Grating Spectroscopy of the M31 Bulge

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An X-ray View of M 31

Sources with \( L_x > 10^{37} \text{ erg/s} \)
XMM-Newton
Chandra
LETG/ACIS Simulation

250 ks

SuperNova Remnant

Supersoft Source
HETGS Simulation

750 ks
Expected HETGS Counts

- 350
- 750
- 2000
- 6500
- 12500
- >15000
Science Goals

❖ Emission Lines from HMXRB winds
❖ Emission Lines in SNR
❖ ISM Edges in LMXRB
❖ Abundances in LMXRBs
❖ SuperSoft Sources
❖ 1000s of X-ray bursts
❖ Oddities: SS 433, Cir X-1
Luminosity Functions

- Inner Bulge (region 1): 2’ x 2’
- Full bulge (Region 2): 8’ x 8’
- Bulge LF break: $5 \times 10^{36}$ erg/s
- HETGS: 2000 counts per $10^{37}$ erg/s in 700 ks
- Brightest SNR at $6 \times 10^{36}$ erg/s
- >20,000 count for NS with $L = L_{\text{edd}}$
HETGS Data
2.5-3.5 keV
Extracting Spectra

❖ Easy Part: PHA2, ARF, RMF for 9 obsIDs, 105 sources, 4 arms (HeG, MEG, +1, -1) = ~3800 spectra

❖ Hard Part: overlapping spectra of A against B
  ❖ Biggest issue: 0th order of A overlaps TG of B
    ❖ See “confusion plots”
    ❖ make “ignore(obsid/<M,H>EG/<+/->1, E1, E2)”
  ❖ MEG rarely overlaps with MEG (parallel!)

❖ HETGS GTO team is prototyping data handling
Brightest Source

- r2-26 (Kong+ '02 catalog)
- 0.12 cps (MEG+HEG) --> 8,300 counts in 1st obsID
- PL fit: $\Gamma = 1.6$, $N_H = 1.4e21$
ISM Probes

- Brightest Source in M31
  - 21 cm: $N_{H,21} = 1.6$
  - XMM: $N_{H,21} = 2.8 \pm 1.2$
  - HETGS: $N_{H,21} = 3.2 \pm 1.4$
- In progress:
  - $N_H$ for other XRBs
  - Compare Fe L (dust!) to O-K
  - Test against MW
Many More Sources
Future of Chandra and You

❖ How can YOU get involved (before Athena, Surveyor)?
  ❖ AGN?, then M 31* spectra, variability
  ❖ XRBs?, then
    ❖ Transient spectroscopy w/o pileup
    ❖ All bulge XRBs observed as a population
  ❖ ISM?: Edges give elemental abundances, spatial variation
  ❖ SNRs? (better line SNRs!)
    ❖ Examine soft lines and ionization states
  ❖ Add pointing to arm of M 31!
  ❖ Challenging analysis? (timing, diffuse emission, isis —> python)
❖ Exposure time goal: consider 10% of Chandra’s (remaining) lifetime!
  ❖ >3 Ms for M 31? 5 Ms for M33, 10 Ms on NGC 300, others?
❖ Get ready for Surveyor!
  ❖ (PS: Ask me about the REDSoX Polarimeter!)

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