IXPE results from BH X-ray binaries

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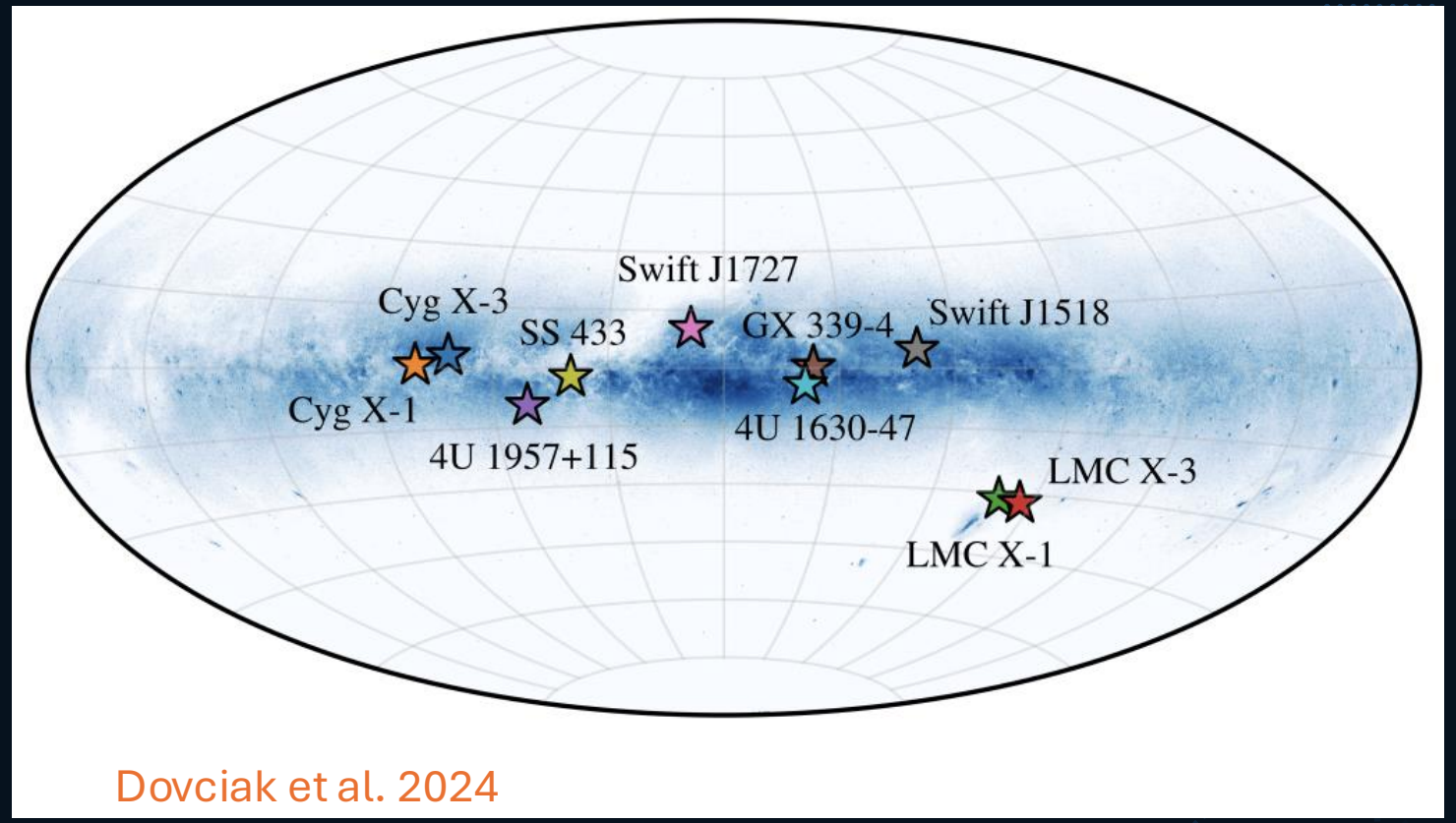
Object (Object Type)	Observation Date	LIVETIME [ks]	State	Energy Flux [a] [mCrab]	Polarisation Degree [a] [%]	Polarisation Angle [a] [deg]
LMC X–1 persistent HMXB	19–28 October 2022	562	SS	14	< 2.5 [h]	—
LMC X–3 persistent LMXB/HMXB	7–20 July 2023	562	SS	16	3.0 ± 0.4	-41 ± 4
4U 1957+11 persistent LMXB	12–24 May 2023	572	SS	22	1.8 ± 0.4	-52 ± 7
4U 1630–47 transient LMXB	23 August 2022 – 2 September 2022	458	SS	181	8.6 ± 0.2	17.6 ± 0.6
	10–13 March 2023	36 102	SPL [c]	389 539	8.3 ± 0.5 6.7 ± 0.3	22 ± 2 21 ± 1
Swift J1727.8–1613 [d] transient LMXB	7–8 September 2023	19	bright HIMS [e]	3920	4.1 ± 0.2	3 ± 2
	16–17 September 2023	37		3574	3.9 ± 0.2	3 ± 1
	27–28 September 2023	21		3050	3.7 ± 0.2	3 ± 2
	4 October 2023	18		3284	3.2 ± 0.2	0 ± 2
	10 October 2023	18		2676	2.8 ± 0.3	-1 ± 3
Swift J1727.8–1613 [d] transient LMXB	11–12 February 2023	67	dim SS [f]	86	<1.1	—
	20–23 February 2023	151		58		
	3–8 April 2023	202	dim HIMS	32	4.0 ± 0.7	6 ± 5
GX 339–4 [g] transient LMXB	14–16 February 2024	95	SIMS	291	1.3 ± 0.4 [h]	-69 ± 8 [h]
	8–10 March 2024	98	SS	94	<1.4 [i]	—
Swift J151857.0–572147 transient	18–20 March 2024	96	SS	300	<1.3 [j]	—
Cyg X–3 [g] persistent HMXB	14 October–6 November 2022	538	HS 1	72	19.5 ± 0.4	89.9 ± 0.5
	17–23 November 2023	291	HS 2	76	20.0 ± 0.5	91.8 ± 0.7
	25–29 December 2022	198	IMS	192	9.3 ± 0.3	92 ± 1
	2–3 June 2024	50	SS	268	11.3 ± 0.5	93 ± 1

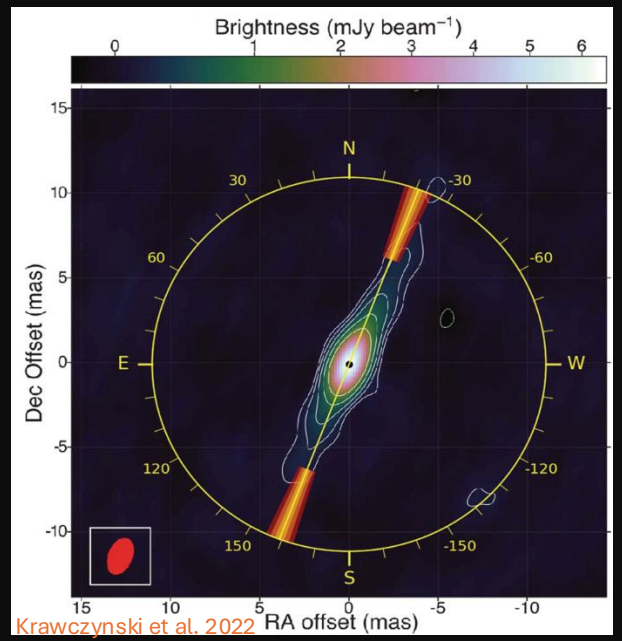


Dovciak et al. 2024

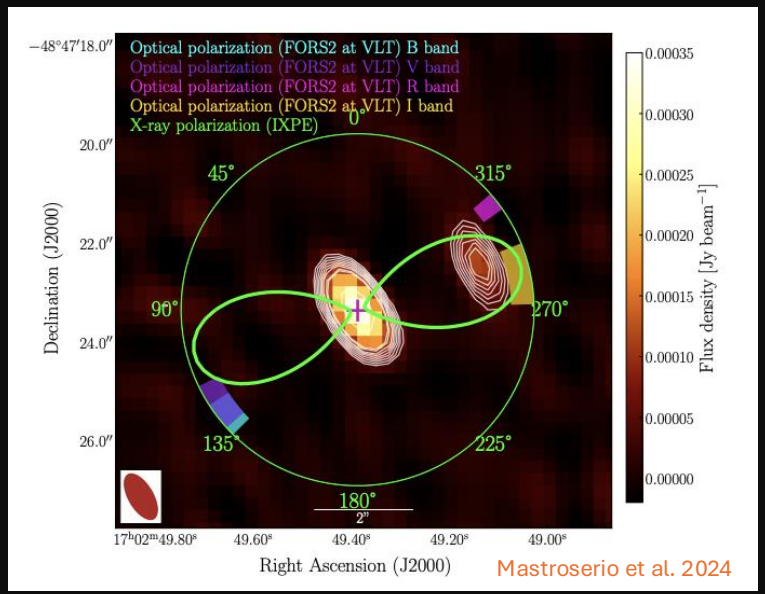
- IXPE observed 10 BH-Xray binaries until now
- Almost persistent sources in HSS.
- Only 3 transients have been observed until now: GX 339-4, 4U 1630-47 and Swift J1727.8–1613

Geometry of the corona: polarization angle is parallel to radio jets

- All accreting BH, having a known direction of the jets, show a polarization angle aligned with the jets
- this is a common characteristic of accreting compact objects (NS-LMXB, AGN) .
- for GX 339-4 we observed simultaneously with ixpe a jet ejection in radio band.
- the alignment of the polarisation direction with the ballistic radio jet may suggest the presence of a corona extended perpendicularly to the jet in this source as well.



Krawczynski et al. 2022



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Geometry of the Corona: Polarization degree increases with energies

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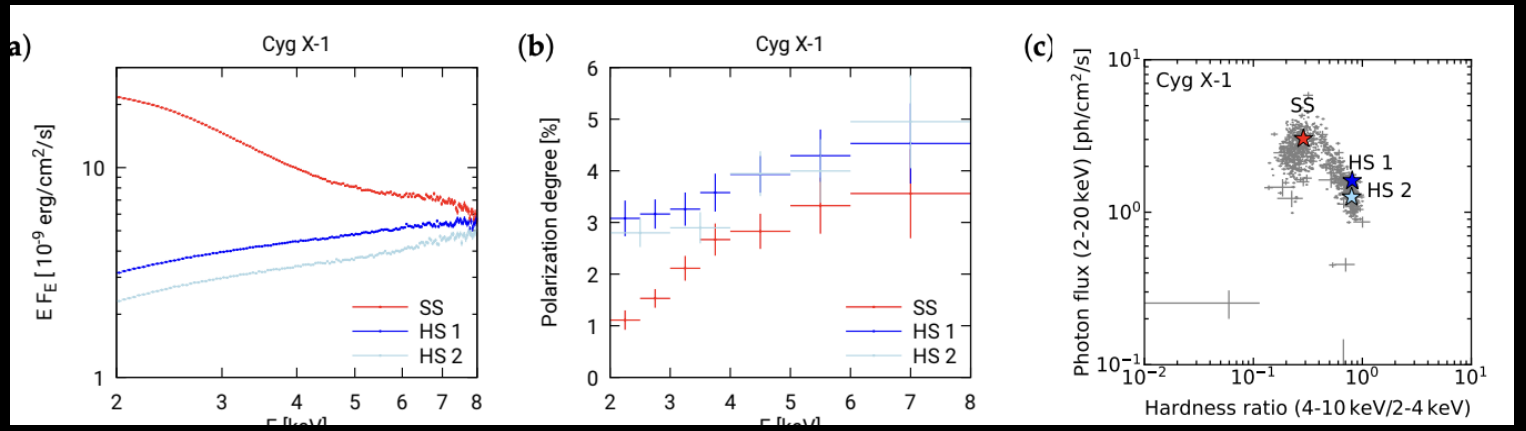
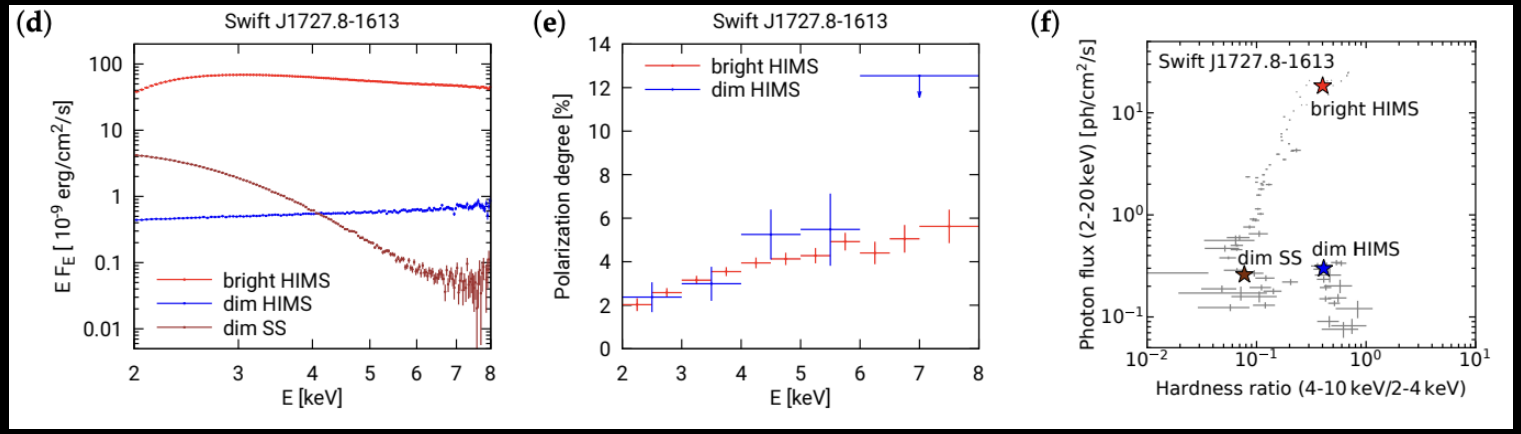
Cyg X-1



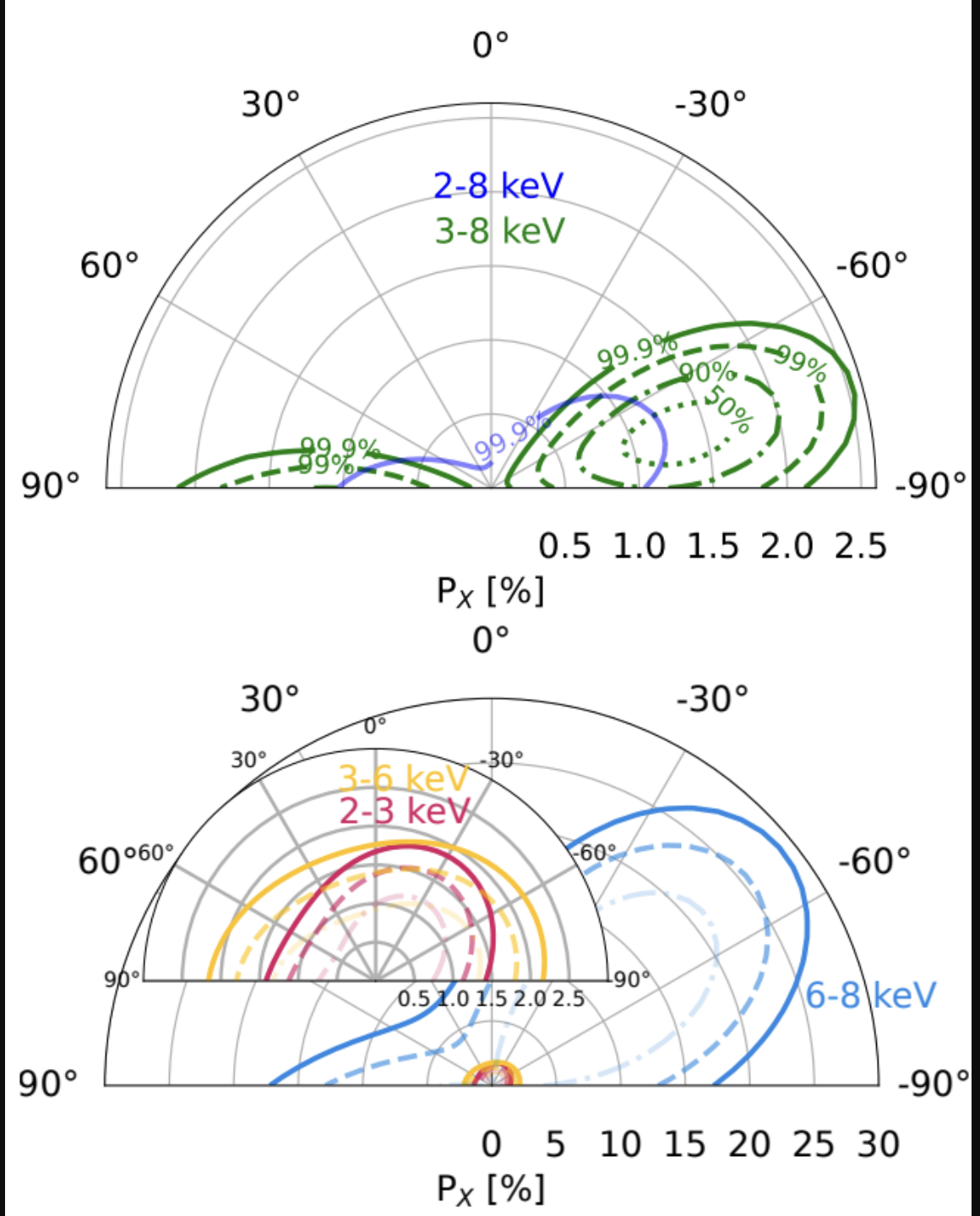
Swift J1727-1613



Geometry of the Corona: Polarization degree value changes with source state

- In HSS the polarization degree is very low and is below or near the detection limit of IXPE.
- As for example, GX 339-4 pass from a low but significative (at 99.9% sigma level) PD =1.3% in SIMS to an upper limit in HSS.
- In case of GX 339-4, based on the alignment of X-ray and optical PA with the radio jet, the favoured system configuration is a corona horizontally extended on the plane of the accretion disk

Mastroserio et al. 2024



Geometry of the Corona: Polarization degree changes with source state. The case of Swift 1727.8-1613

- Recovering of polarization degree value after transition back to HS (at least in the case of Swift 1727.8-1613)
- The geometry of the thermal corona, should have similar geometries in both the initial bright HIMS and in the dim HIMS at the end of the outburst

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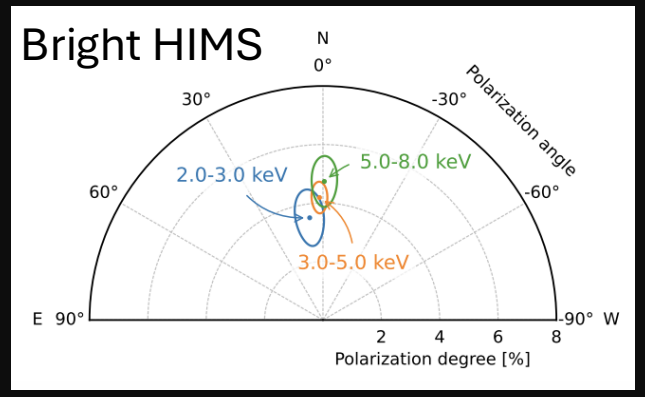
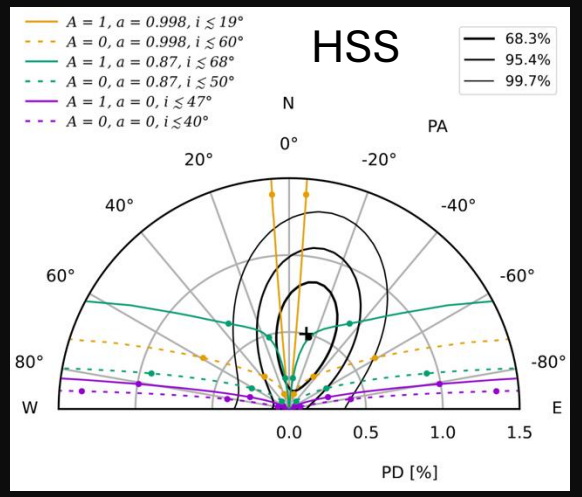
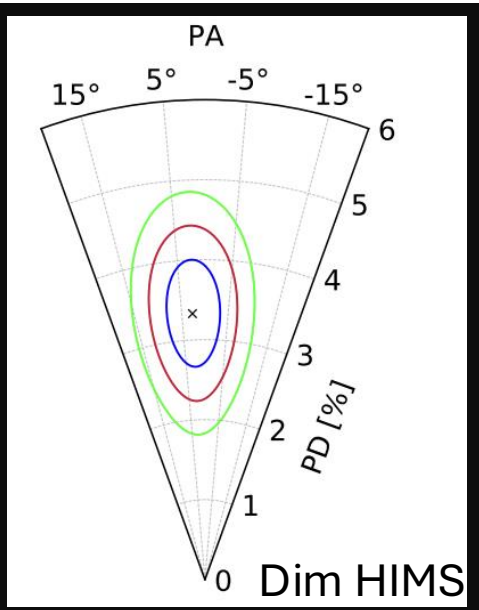




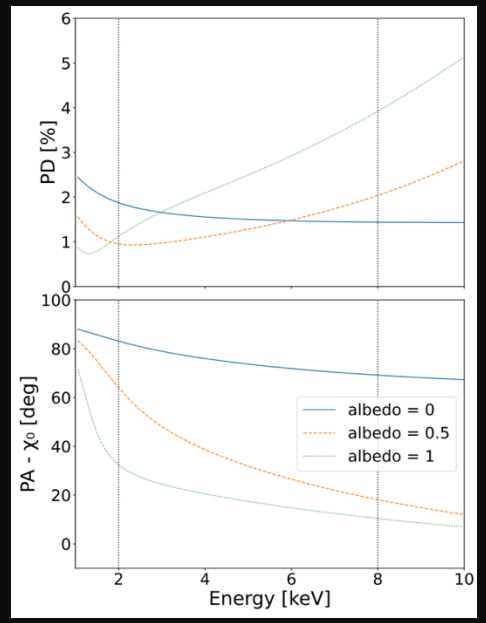


BH-XRB shows a “moderate” level of polarization degree

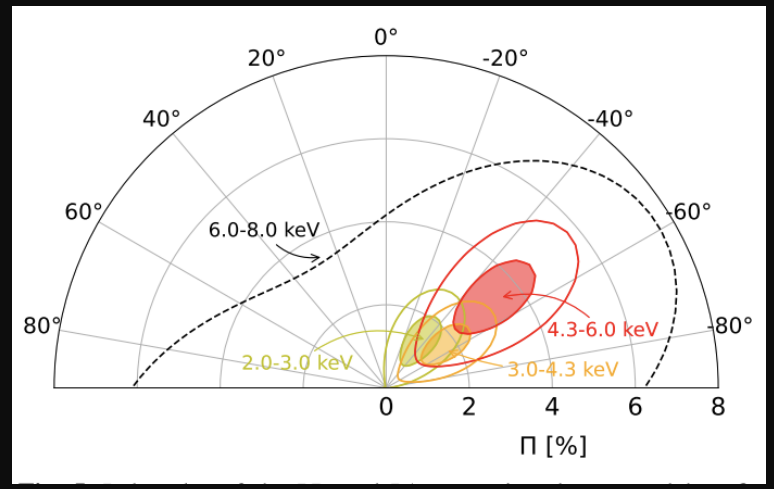
- The averaged value of polarization degree < 4%
- The polarized light observed in the 2-8 keV is due to the superposition of different contributions:
- Intrinsic disk polarization,
- The inverse Compton scattering
- Scattering due to reflection.
- The presence of wind should increase the PD
- All these components are not oriented in the same direction (different polarization angle): effects partial or total subtraction
- 4U 1630-47 and Cyg X-3 represent an exception.

Spin measurements : the case of 4U 1957+115

- IXPE was able to constrain BH spins using spectral polarimetry of BH XRBs by observing in the HSS
- In HSS the X-ray emission is dominated by the inner regions of the accretion disc, where the gravity of the BH has the strongest effect.
- The GR effects and the returning radiation in the vicinity of the BH introduce an energy dependence on the observed polarisation properties of the thermal emission making polarimetric data a valuable tool for estimating the BH spin via the relation between the ISCO radius and spin
- The spin measured was consistent with previous measurements
- The spin has been measured for: LMC X–3, 4U 1957+11, and Cyg X–1.



Marra et al. 2024



(Connors & Stark 1977; Stark & Connors 1977; Connors et al. 1980; Schnittman & Krolik 2009; Tanaka & Lewin 1995; Steiner et al. 2010; Dovciak et al. ˇ 2008; Taverna et al. 2020 Fabian & Lasenby 2019).

Conclusions

- The IXPE observations have shown that all BH X-ray binaries observed until now share same properties with the exception of Cyg X-3 and 4U 1630-47.
- With polarization is possible to constrain:
- the geometry of the corona
- the spin of the BH
- However, not all the polarization properties have been already explained

- There are several INTEGRAL/IXPE simultaneous data that are crucial to constrain the high energy behavior .
- The spectral analysis in not easy to do but the work in on going:
  - Swift 1727.8, Mastroserio et al. in prep;
  - 4U 1630-47, Capitanio et al in prep
  - GX 339-4 ; Cyg X-1 and Cyg X-3

Thank you