The X-ray Imaging Polarimetry Explorer (XIPE) under phase A study (ESA M4 call)

Opening a new observational window: what we want to observe and why

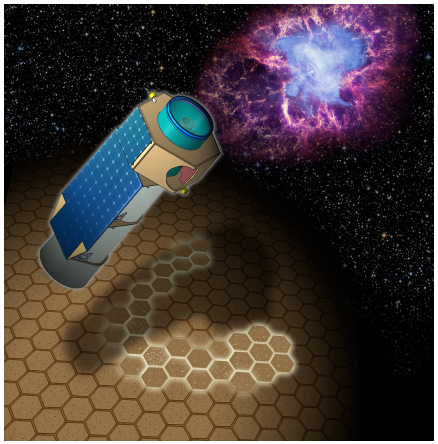
What imaging X-ray polarimetry can do for:

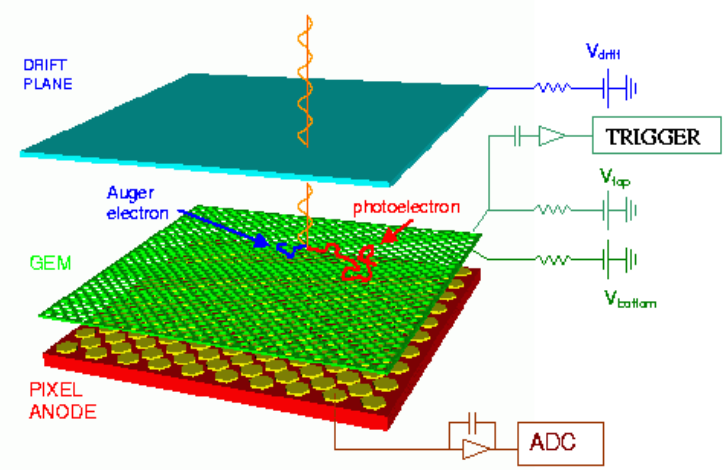
- **Resolved sources**:
  Study emission mechanisms, map mag. field:
  PWNs, SNR and extragalactic jets,
- **Unresolved sources**:
  Inner part geometry of compact sources:
  X-ray pulsars, corona in XRBs and AGNs.

Also: studying fundamental physics, like QED birefringence in the strong mag. fields of magnetars.

If selected, XIPE is launched during 2024-2026 with more than 200 sources to be observed in a nominal life time of 3 years.

XIPE and the Gas Pixel Detector to image X-ray polarization





A **large** number of scientific topics and observable sources:

Astrophysics

Acceleration phenomena
- Pulsar wind nebulae
- SNRs
- Jets

Emission in strong magnetic fields
- Magnetic cataclysmic variables
- Accreting millisecond pulsars
- Accreting X-ray pulsars
- Magnetars

Scattering in aspherical situations
- X-ray binaries and AGN
- X-ray reflection nebulae

Fundamental Physics

Matter in Extreme Magnetic Fields:
- QED effects

Matter in Strong Gravity Fields:
- GR effects close to accreting BHs

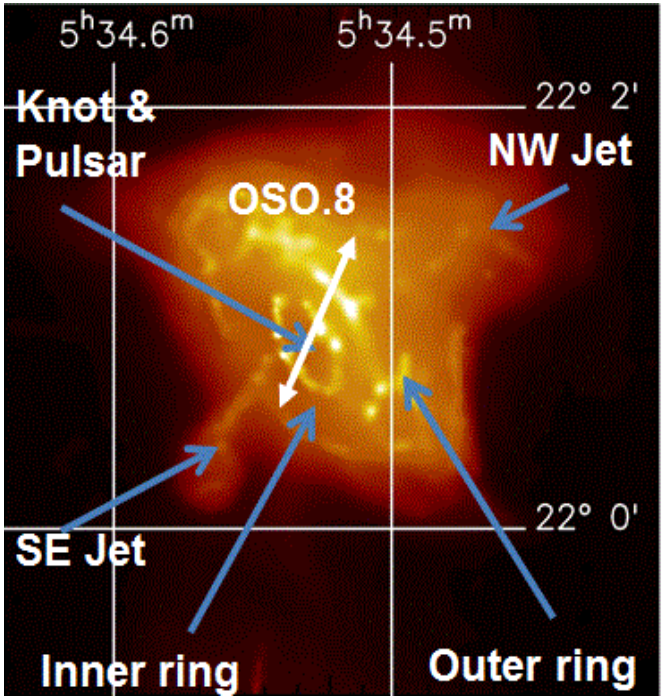
Quantum Gravity

Search for axion-like particles

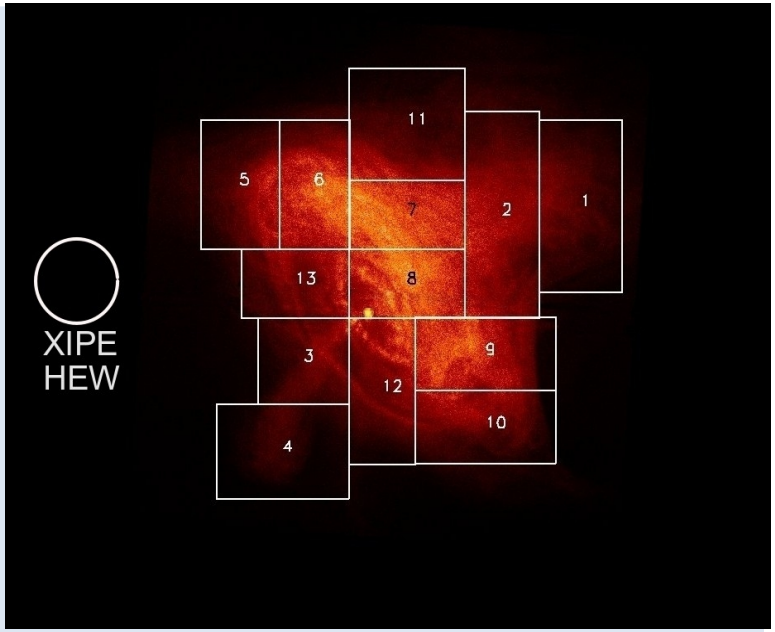
XIPE is going to observe **almost all classes of X-ray sources !**

Acceleration phenomena: The Crab Nebula and other PWNe

Spotlight I on a unique contribution: polarization mapping of the sub-structure of PWNe



Region	σ_{degree} (%)	σ_{angle} (deg)	MDP (%)
1	±0.60	±0.96	1.90
2	±0.41	±0.65	1.30
3	±0.68	±1.10	2.17
4	±0.86	±1.39	2.76
5	±0.61	±0.97	1.93
6	±0.46	±0.75	1.48
7	±0.44	±0.70	1.40
8	±0.44	±0.71	1.41
9	±0.46	±0.74	1.47
10	±0.60	±0.97	1.92
11	±0.52	±0.83	1.65
12	±0.53	±0.85	1.69
13	±0.59	±0.95	1.89



20 ks with XIPE

The only historical X-ray polarimetry measurement from OSO-8 (1970s) is integrated over the entire nebula and measured a position angle that is tilted with respect to the jets and torus axes.

- **New:** XIPE imaging capabilities will allow us to measure the pulsar polarization by separating it from the much brighter nebula emission.
- **New:** X-ray polarimetry probes the mag. field *at the acceleration site(s)*. What is the role of the mag. field (is it turbulent or not?) in accelerating particles and forming structures?
- Other PWN are accessible for larger exposure times (e.g. Vela or the “Hand of God”).
- Several supernova remnants are also accessible (e.g. Cas A or Tycho) for polarization imaging with XIPE and can be studied in the same manner.

QED birefringence in the magnetosphere of magnetars

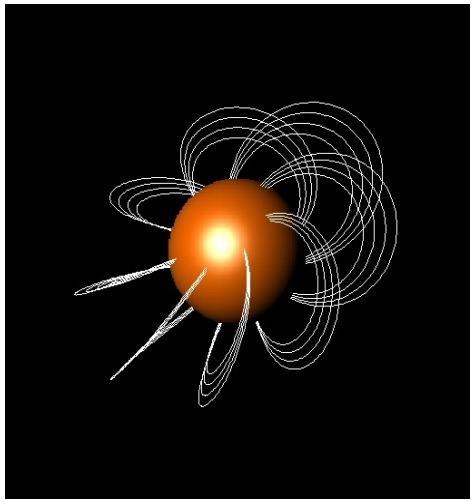
Spotlight II on a unique contribution: QED birefringence in strong magnetic fields

Magnetars are isolated neutron stars with likely very Strong magnetic fields (B up to 10^{15} Gauss).

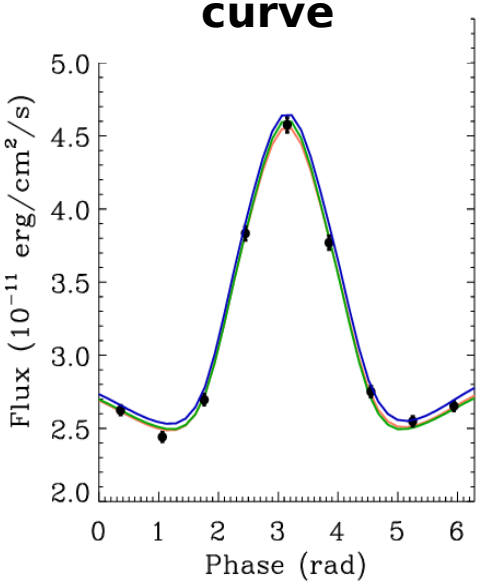
It heats the star crust and explains why the X-ray luminosity largely exceeds the spin-down energy loss.

QED predicts vacuum birefringence, an effect predicted 80 years ago. It is expected in such a strong magnetic field but has never been detected.

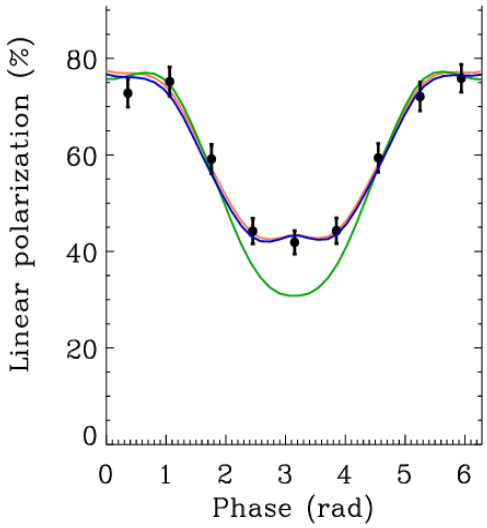
A twisted magnetic field



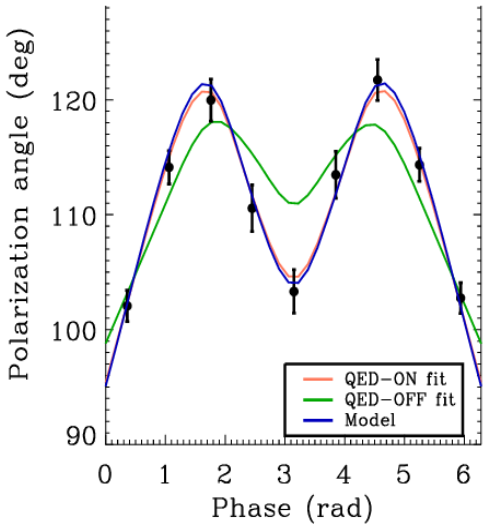
Light curve



Polarization degree



Polarization angle



The effect is **only** visible in the phase dependent polarization degree and angle.

Visit the XIPE website at:
http://www.isdc.unige.ch/xipe/index.php