AtomDB: Atomic Data for Astrophysics

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Major needs are **H-like**, **He-like**, and **Fe** (and to a lesser extent Ni) **L-shell** line data
Non equilibrium modeling

Cas A
Non equilibrium modeling

Cas A
Tycho SNR
Type 1a
Exploded 1572
Tycho SNR
Type 1a
Exploded 1572
Inner Shell Processes

Fluorescence

Autoionization

Autoionization+

Fluorescence Yield:

\[ \omega = \frac{Ar}{(Ar + Aa)} \]
Modeling NEI emission
New Model

Build in proper handling of autoionizing levels to AtomDB.

- Inner shell excitation
- Inner shell ionization
- Fluorescence
- Auger breakup

- Include levels for Kβ, Ky.
Method

- Large scale Flexible Atomic Code runs
  All ions, all 14 most common elements
- Fe data for L & K shell ions from Eriksen+ 2013
Effect of NEI Modelling

(a) $K\alpha$ centroid

(b) $K\beta$ centroid

(c) $K\beta/K\alpha$ flux ratio

Fe $K\alpha$

Red: $Fe^{16+}$ ($K\beta/K\alpha \sim 0.01$)
Green: $Fe^{8+}$ ($K\beta/K\alpha \sim 0.15$)

Surface Brightness

$K\alpha \times 0.1$

$K\beta$
Recombining plasma

Observed in many SNR
Ozawa+ 2009, W49B
\( kT_e = 1.5 \text{keV} \)
\( kT_i = 2.7 \text{keV} \)
Recombining NEI run
AtomDB CX Model

If there is neutral H and/or He to mix with hot ions, charge exchange dominates!

No comprehensive model of CX emission available

Low energy:
400-700km/s = 1-3 keV/amu
CX Model

\[ \varepsilon = \int N_H N_{\text{ion}} \sigma_{\text{cx}}(E) \, dl \]

Assume \( \sigma_{\text{tot}} \) constant = \( 3 \times 10^{-13} \) cm\(^2\)

Peak n shell:

\[ n' = q \sqrt{\frac{1}{2} \frac{I_H}{I_p}} \left(1 + \frac{q-1}{\sqrt{2}q} \right)^{-\frac{1}{2}} \]
CX Model

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![Graph showing fraction of capture into n'=g shell vs shell number (l)]
CX Testing

![Graph showing count rate versus wavelength.](image-url)
CX Testing

We find that the existing atomic emission data for this energy band are not adequate to fit the measured spectrum of the hot interstellar medium. We will continue to work with atomic physicists to calculate new theoretical spectra of relevant ions, and to benchmark these spectra against astrophysical spectra of bright, relatively well-understood stars that have been obtained with the Chandra X-ray Observatory. When we have adequate atomic data for the
CX Testing

![Graph showing CX lines and data consistency with flux of ~6 LU](image_url)

- O VI CX lines?
- Fe IX; data consistent with flux of ~6 LU
- LHB only model
- Background

CHIPS, Hurwitz+05
New Model

DXS spectral data

Total Fit
- LHB
- Slow SWCX
- Fast SWCX

Surface Brightness (counts/s/sr)

Wavelength (Å)
Queries and Questions...

• Inner shell data – better sources?

• CX data – low energy model improvements?

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