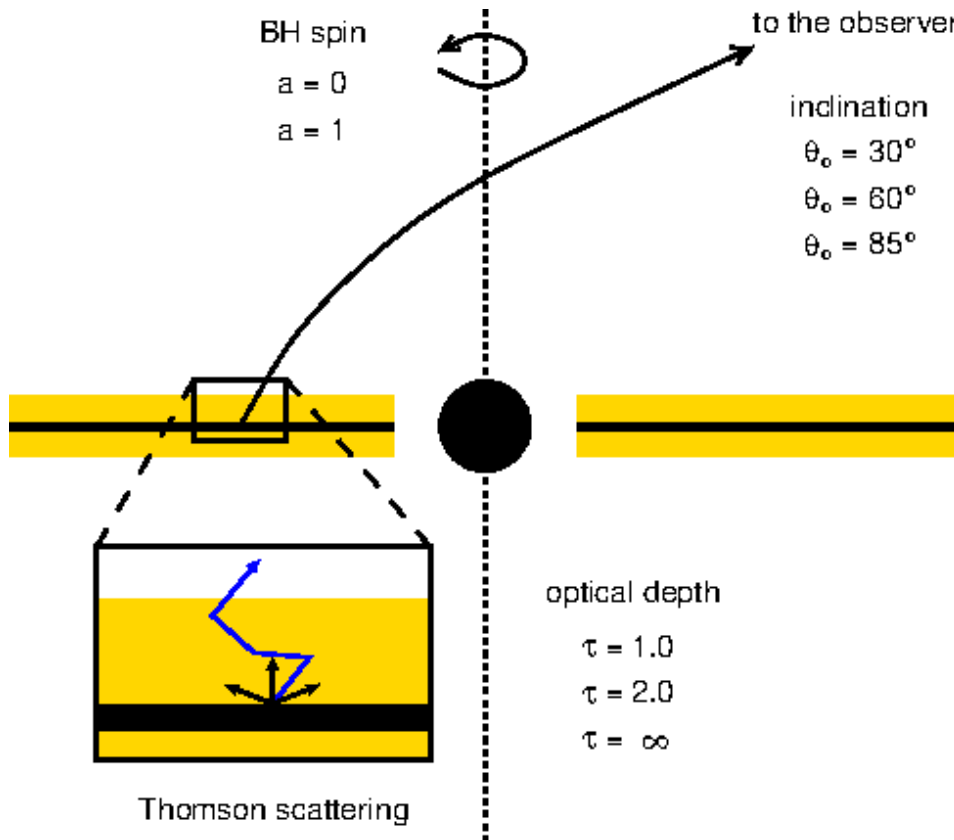
ACCRETING STELLAR MASS BLACK HOLES

▪ Black hole spin measurement from thermal spectrum



KYNBB POLARIZATION OF THERMAL RADIATION

Modeling the source: multicolor black body with KYNBB (Dovčiak+2004, Dovčiak+2008)



- Thermal radiation (Novikov Thorne disk)
- Photons in the disk partially Comptonized, which is accounted for using color correction factor ($T = f_C * T_{NT}$) and Thomson scattering on electrons
- Polarization due to scattering computed using **STOKES** code (R. Goosmann & F. Marin) <http://www.stokes-program.info/>

KYNBB ROTATION OF POLARIZATION ANGLE WITH ENERGY

- Upper: BH (spin=1) on the sky of the observer
- Bottom left: flux dependence on energy
- Bottom right: energy dependent rotation of polarization angle due to relativistic effects
- Photons from the inner regions of the disk are more energetic and of a different PA compared to the less energetic photons produced in the outer disk regions

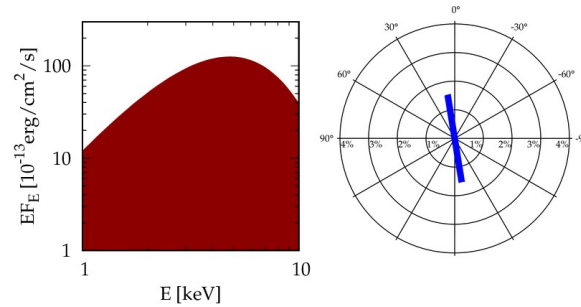
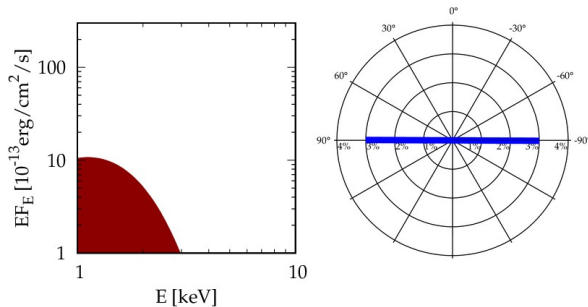
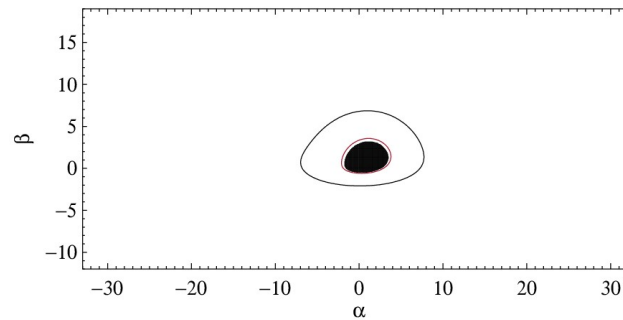
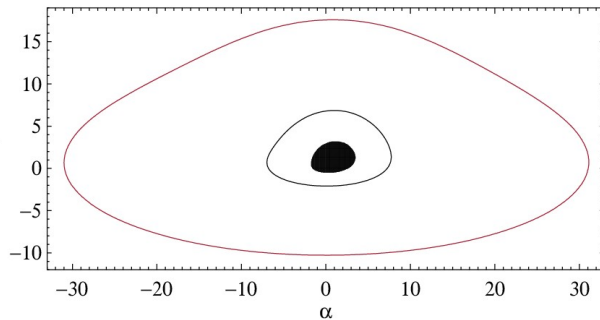
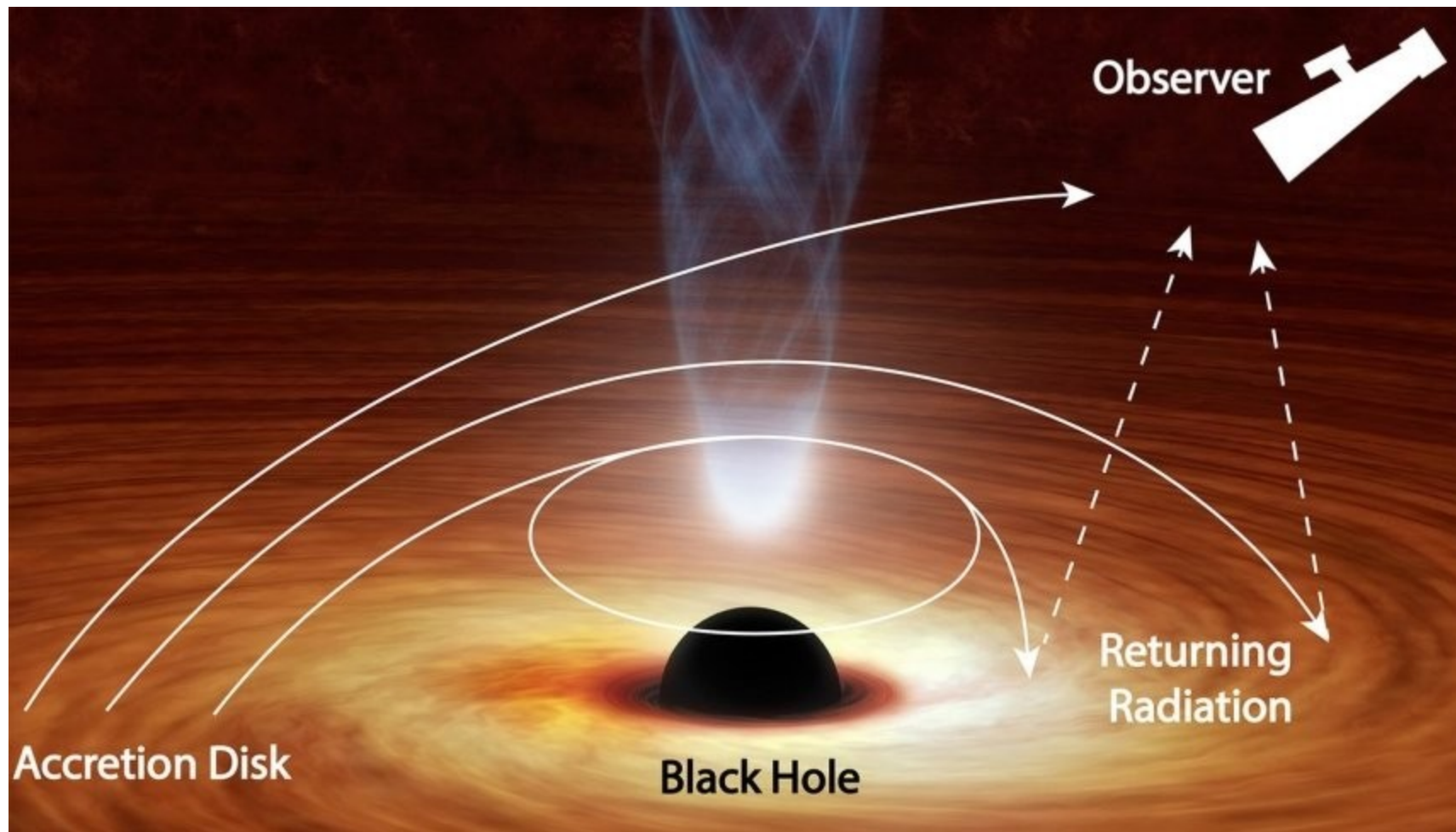


Image credit: Michal Dovciak

KYNBBRR RETURNING RADIATION

▪ Returning radiation (Taverna+2020) (KYNBBRR)





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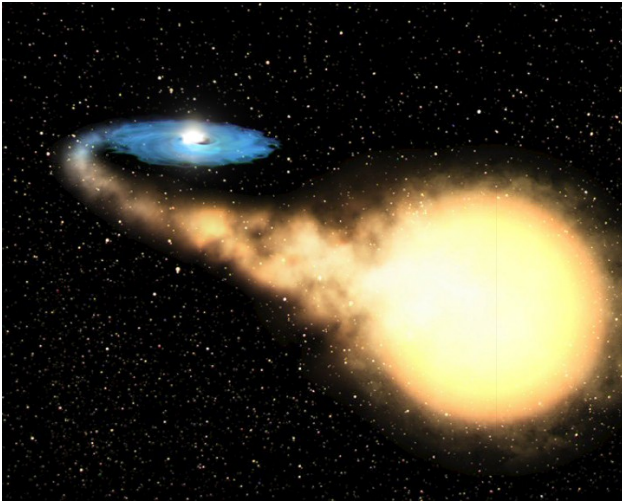
- **So, what do we actually do?**



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MODELING GRS 1915+105



- Multicolor black-body code (KYNBBRR) used to model GRS 1915+105 for spin: 0, 0.7, 0.9 and 0.998 and albedo 50%

Image credit: ESA, NASA and Felix Mirabel

SIMULATING OBSERVATIONS OF GRS 1915+105

- Multicolor black-body code (KYNBBRR) used to model GRS 1915+105 for spin: 0, 0.7, 0.9 and 0.998 and albedo 50%
- Simulation of polarimetric observations using an X-ray polarimetry simulation framework
- Output: PD & PA, Stokes Q & U, X-ray spectra

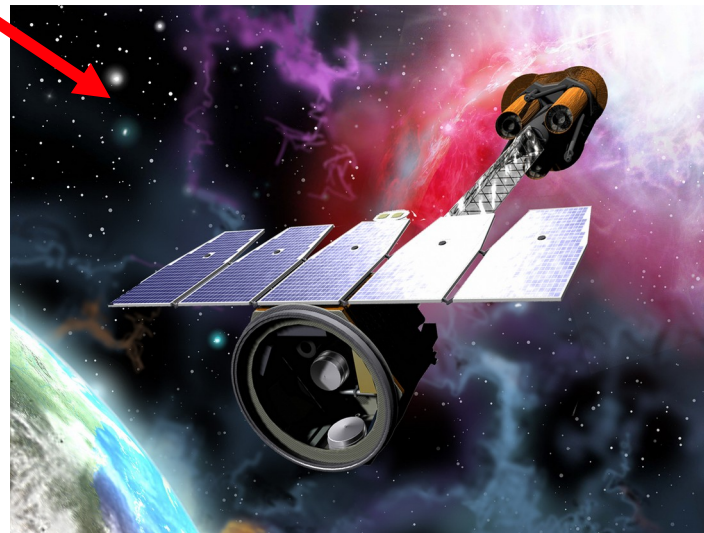
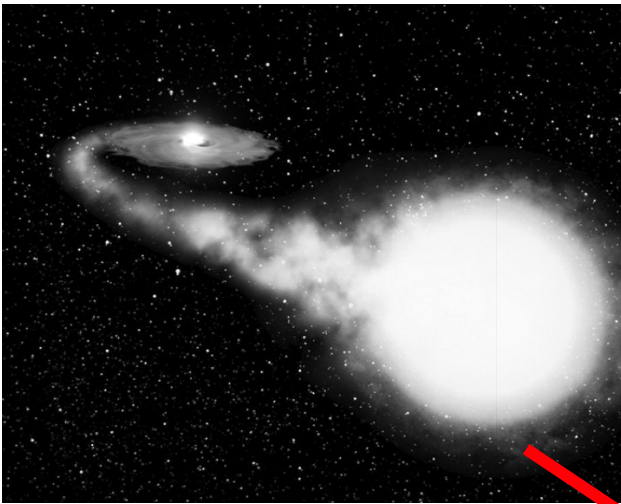


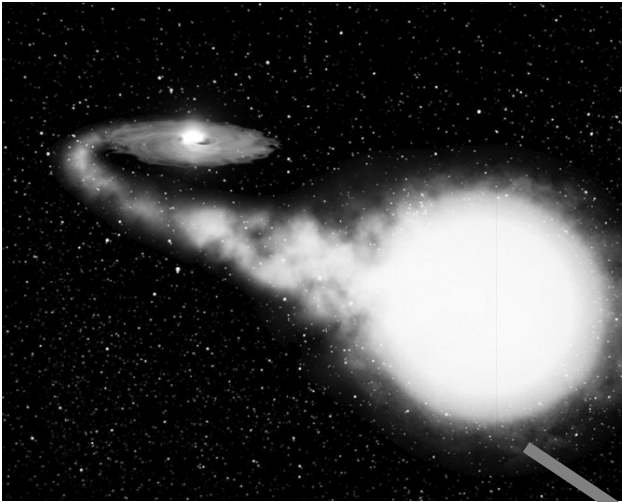
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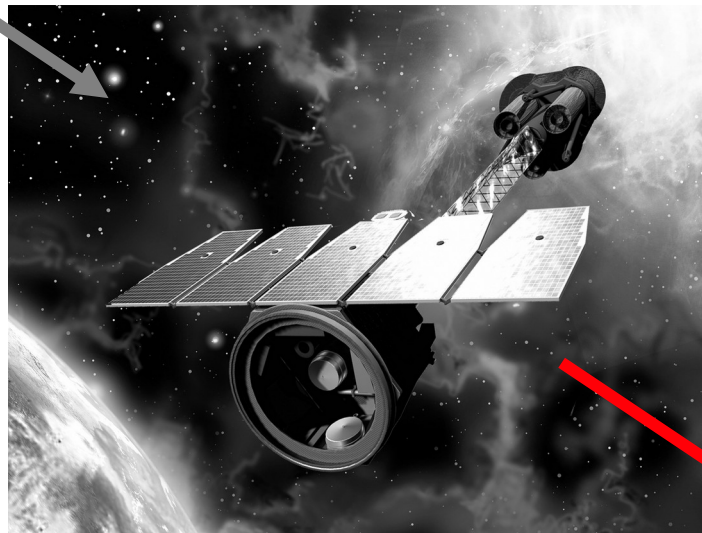
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ANALYZING GRS 1915+105



- Multicolor black-body code (KYNBBRR) used to model GRS 1915+105 for spin: 0, 0.7, 0.9 and 0.998 and albedo 50%
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- Reconstruction of spin & albedo

Xspec

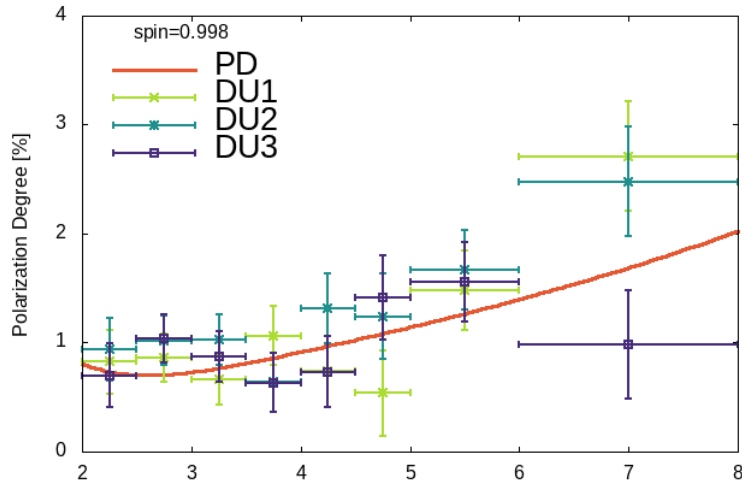


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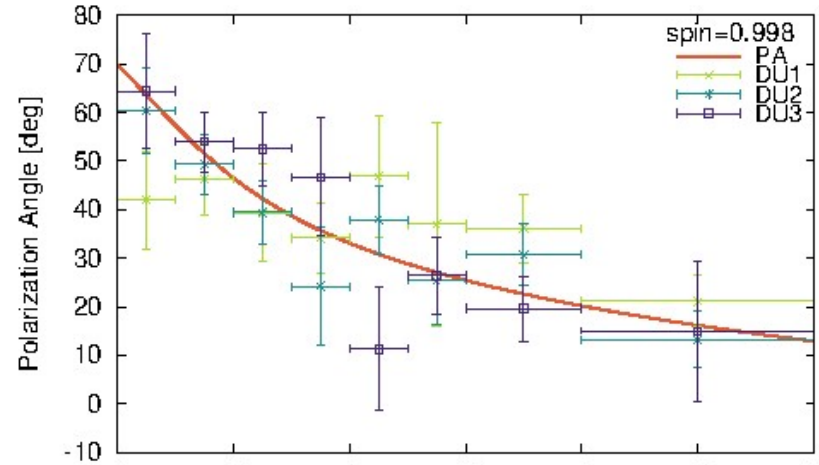
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RESULTS GRS1915+105

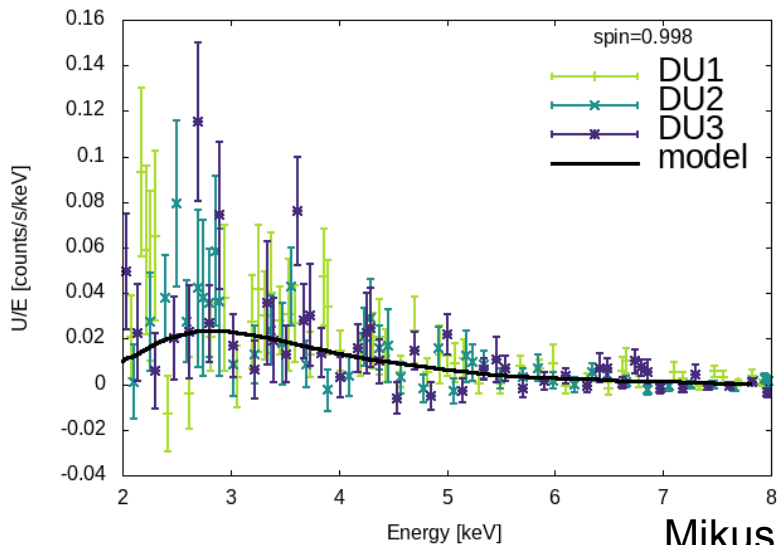
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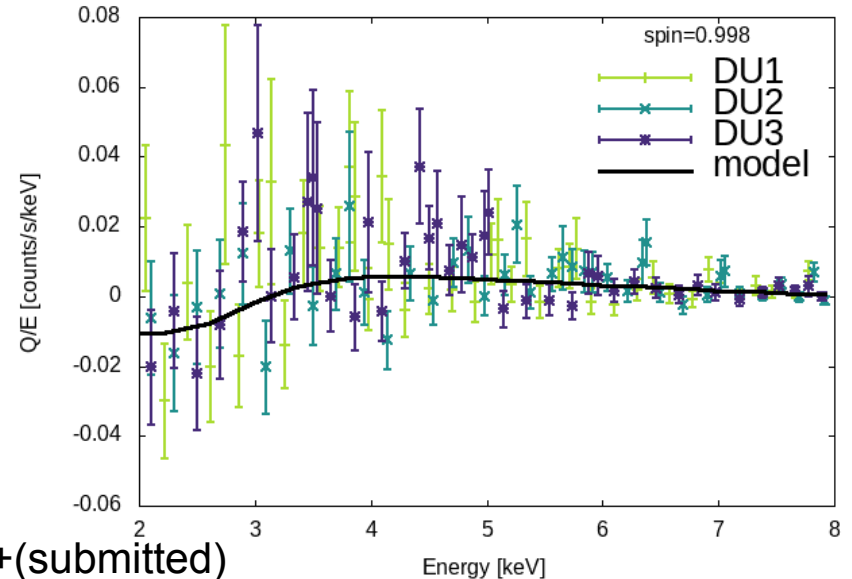
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a/M=0.998, theta=70 deg, tau=inf, arate=0.185 Ledd, albedo=50%



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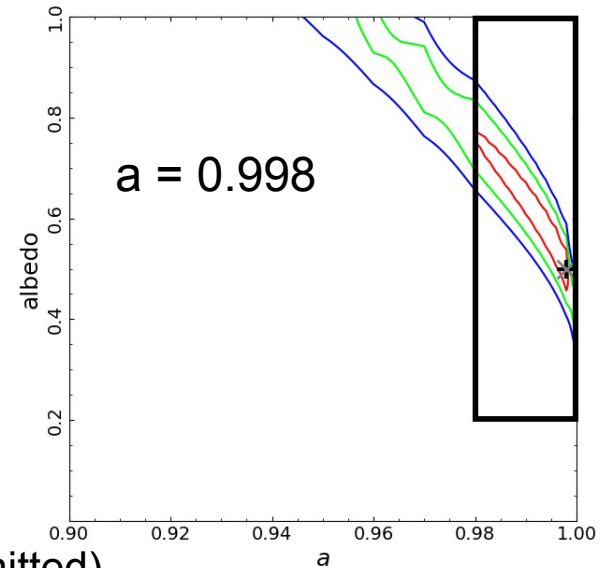
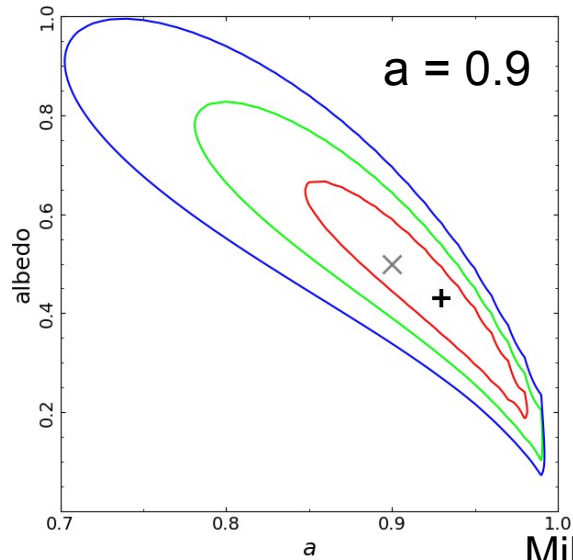
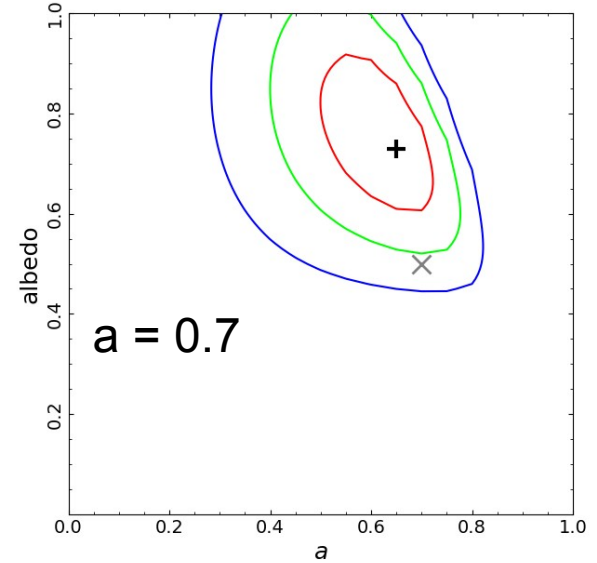
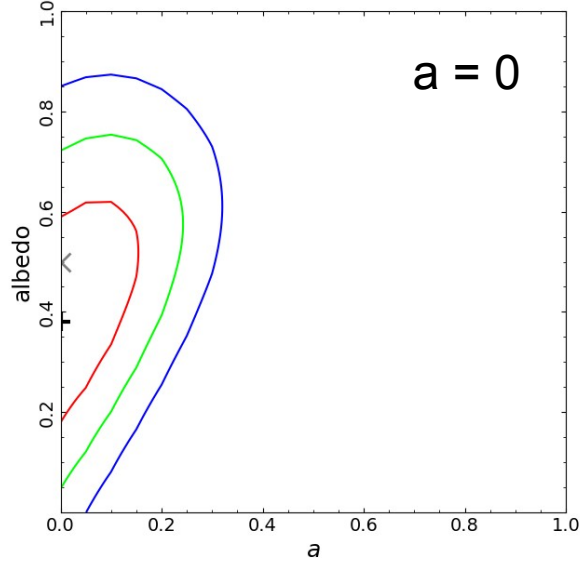
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RESULTS

GRS1915+105



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CONCLUSIONS FUTURE PROSPECTS

- We modeled and analyzed polarimetric properties of X-ray binary source GRS 1915+105 in thermal state with returning radiation
- Varying albedo profile & absorption effect (Taverna+2021)
 - Scattering + absorption as polarization-inducing process
- Launch of IXPE: December 9, 2021
- X-ray polarimetry is a new method for Black Hole spin measurement that will shed a new light in the spin and system geometry constraints
- GRS 1915+105 has been in an obscured state since 2018 (Ratheesh+2021)
- Obtained results are applicable to any bright source in thermal state
- Applicability to eXTP



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.thank you



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