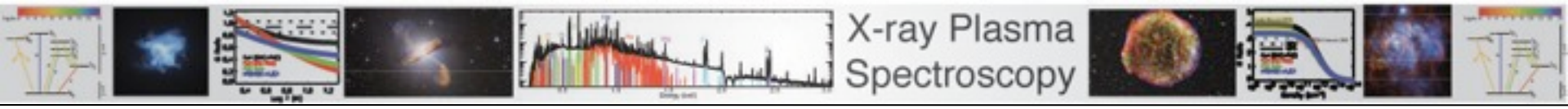


AtomDB – A Status Report

Randall K. Smith

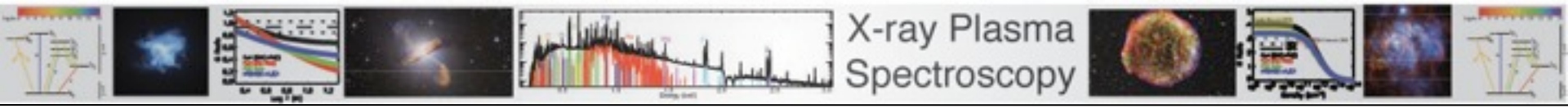
and Adam Foster

Smithsonian Astrophysical Observatory

Quick Update

- 2009 ADP for AtomDB
  - Co-Is Brickhouse, Kallman
  - Funding post-doc Adam Foster @ CfA, previously in the fusion / ADAS world
  - Will update and merge collisional, photoionized atomic databases
  - Version 2.0.0 of AtomDB being readied now.
  - Will include apec release, with built-in NEI and density-dependent abilities.

All ions are equally important.



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...but some are more equal than others.

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H-like : All transitions of astrophysically abundant metals (C→Ni) are in the X-ray band. Lyα/Lyβ is a useful temperature diagnostic; Lyα is quite bright.

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He-like: $\Delta n \geq 1$ transitions are all bright and in X-ray. The n=2→1 transitions have 4 transitions which are useful diagnostics, although R=300 required to separate them.

Ne-like: Primarily Fe XVII; two groups of bright emission lines at 15Å and 17Å; ionization state and density diagnostics.

… and don't forget the Fe L-shell in general…

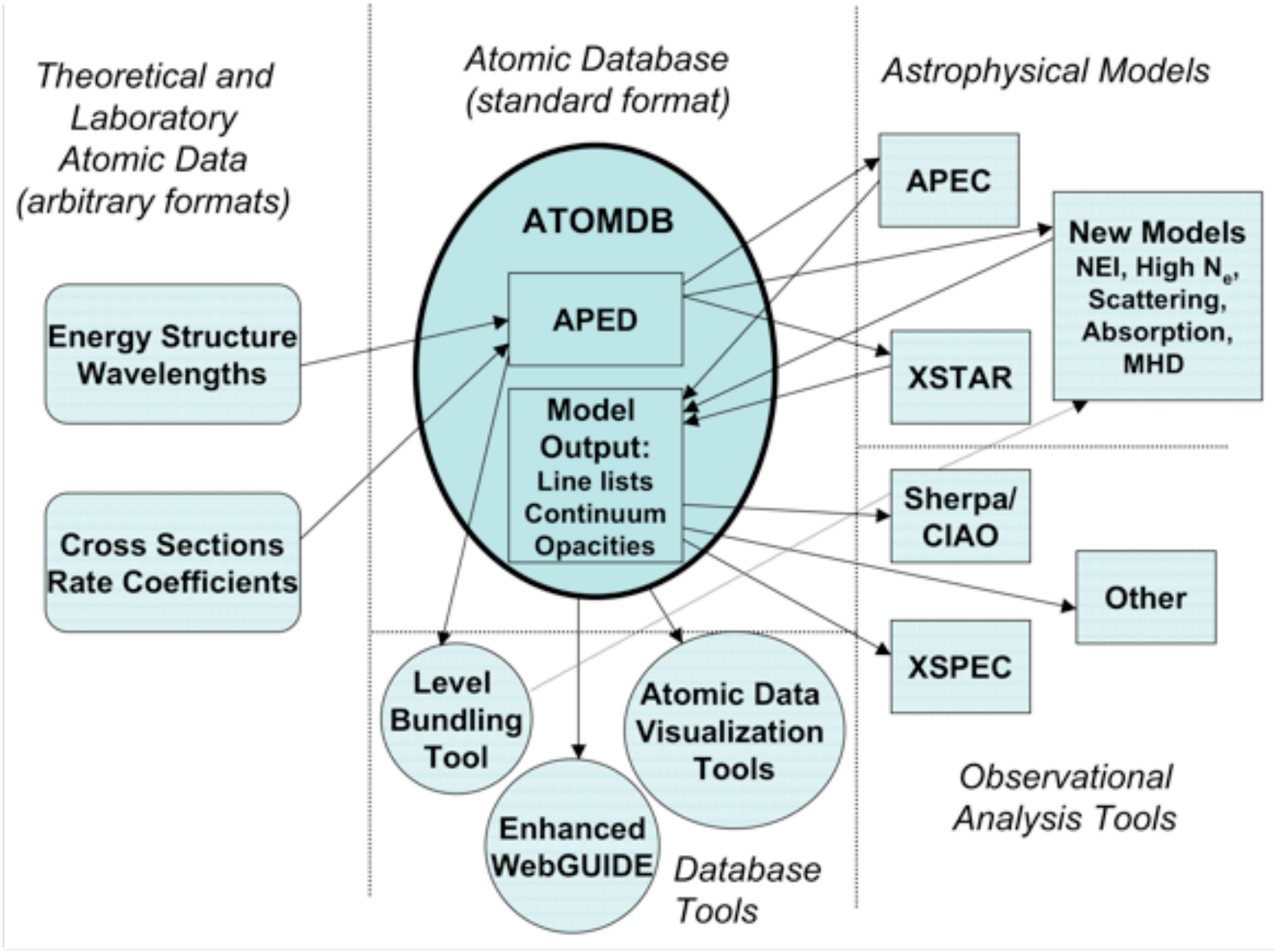
All ions are equally important.

...but some are more equal than others.

H-like : Up to n=10, n<6 from R-matrix, n>5 from FAC. All elements with Z=6 – 30 included. Also DR, RR updates

He-like: Up to n=10, n<6 from R-matrix, n>5 from FAC. All elements with Z=6 – 30 included. Also DR, RR updates

Fe L shell: Updated using R-matrix calculations from the Iron Project. Higher n transitions from existing HULLAC calculations retained. Also DR, RR updates.


Theoretical and Laboratory Atomic Data (arbitrary formats)
Energy Structure Wavelengths
Cross Sections Rate Coefficients
Atomic Database (standard format)
ATOMDB
APED
Model Output: Line lists Continuum Opacities
Level Bundling Tool
Atomic Data Visualization Tools
Enhanced WebGUIDE
Database Tools
Astrophysical Models
APEC
New Models NEI, High N_e, Scattering, Absorption, MHD
XSTAR
Sherpa/ CIAO
Other
XSPEC
Observational Analysis Tools

ATOMDB

- New web site:

http://www.atomdb.org/

Describes code, physics, answers basic questions

- Will have new tools to simplify data analysis
- Will allow submission of new data for consideration (we'll still trawl the journals too)

ATOMDB Atomic Data for Astrophysicists

Features Comparisons Physics FAQ Download

Overview
Density Diagnostics
Spectrum Calculation
GUIDE Routines
IDL Routines
File Formats
WebGUIDE

What is the ATOMDB?

ATOMDB i base useful for X-ray plasma spectral modeling. The current version of ATOMDB i or modeing collisional plasmas, those where hot electrons colliding with astrophysi lements and ions create X-ray emission. However, ATOMDB is also useful wh rption by elements and ions or even photoionized plasmas, where X-ray photons (le power-law source) interacting with elements and ions create complex s

Our goal i not only all relevant data, generated both from theoretical models and experimer tically evaluate this data to create recommended models. Each revision of the criti database is given a version number to aid reference.

The current release is version 1.3.2. This is an interim update to version 1.3.0, with no changes to the underlying atomic database.The only change is that the models now extend to 50 keV, and some internal keywords have been updated. Please see the the release notes for more details.

For interactive line lists and data, we provide the ATOMDB WebGUIDE.

ATOMDB provides improved spectral modeling capability through additional emission lines, accurate wavelengths for most strong X-ray transitions, and new density-dependent calculations. While many of the improvements are directed toward X-ray grating data analysis, some differences between ATOMDB and other models might be noticeable even at moderate (CCD) resolution.

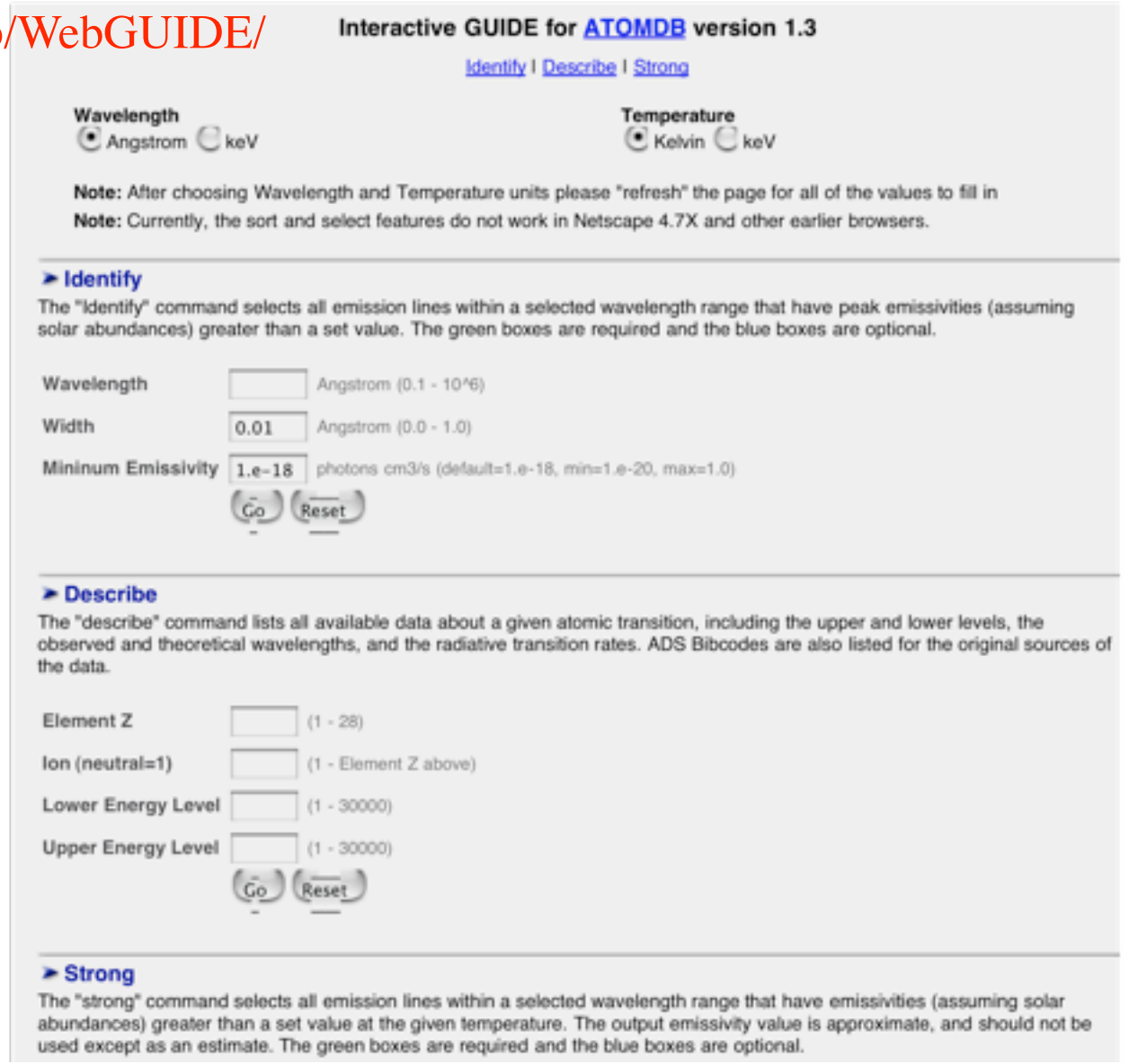
The atomic database ATOMDB includes the Astrophysical Plasma Emission Database (APED) and the spectral models output from the Astrophysical Plasma Emission Code (APEC). The APED files contain information such as wavelengths, radiative transition rates, and electron collisional excitation rate coefficients. APEC uses these data to calculate plasma model spectra. The APEC output models in ATOMDB are for optically-thin plasmas in collisional ionization equilibrium. APEC outputs separate continuum and line emissivity files, making it easy to model continuum and line emission separately as well as together.

The ATOMDB is used by Sherpa, GUIDE and ISIS to identify emission lines and to calculate spectra for comparison with observations. All the files in the ATOMDB are in FITS format, and can be easily read using the CIAO's Prism.

WARNING: There are a number of important caveats to this release. Despite the many improvements we have made, in some cases using the mekal or raymond models may be a better choice. Please read the caveats carefully!

http://cxc.harvard.edu/atomdb/WebGUIDE/

Webguide will see some major advances – please let me know what you'd like to see in the 'new' Webguide



Interactive GUIDE for ATOMDB version 1.3

Identify | Describe | Strong

Wavelength ◉ Angstrom ○ keV

Temperature ◉ Kelvin ○ keV

Note: After choosing Wavelength and Temperature units please "refresh" the page for all of the values to fill in

Note: Currently, the sort and select features do not work in Netscape 4.7X and other earlier browsers.

Identify

The "Identify" command selects all emission lines within a selected wavelength range that have peak emissivities (assuming solar abundances) greater than a set value. The green boxes are required and the blue boxes are optional.

Wavelength		Angstrom (0.1 - 10^6)
Width	0.01	Angstrom (0.0 - 1.0)
Mininum Emissivity	1.e-18	photons cm3/s (default=1.e-18, min=1.e-20, max=1.0)

Go Reset

Describe

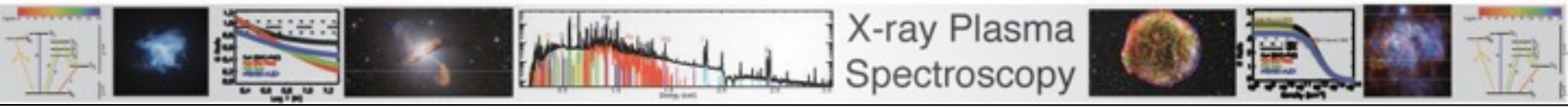
The "describe" command lists all available data about a given atomic transition, including the upper and lower levels, the observed and theoretical wavelengths, and the radiative transition rates. ADS Bibcodes are also listed for the original sources of the data.

Element Z		(1 - 28)
Ion (neutral=1)		(1 - Element Z above)
Lower Energy Level		(1 - 30000)
Upper Energy Level		(1 - 30000)

Go Reset

Strong

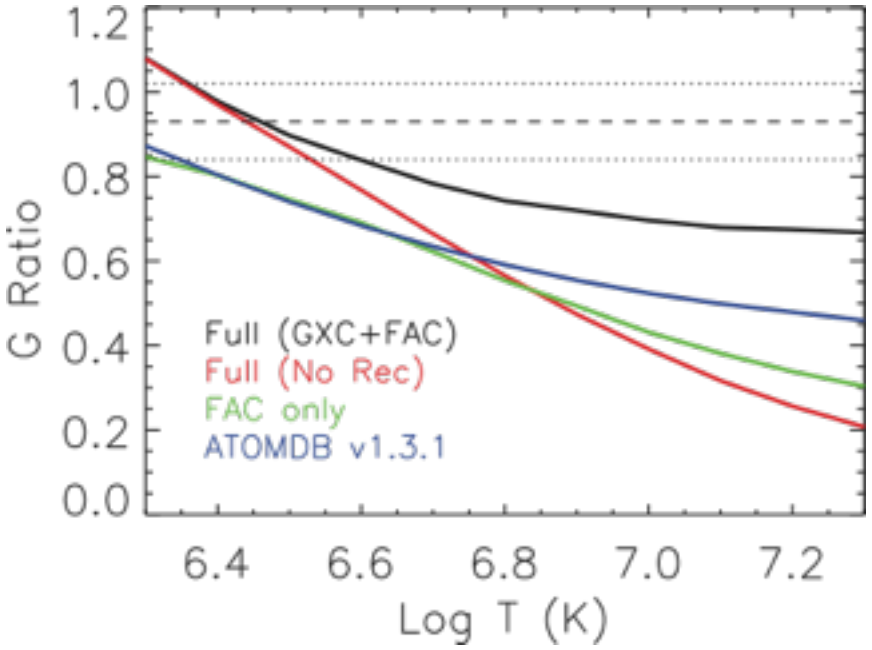
The "strong" command selects all emission lines within a selected wavelength range that have emissivities (assuming solar abundances) greater than a set value at the given temperature. The output emissivity value is approximate, and should not be used except as an estimate. The green boxes are required and the blue boxes are optional.

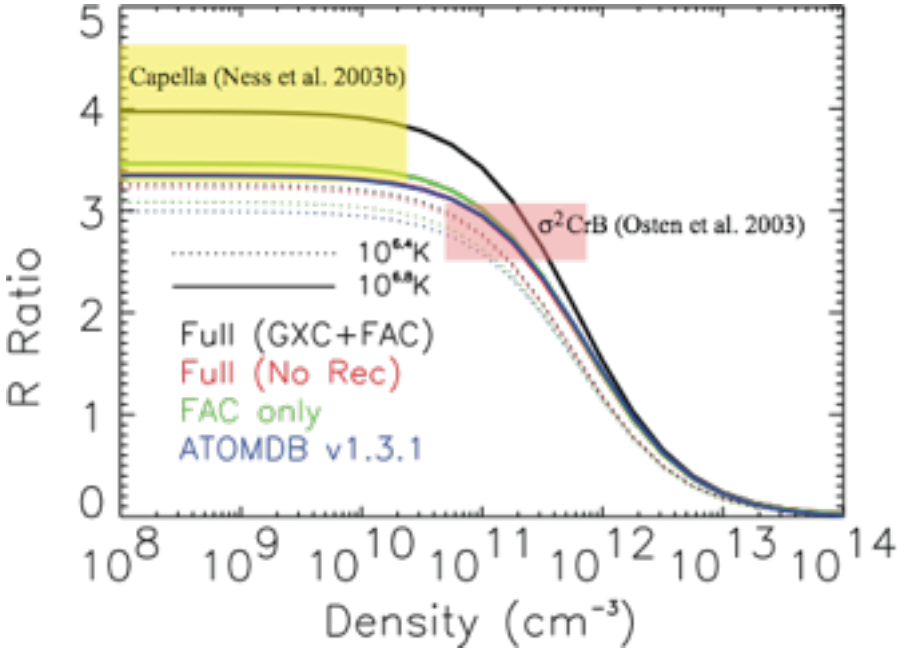


Spectroscopy Issues & Answers

- Accurate Line Ratios
- Complete Line Lists
- Fe L shell Problems
- Model Errors

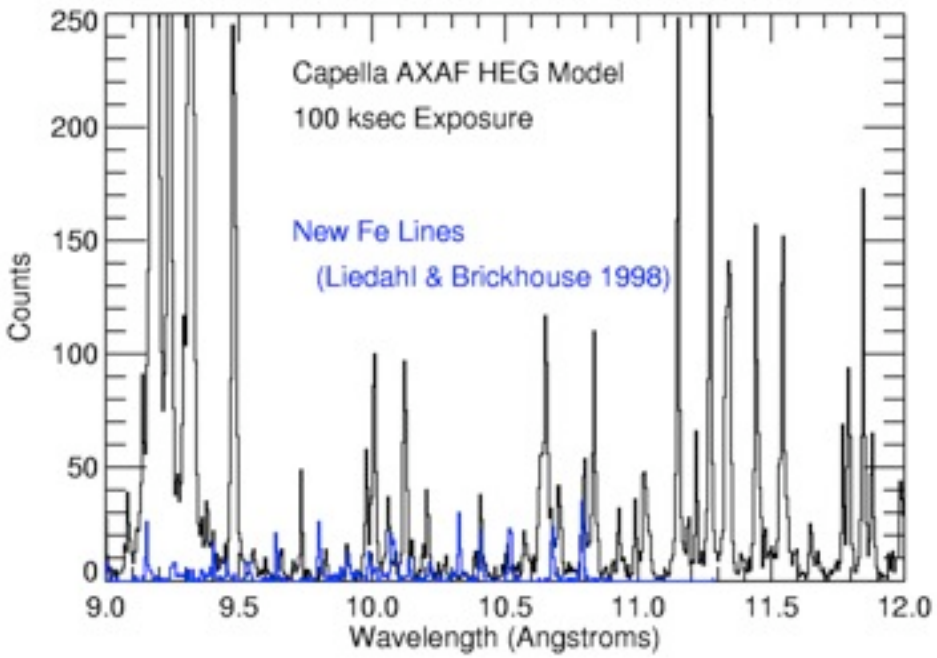
Line Ratio Uses

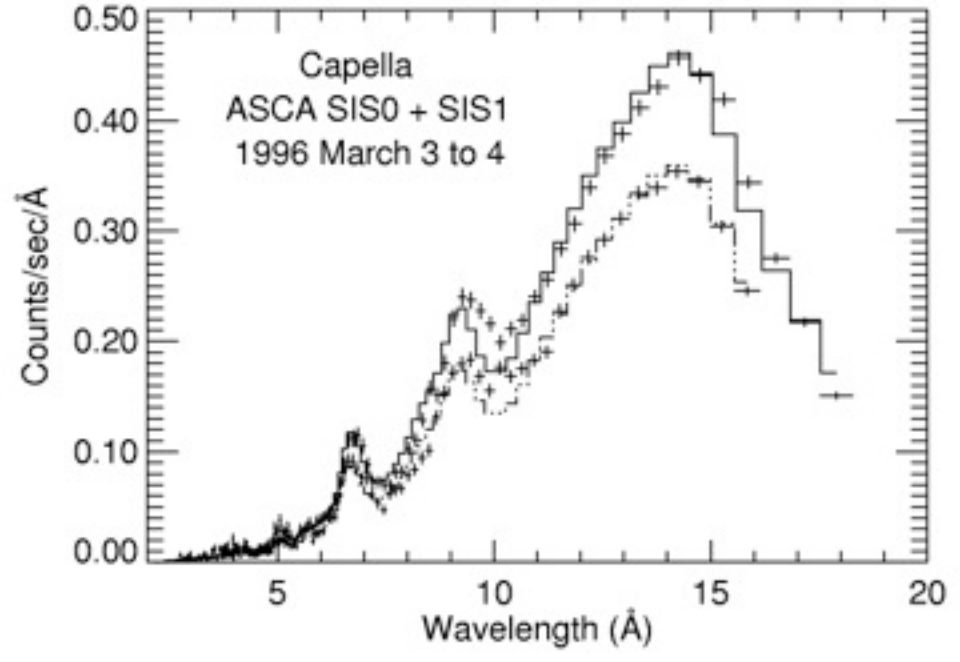




[Left] Temperature diagnostic in Ne IX (triplets/singlet)
[Right] Density diagnostic in Ne IX (forbidden/intercomb)

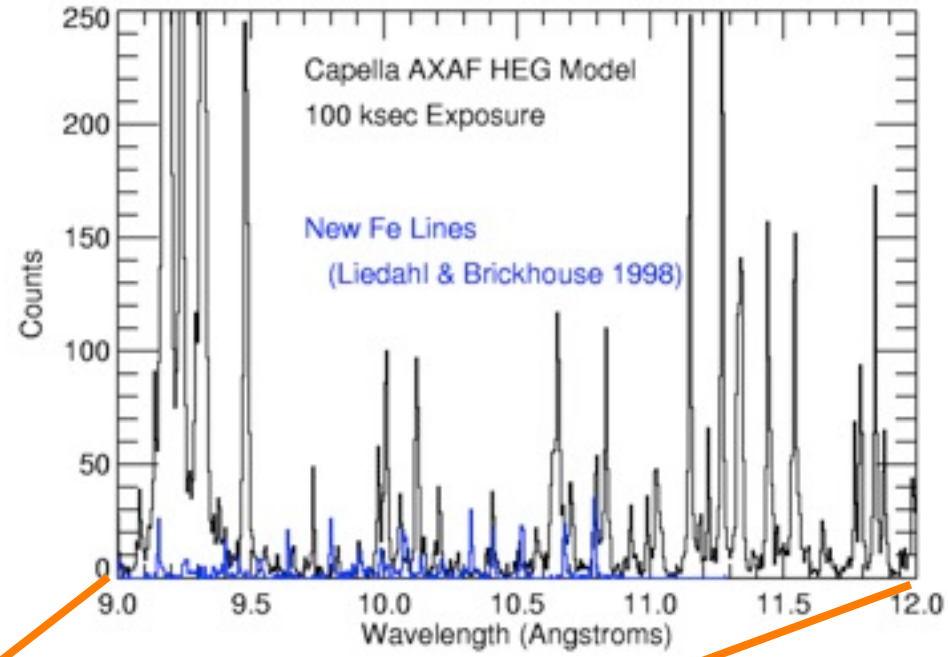
Capella from days of yore…

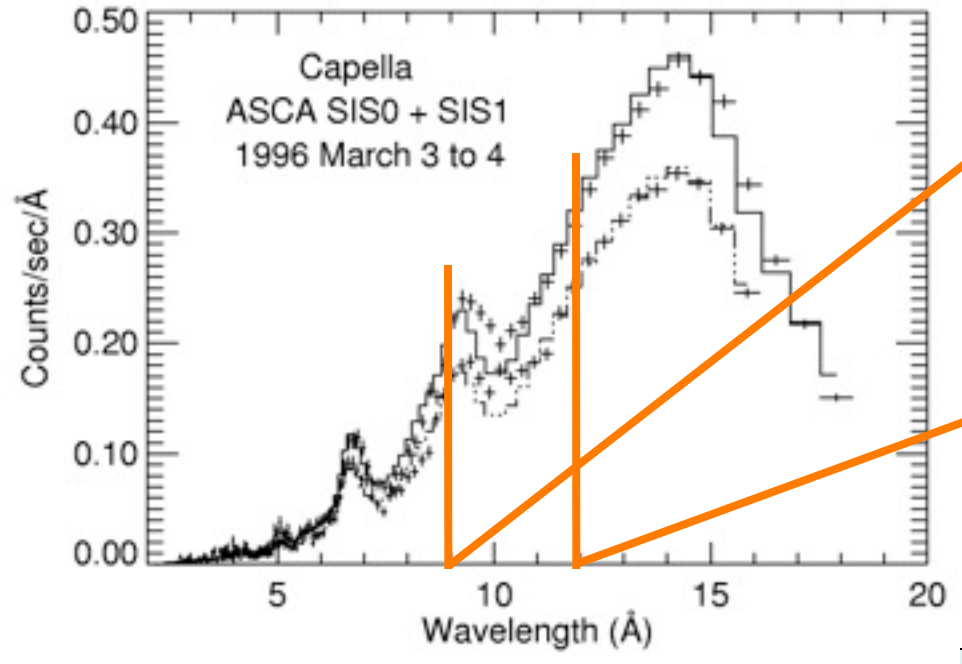




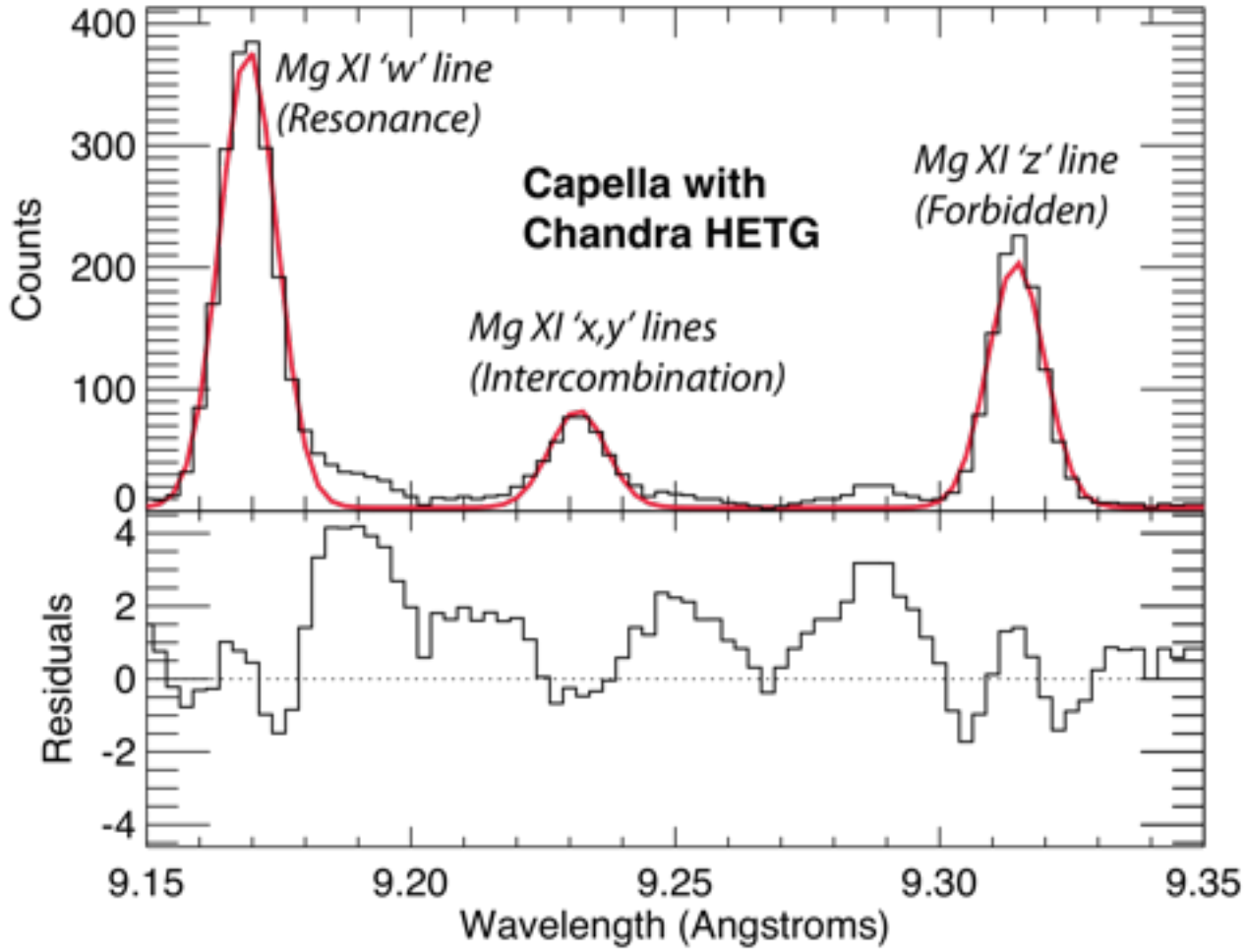
Capella from days of yore…

The poor fit between 9-12 Å is likely due to missing lines, not bad modeling.

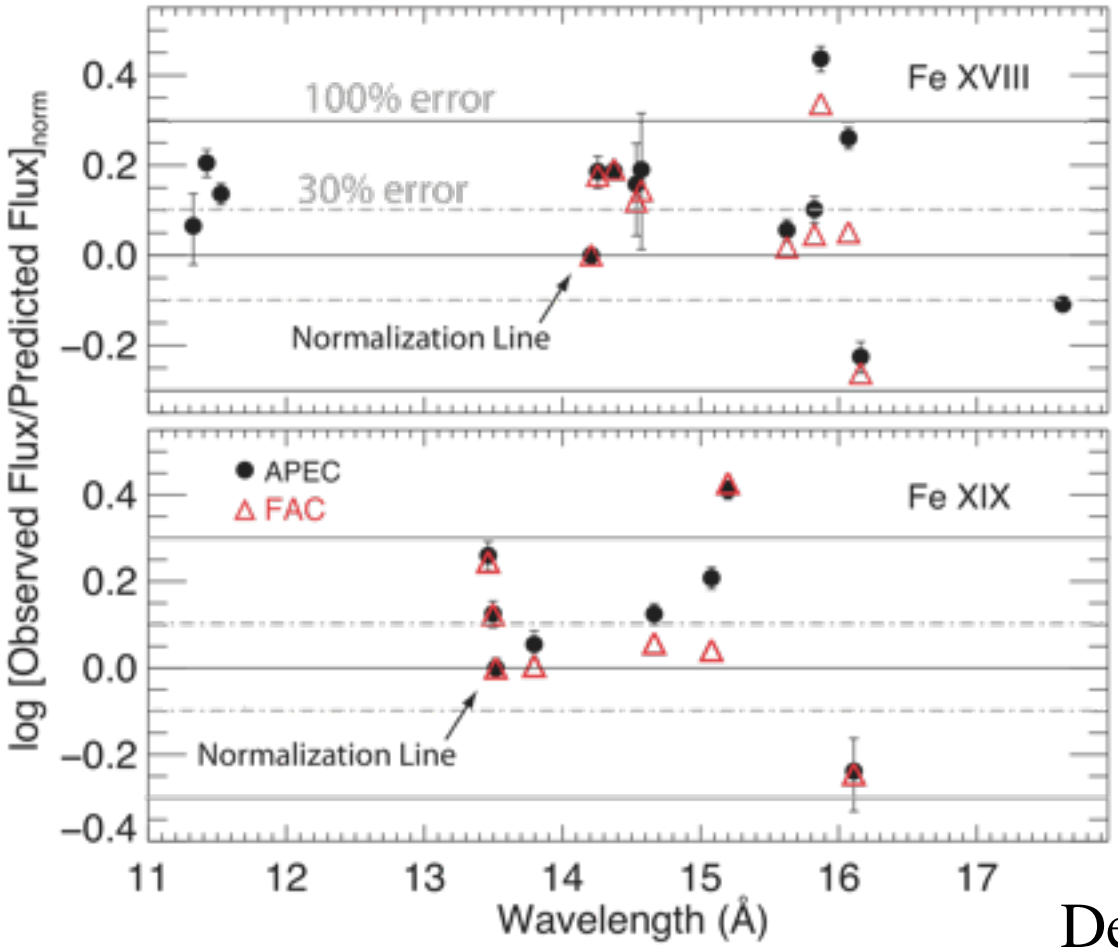




But we're still missing lines…



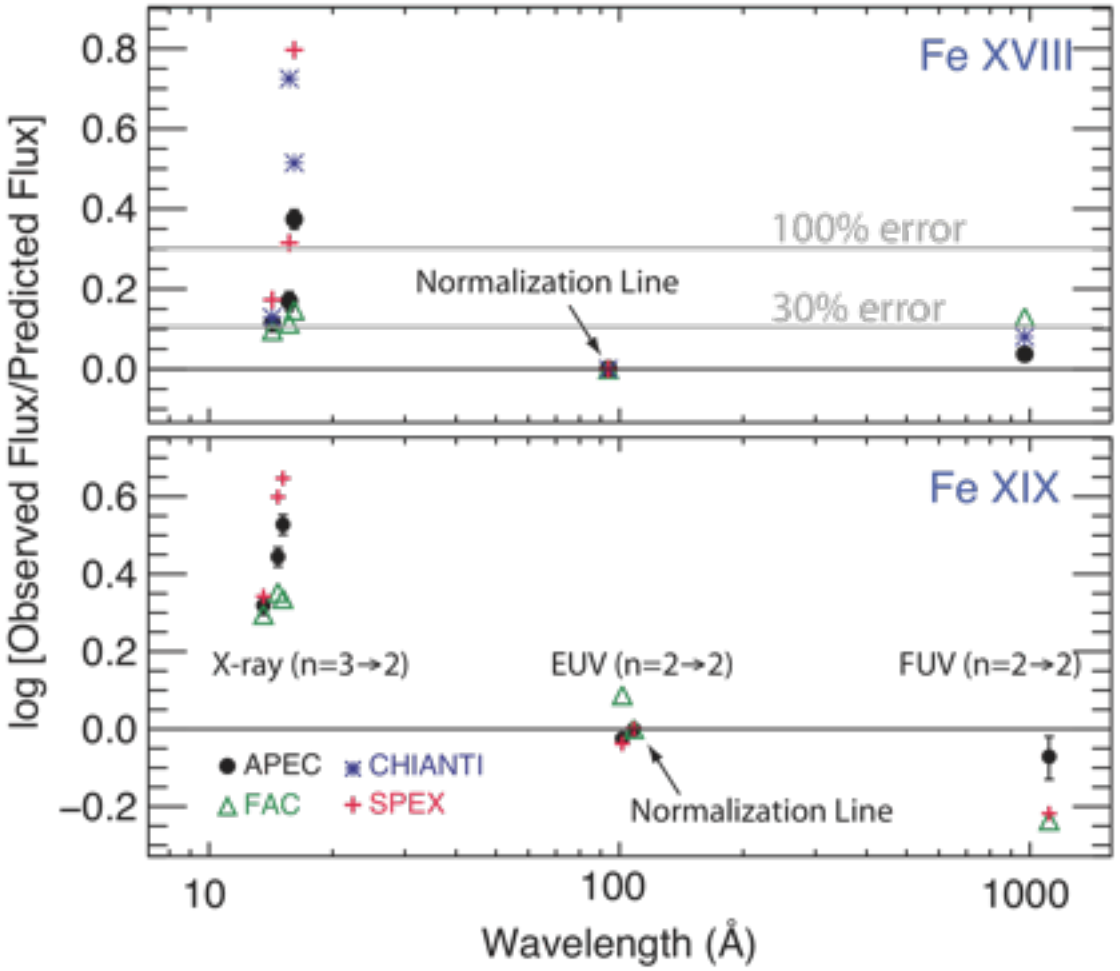
Fe L: Accuracy of APEC, FAC



Desai+ 05

Adding DR transitions helps significantly (Gu 03)

But look at a larger bandpass…

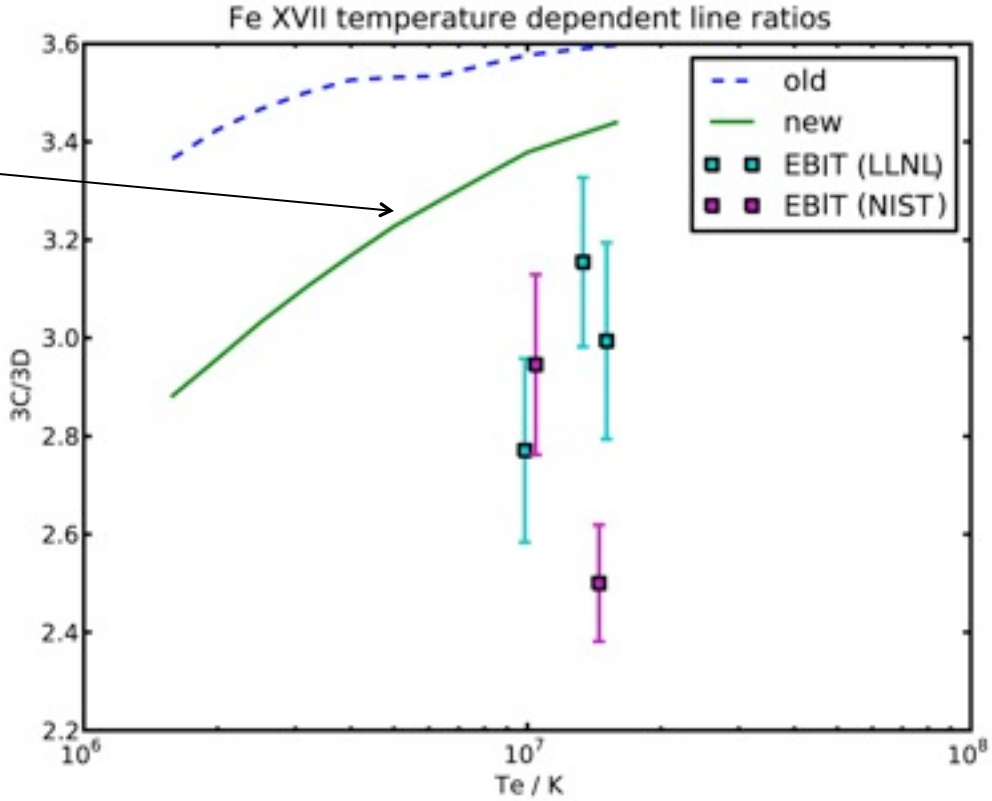


Note the issues when comparing UV and X-ray lines…

Desai et al 2005

These uncertainties cause real problems

AtomDB 2.0.0 curve



Substantial differences persist between experimental and calculated ratios

Dealing With Model Error

"The model rates are error free. We define an approximation and calculate the rates within that framework. There is **no error** in these rates…"

Dealing With Model Error

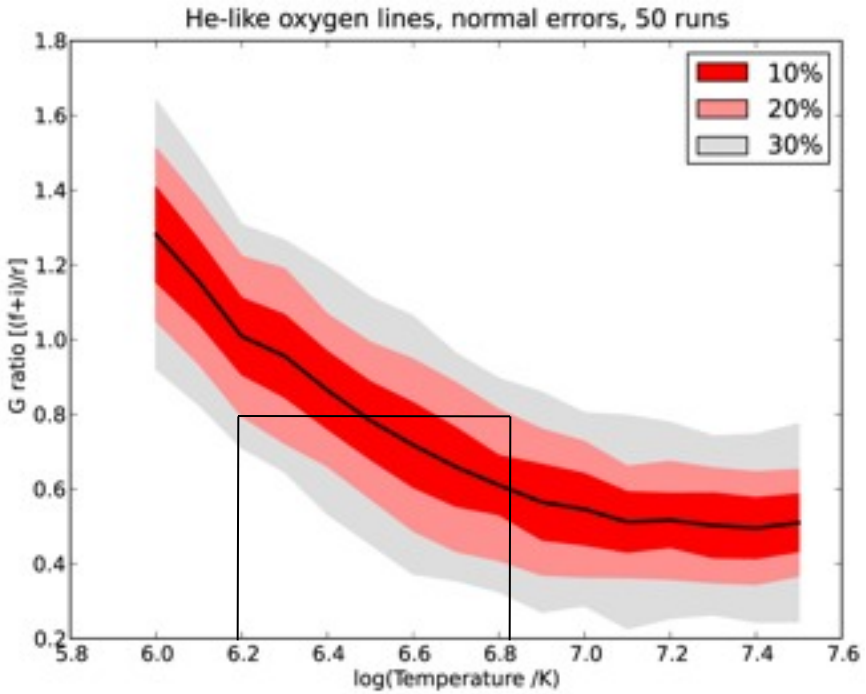
"The model rates are error free. We define an approximation and calculate the rates within that framework. There is **no error** in these rates…"

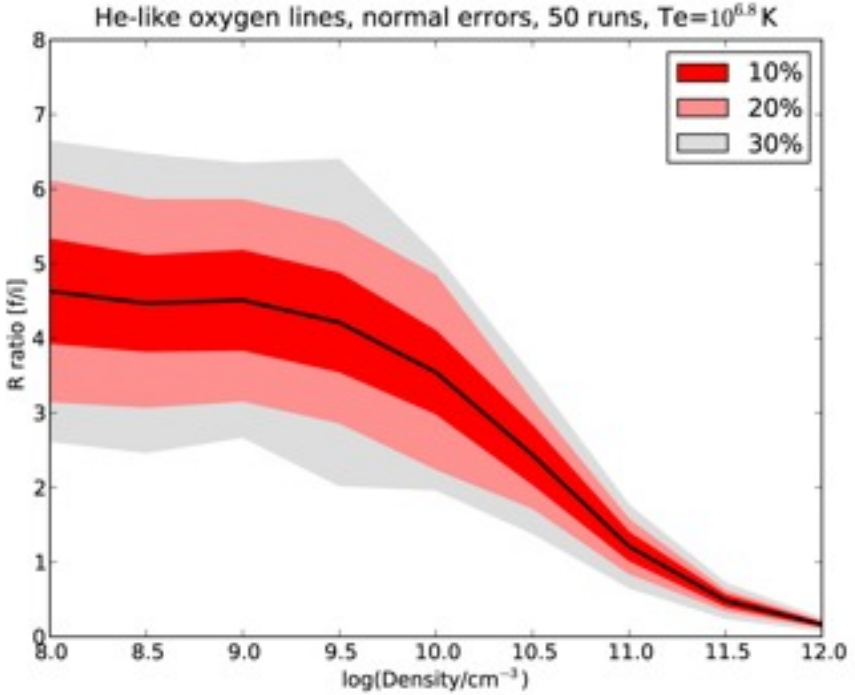
But errors in the approximation method, of course, are beyond the scope of this statement. It is hard to know the accuracy of your atomic model in any detail.

Dealing with Model Errors

- Theoretical cross section errors tend to be correlated, not random
- Typical quoted values range from 5-30% for rates & cross sections.
- Wavelengths are often 1%, or with great effort, 0.1%. (Remember that at 10Å, 0.1% is 0.01Å, or 300 km/s)
- I propose running a range of test cases to check sensitivity of results to input errors and to give users some advice…

He-like Sensitivity Testing

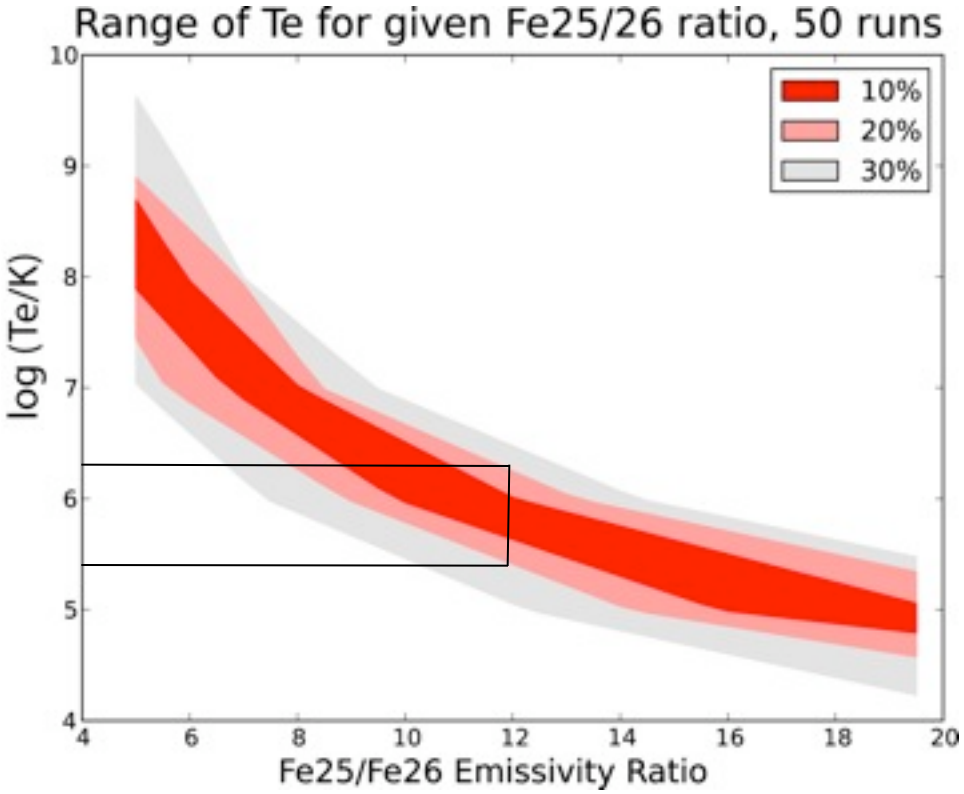




Oxygen He-like lines: 20% error in atomic data

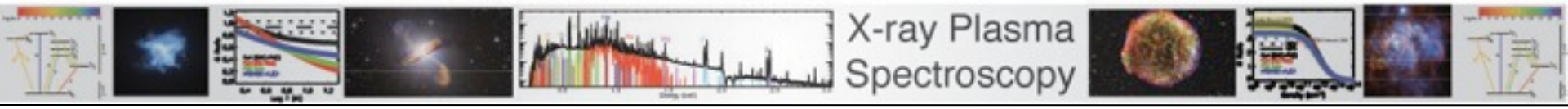
➔ factor of 2 error in Te

Becomes worse as Z increases



Iron He-like/Lyman: 20% error in atomic data

➔ factor of 3 error in Te

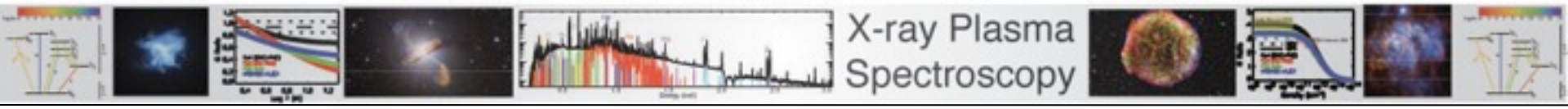


Conclusion

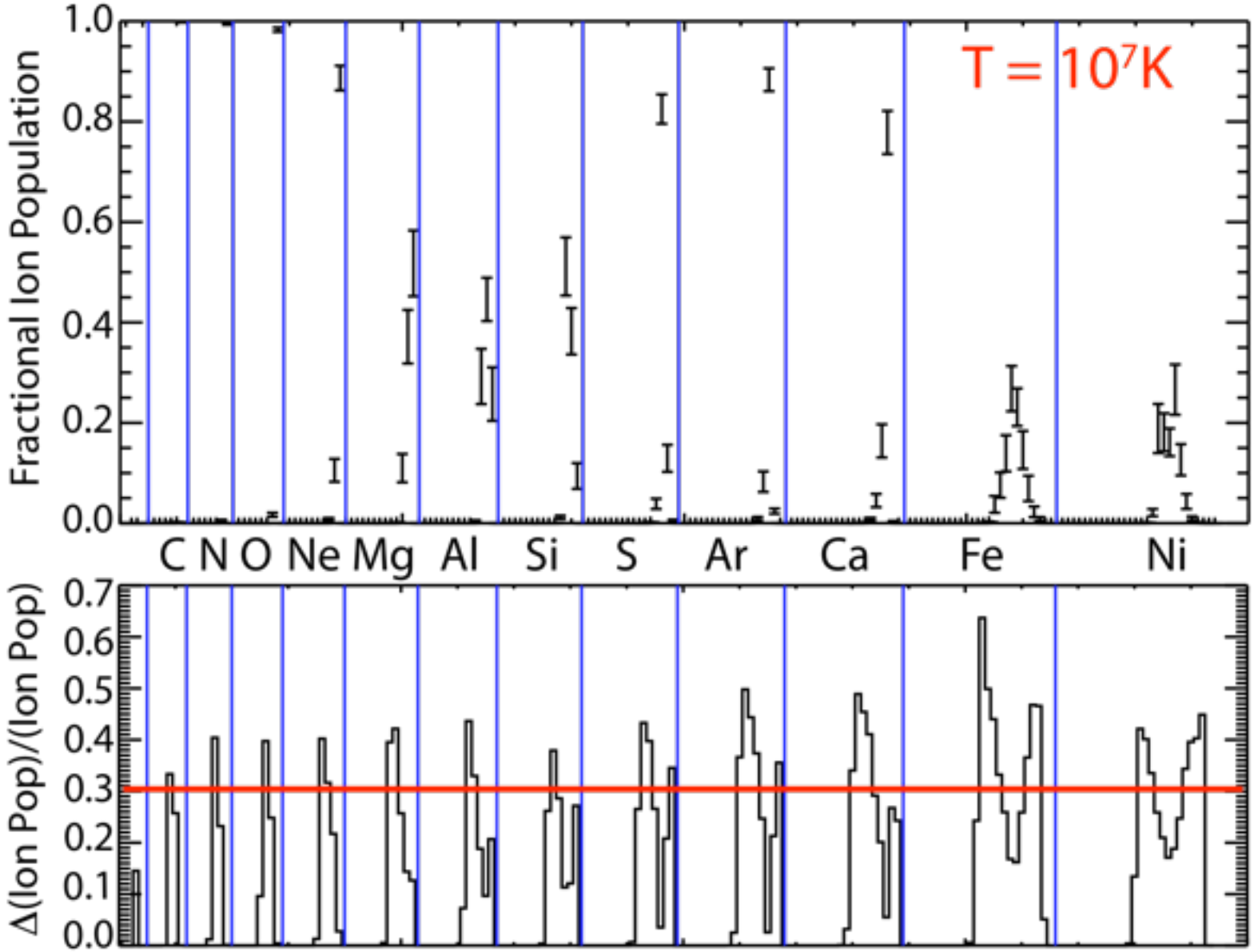
As more high-resolution X-ray spectra become available, the X-ray astrophysics community, **including**

laboratory astrophysicists,
observers, and
modellers,

needs a common storehouse of accurate and complete atomic data that can be easily accessed in order to analyze this data.



Backup


T = 10^7K
Fractional Ion Population
1.0
0.8
0.6
0.4
0.2
0.0
C N O Ne Mg Al Si S Ar Ca Fe Ni
Δ(Ion Pop)/(Ion Pop)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0

AtomDB v2.0.0

- The next release for AtomDB is undergoing beta testing now.
- Major updates include R-matrix data for He and H like ions, and for all the iron L-shell.
- Release should be soon. Sign up for updates/downloads at www.atomdb.org!

Ever heard of ADAS?

http://open.adas.ac.uk/

- The fusion community is, in a number of ways, ahead of us.
- ADAS (Atomic Data and Analysis Structure) is a suite of atomic codes, analysis tools, and atomic data
- Now available at OPEN-ADAS
- **But!** designed for atomic physicists, not astrophysicists