Composition of the Chandra ACIS Contaminant

Herman L. Marshall (MIT),
Allyn Tennant (MSFC), Catherine E. Grant (MIT), Adam P. Hitchcock (Dept. Chemistry, McMaster U.), Steve O’Dell (MSFC), Paul P. Plucinsky (SAO)
Early Findings

★ Observations of AGN with ACIS/LETG led to discovery of contaminant C-K edge

★ Early repair was a one-time fix, good for observations in early 2000
C-K Edge is Unlike the Edge in the ACIS Filter

- Count spectrum from XTE J1118+480
- Filter dominates below .2867 keV, contaminant above
Modeling the C-K edge: EXAFS

- Data taken from June 2002 observation of PKS 2155-304
- Fit to power law without the 0.28-1.0 keV region
- Henke constants used above 0.4 keV
- Slight feature in 0.285-0.287 keV region added
- No N-K to <5%
Modeling the C-K edge: EXAFS

- Opacity due to C-K edge in contaminant is adjusted near the edge
- Adjustment has “ripple” and exponential drop away from edge
- Edge is at 0.2867 keV
Modeling the O-K and F-K edges (Mk 421)

- TOO on Mk 421 gave a very good spectrum: over 4e6 counts
- Accounting for new C-K edge, O-K and F-K detected
  - F-K is not ID’ed with Fe-L in source frame
- O-K edge model derived from O in polyimide
- F-K edge constructed as in C-K, with NEXAFS & EXAFS
Checking the Model Fit

- Good fits obtained in F-K and O-K edge regions
- Features that remain are
  - intrinsic (ISM), or
  - due to uncorrected BI/FI relative errors
Abundances in the ACIS Contaminant

- Column densities, in atoms per sq. cm are
  - Carbon: $2 \times 10^{18}$
  - Nitrogen: $< 7 \times 10^{16}$
  - Oxygen: $1.75 \times 10^{17}$
  - Fluorine: $1.45 \times 10^{17}$

- Relative to Carbon:
  - N/C < 30
  - O/C = 11.5 ± 1
  - F/C = 14 ± 1

- Fluorinated compounds in Chandra (Braycote, Krytox) do not have so little F or O relative to C
  - Fluorocarbons must comprise only a small part of contaminant
  - Fluorocarbons can “crack” due to radiation into smaller compounds that may be hydrocarbons
Lack of 0.285 keV absorption spike due to C=C double bonds indicates that contaminant is not aromatic (benzene rings)

Contaminant does not have absorption like Teflon associated with C-F bonds

Aliphatic hydrocarbons (like amine epoxy) with simple C-H bonds gives the best match

Contaminant is mostly comprised of aliphatic hydrocarbons
Contamination Buildup

- C-K edge depth is easily measured in each LETG/ACIS data set
- Model is asymptotically linear, forced to go through zero at ACIS opening
- Model fits C-K edge data well but O-K edges are smaller than expected
Comparison to the External Cal Source

- The ACIS External Calibration Source (ECS) illuminates ACIS with Mn L & K lines for gain monitoring.
- Ratio of ECS Mn L to K varies and provides an optical depth.
- Optical depth in 2001-2003 is 20% higher than predicted from C-K (10-15% less throughput at 0.7 keV).
- No good explanation for difference yet ...

Extra absorbers like Si have undetected K or L edges.
ECS may be too warm to have its own contamination.
H opacity? H/C ~ 1000 required for odd material.
Conclusions & Future Work

See: http://space.mit.edu/ASC/calib/letg_contamination.html

- Chandra ACIS contaminant consists mostly of carbon with some oxygen and fluorine
- Ratios do not match fluorinated compounds on Chandra
- C-K edge does not match fluorinated compounds
- We suggest that Bracyote (or Krytox) cracks upon radiation damage and that mobile components are aliphatic hydrocarbons
- We are investigating spatial variations — including small-scale variations (fluffy?)
  - Scale of few mm seems consistent with ECS
  - Small-scale change investigation requires self-consistent approach
- X-ray transmission of radiation-damaged Bracyote indicates aliphatics result