IXPE
Imaging X-Ray Polarimetry Explorer

ROMA TRE
UNIVERSITÀ DEGLI STUDI

Modelling Polarization Properties of Neutron Stars in LMXBs

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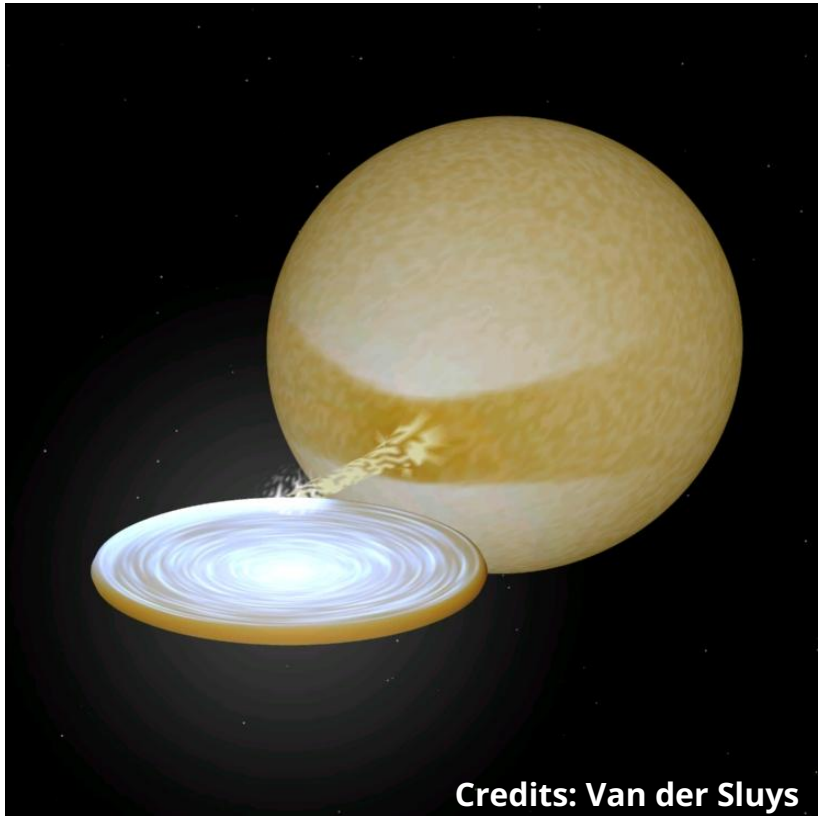
Weakly Magnetized NS in LMXBs

- **Accrete matter** via **Roche-Lobe overflow** from a companion (late Main Sequence) star or white dwarf
- Classified in **High Soft** or **Low Hard** state by their joint timing and spectral properties
- **Highly variable sources**, with possible X-ray bursts
- The presence of the NS stops the accretion flow forming a **boundary** or **transition layer**, extending also at high latitudes on the NS surface



X-ray Emission of NS-LMXBs

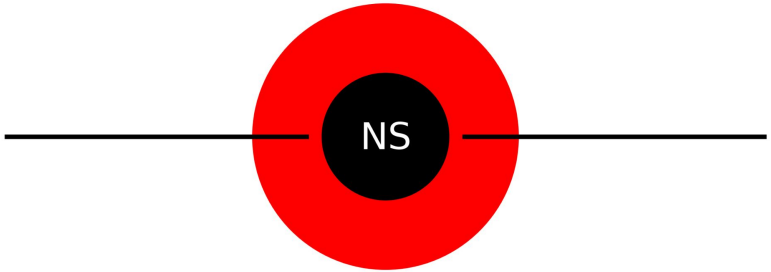
X-ray radiation coming from NS-LMXBs is generally modelled with a **thermal emission** (either from the NS or the disc) and a **Comptonised one** by the hot electron corona

Western Model
(White et al. 1988)

- NS pure blackbody
- Disc photons Comptonised

Eastern Model
(Mitsuda et al. 1984)

- Multicolour disc blackbody
- NS photons Comptonised



MONK: GR Monte Carlo Radiative Transfer Code

Capable of calculating the energy spectrum, lightcurves and polarization of the radiation coming from a NS-LMXB, including the emission of the corona illuminated by both the NS and the disc (Zhang et al. 2019, 2022):

- BB spectrum (kT_{NS}) assumed to model the unpolarized NS emission
- Disc seed photons generated according to disc emissivity and can be considered either polarized (Chandrasekhar 1960) or not

Raytraces photons along null geodesics in curved spacetimes and collects photons arriving at infinity

Includes all SR and GR effects (gravitational redshift, light bending, rotation of polarization vector)

Numerical Setup

NS Parameters:

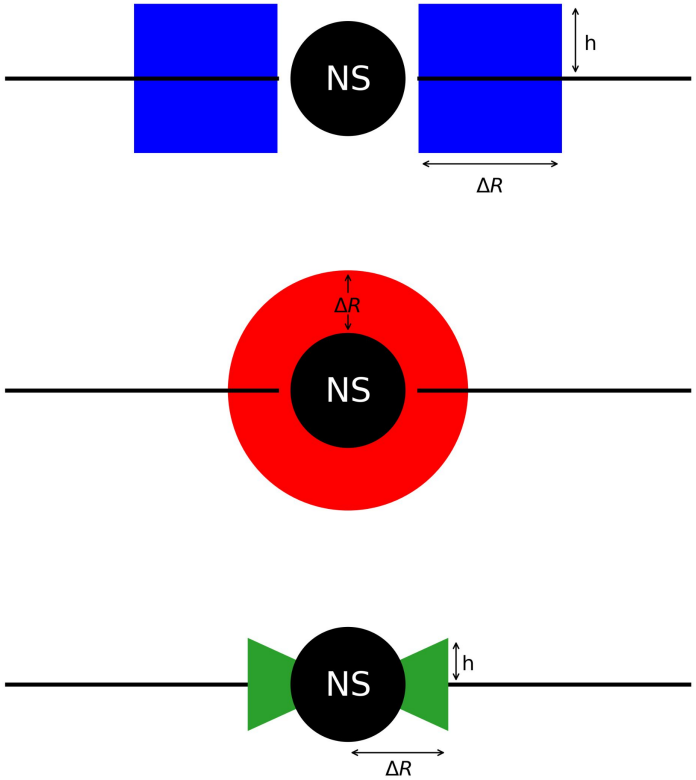
- $M_{NS} = 1.4\ M_{\odot}$
- $R_{NS} = 12$ km
- $P_{NS} = 3$ ms
- $kT_{NS} = 1.5$ keV

Disc Parameters:

- $f_{col} = 1.8$
- $R_{in} = 8\ R_G$
- $R_{out} = 50\ R_G$
- $\dot{M} \approx \dot{M}_{Edd}$

Corona Parameters: $kT_e = 3$ keV, $\tau = 4 - 8$

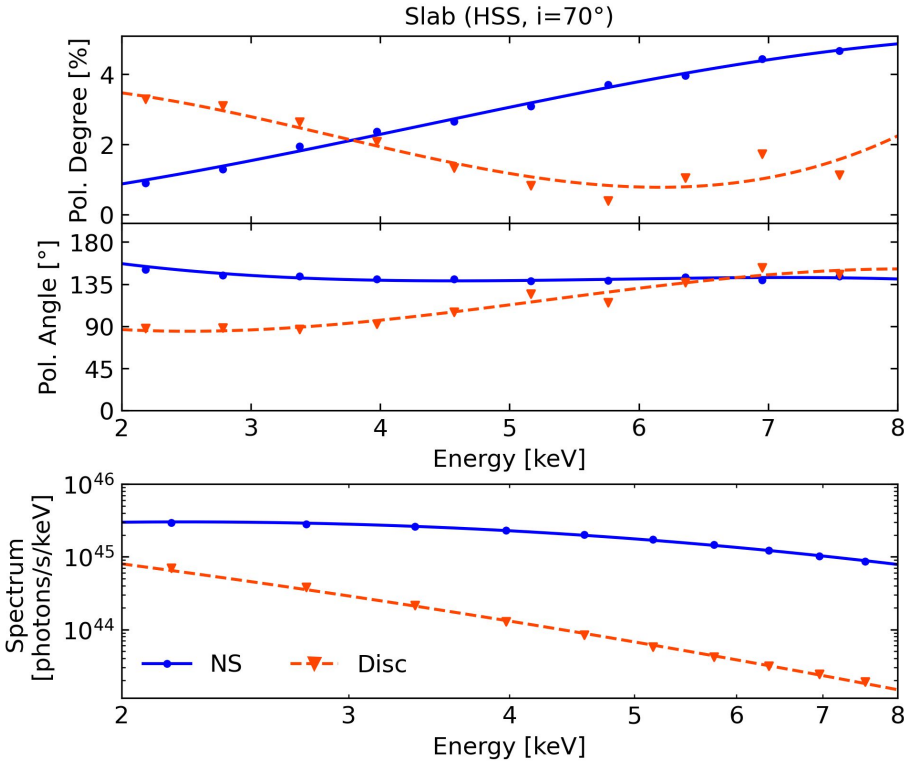
- Slab: $H \approx R_{NS}$, $\Delta R = 2H$
- Shell: $\Delta R \approx R_{NS}$
- Wedge: $H \approx R_{NS}$, $\Delta R = R_{in}$



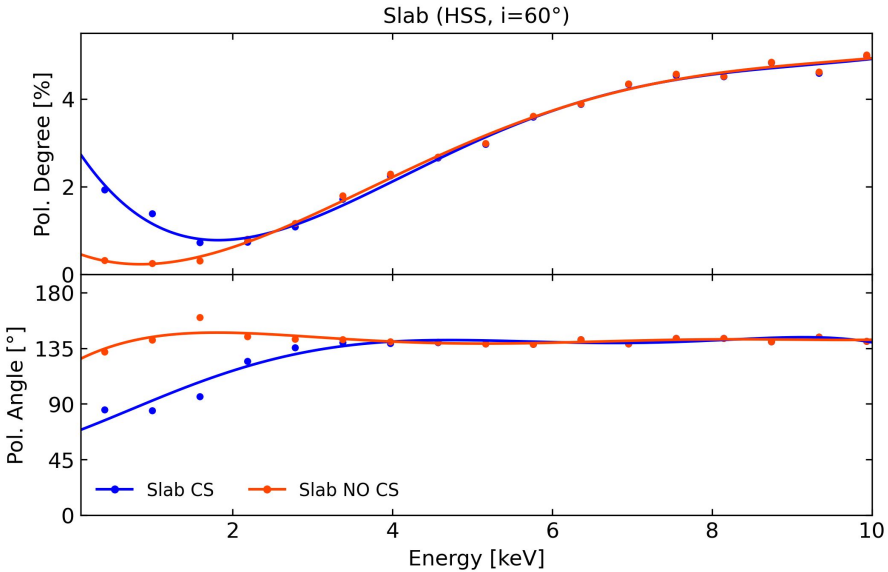
Gnarini et al. 2022

Slab Corona

Gnarini et al. 2022

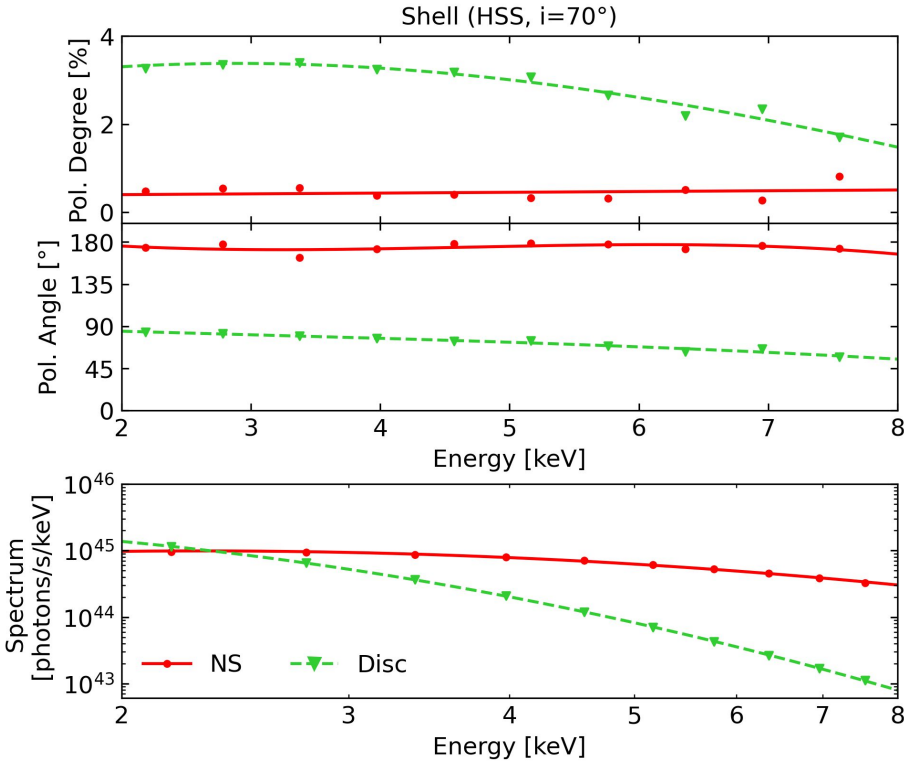


Assuming or not intrinsic disc polarization (Chandrasekhar 1960)

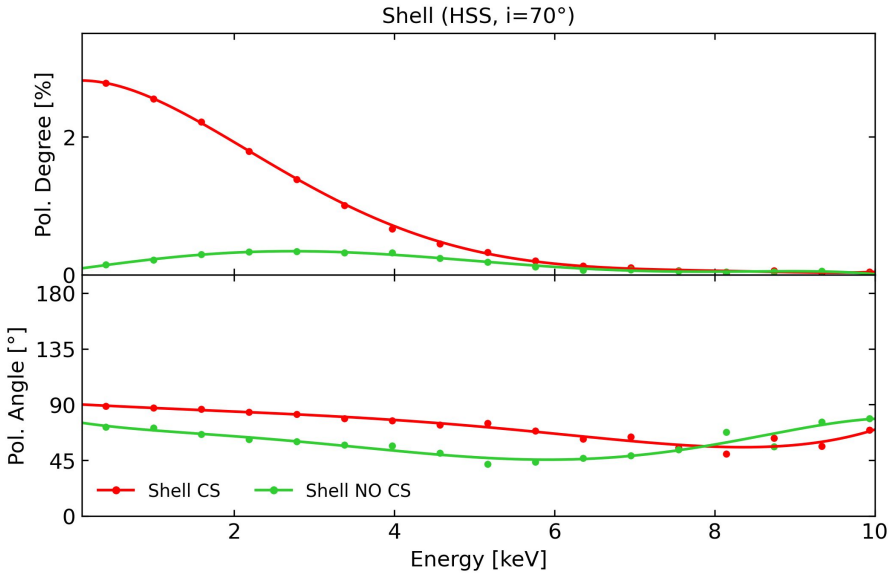


Spherical Shell Corona

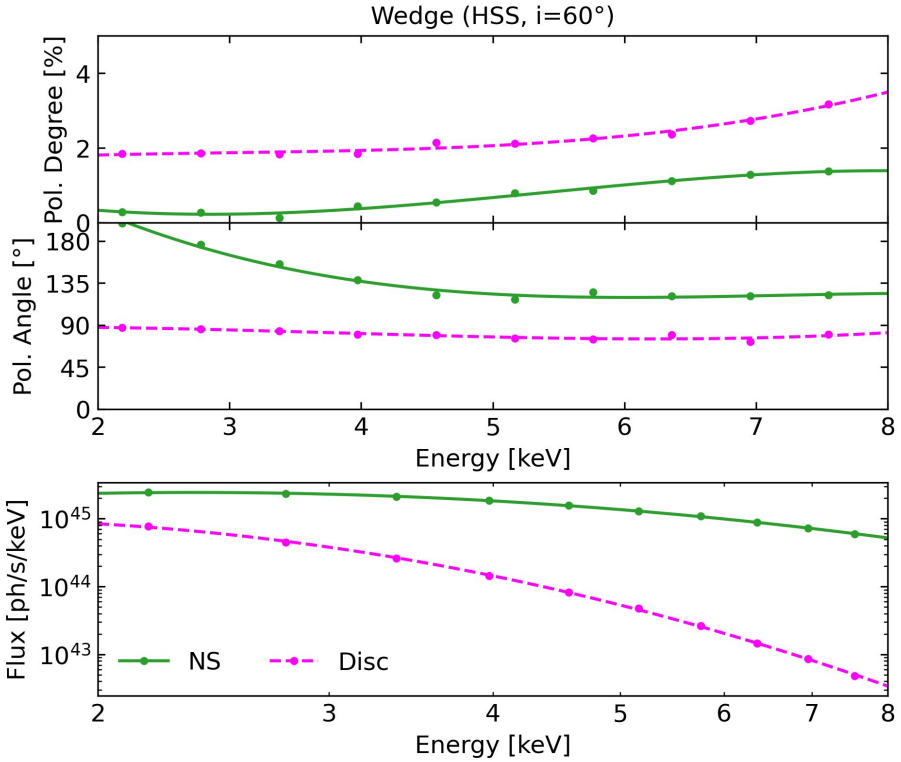
Gnarini et al. 2022



Assuming or not intrinsic disc polarization (Chandrasekhar 1960)



Wedge Corona



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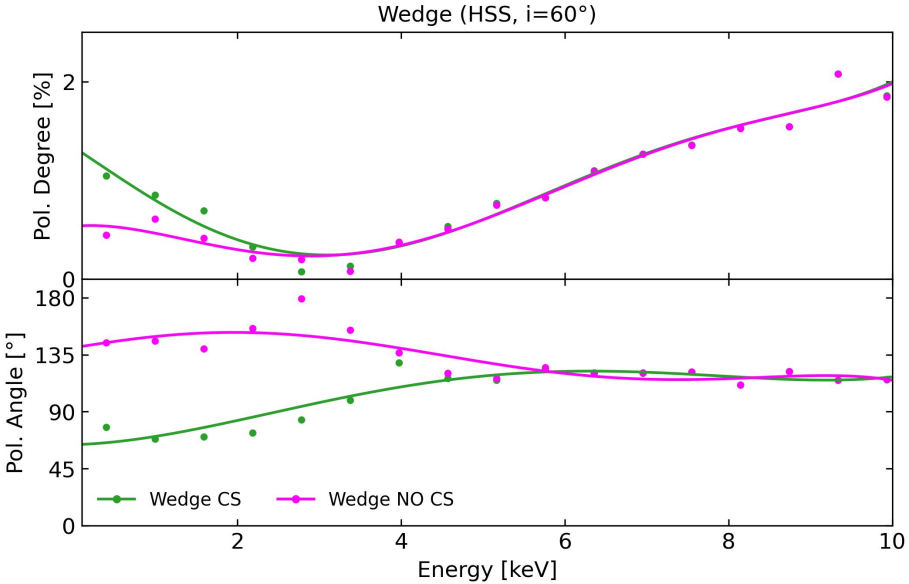
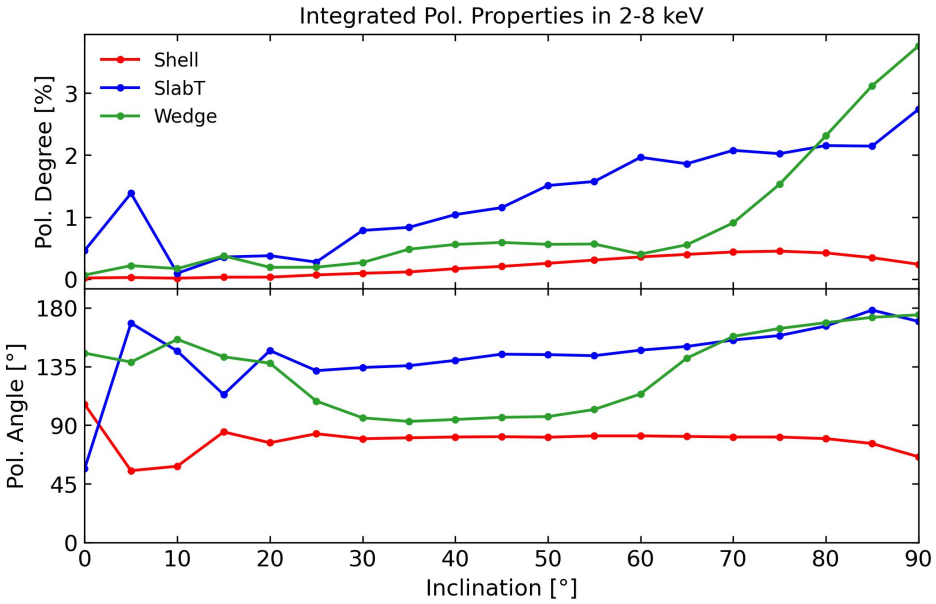
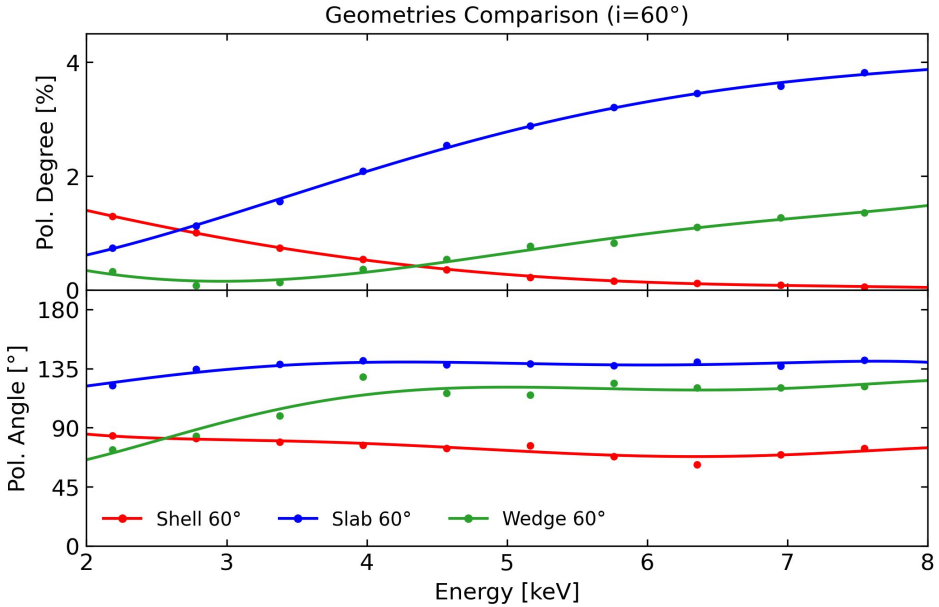


Different Inclinations & Geometries Comparison





IXPE Observations of NS-LMXBs

- **GS 1826-238** observed on 2022 March 29–31, for a total net exposure time of 85 ks (+ joint NICER and INTEGRAL obs.)
- **Cygnus X-2** observed from 2022 April 30 to May 02 for about 75.5-ks of net exposure time (+ joint NICER and INTEGRAL obs.)
- **GX 9+9** will be observed in October for 100 ks (+ joint NuSTAR, NICER and INTEGRAL obs.)

+ XTE J1701-462 (after 15 years of quiescence) **& 4U 1820-303** scheduled for the second observing period (October 2022 to March 2023) + ...

Best-fit parameters obtained from NuSTAR+NICER+INTEGRAL spectra **used** as **input parameter** for MONK simulations to compare the results with real IXPE observations

Summary and Conclusions

- For all geometries and spectral states, **higher inclinations** lead to **higher polarization degree**
- **Polarization degree** and **angle** can be **very distinctive** between the **corona geometries**: the slab and the wedge are characterized by a significantly higher PD than the spherical shell
- For **GS 1826-238 no polarization detected** → only an **upper limit on the inclination** of the system or the **corona configuration** is very **spherically symmetric**
- Fo[illegible] **stent with** [illegible] and disc photons must be polarized along the jet (i.e. perpendicular to the disc) or reflection radiation could be a significant contribution

SPOILER!
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FOR IXPE OBSERVATIONS RESULTS