Effective Area Analysis using the Chandra HETGS

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Chandra Effective Area

Herman Marshall (MIT CXC)

Mallorca Feb. 05
HETGS Effective Area Calibration

- **ACIS-S**
  - BI QE vs. FI QE — now down from <15% to <5%
  - Pileup — impact depends on source brightness
  - Si-K edge — 6% edge residual
  - N-K edge in FI chips — more important for LETG/ACIS
  - Contamination — not this talk

- **ACIS OBF**
  - C-K edge energy shift — only important for LETG/ACIS
  - O-K edge — incomplete, depends on contamination

- **HETG Efficiency**
  - MEG/HEG ratio update ready — <7% for E > 0.8 keV
  - Compare LETG to HETG — incomplete

- **HRMA Effective Area**
  - Ir-M edge — 10% jump at 2.075 keV
ACIS BI/FI QE

- New BI QEs improve matters considerably
- FI loss due to CR blooms is included
- At most 3-4% differences in 2-10 keV range
- No problems within HETGS data
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HETGS and LETGS Pileup

- Edge appears at 2.1 keV due to EA jump
- Rate ($R_f$) $\sim 0.01$ ct/frame/col., 5% loss
- Mk 421 (4148): $R_f = 0.05$, giving jump of 19%
LETGS — Pileup

Flux (ph/cm²/s/keV)

Energy (keV)

$N_H$: $2.1150617e+20$

$A_1$: 2.0493584

$\Gamma_1$: 1.9017482

$A_2$: 0.53020634

$\Gamma_2$: 1.8563525

$\tau_{C-K}$: 2.0767686

$\tau_{N-K}$: -0.016886855

$\tau_{O-K}$: 0.033560230

$\tau_{F-K}$: 0.0073570022

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Si-K Edge in BI QE

- Appears when using the new BI QE models
- Effect is an inverse, reversed edge
- Jump is about 6%

MEG, 15 sources

Counts (+1)

Wavelength (Å)
Fitting Si-K Edge in HETGS Residuals

- Use 13 blazar observations
- Si-K is near Ir-M
  - Fixing Ir-M edge requires good fit to Si-K
  - Use 2 steps: approx. Si-K to get Ir-M, then use good Ir-M fix to finish Si-K fix adjustment
- Residual has near edge structure — use Si-K opacity from ACIS team
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HETGS Residuals after fixing Ir-M edge
Fit to Si-K edge

MEG and HEG fits in Si–K region

$\tau_{\text{Si-K}} = 0.0619 \pm 0.0036$

Residual

Wavelength (Å)

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N-K Edge in FI QE

- Found 2 yr ago in PKS 2155-304 data
- Objective was to find N-K in contaminant
- Target was offset to put N-K on Bl chip
- N-K is OK in filter, not in Fl chip
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Contamination

- Filter dominates below .2867 keV, contaminant above
- Composition from edges: C:O:F:N ~ 55:5:4:<2
- ECS gives slower deepening than elemental model
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HRMA Ir-M fix & HETGS

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HEG/MEG Comparison

Fit spans full HEG wavelength range

Damp polynomial here
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HRMA Ir-M edge

- Jump is about 10%
- MEG and HEG agree
- See Diab Jerius’ talk
HRMA Overlayer Study

HETGS, 13 Blazars (10/99 through 7/04)

10 Å overlayer

15 Å overlayer

25 Å overlayer

20 Å overlayer

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HRMA Overlayer: \( 20 \pm 5 \) Å
(Updated Optical Constants)

- 20 Å overlayer is best now
- Si-K edge was updated, no residual observed
- Offset of 5% due to poor fit to PL models
Fit Results

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Fit Results

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Fit Results

$\ln(\text{Flux, ph/cm}^2\text{s/keV})$ vs $\ln(E, \text{keV})$

$A: 0.021147127$

$\Gamma: 1.6652503$
MEG-HEG Consistency

- Fit PL models to MEG and HEG independently
- Fit parameters show slight calibration biases
HETGS of 1H1426+42

1H1426+428 (HETGS, new EA) MEG

Gamma = 1.9582410
N_H = 1.36000e+20

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HETGS of 1H1426+42

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Summary

• Most spectral edges and narrow features are fixed (or fixable)

• HRMA and ACIS EA require 2 more adjustments
  • Si-K edge
  • Ir-M edge

• MEG fix relative to HEG is still not right
  • Smoother spectra are possible
  • Cross-calibration with XMM will help