Soft X-ray Polarimetry using Multilayer Coated Mirrors

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Overview

• **Goals**: measure X-ray polarization from
  • Accretion onto and jets from black holes
  • Strong B-fields of neutron stars
  • Any other scattered or synchrotron emission and propagation in high B
• **Concept**: Bragg reflection at Brewster angle \(45^\circ\) completely polarizes
  • Multilayer coatings give high reflectivity in 0.1-1.0 keV band
  • Coatings have narrow bandpasses but polarized light is likely to be a continuum
  • Disperse with gratings to match ML bandpasses to get broad band
• **Development**: lab work on potential flight components
  • Lab work is funded by NASA APRA for two years
  • Need: better gratings, detailed mission design, ML tech. improvement
Polarimetry of AGN

- Scattered return radiation will be polarized
- Polarization fraction and angle depend on $a/M$, $L/L_{\text{Edd}}$
- Soft and Hard X-ray measurements are needed

GEMS

Schnittman & Krolik 2009

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Neutron Star Atmospheres

- Isolated neutron stars are often cool, kT < 1 keV
- A few soft X-ray spectra show features
- Polarization distinguishes features in spectra
- Atmosphere models are used to determine $R^2$, g to give M,R
Soft X-ray Polarimetry

- Start with general use broad-band mirror

- Use (blazed) gratings (NASA SAT funding) to disperse X-rays

- Add Bragg reflector: multilayer (ML) coated, flat mirror
  - Reflect at 45° angle (Brewster angle) to select polarized photons
  - Many layers in ML brings reflectivity to 10-20%
  - Vary ML period along dispersion to match wavelength

- Total bandpass: 0.2-0.7 keV

- Currently testing concept at MIT
  - Kavli seed funding
  - Recent: NASA APRA
Critical Angle Transmission Gratings

Heilmann+ '12

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A Soft X-ray Spectropolarimeter
Flight Design

grating blaze

ML Mirror

Detector

from above

Detector

Polarizing mirror

CCD

long λ
large D

from side

short λ
small D

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Summary

• Feasible goals: measure X-ray polarization from
  • Accretion onto and jets from black holes
  • Strong B-fields of neutron stars
  • Any other scattered or synchrotron emission and propagation in high B fields
• Concept: Bragg reflection at Brewster angle (45°) completely polarizes
  • Multilayer coatings give high reflectivity (E < 0.8 keV)
  • Disperse with gratings to match ML bandpasses for broad band
• Development: lab work on potential flight components
  • Lab work is funded by NASA APRA for two years
    • testing efficiency, accuracy of graded ML coatings
  • Need: CAT grating X-ray tests, tolerance analysis
  • Mission design: suborbital is tough, “Explorer-Lite” could work