AtomDB: Updates for Plasma Models of [~~Recombination and Charge Exchange~~] Resonant Scattering in and Uncertainties on Plasmas

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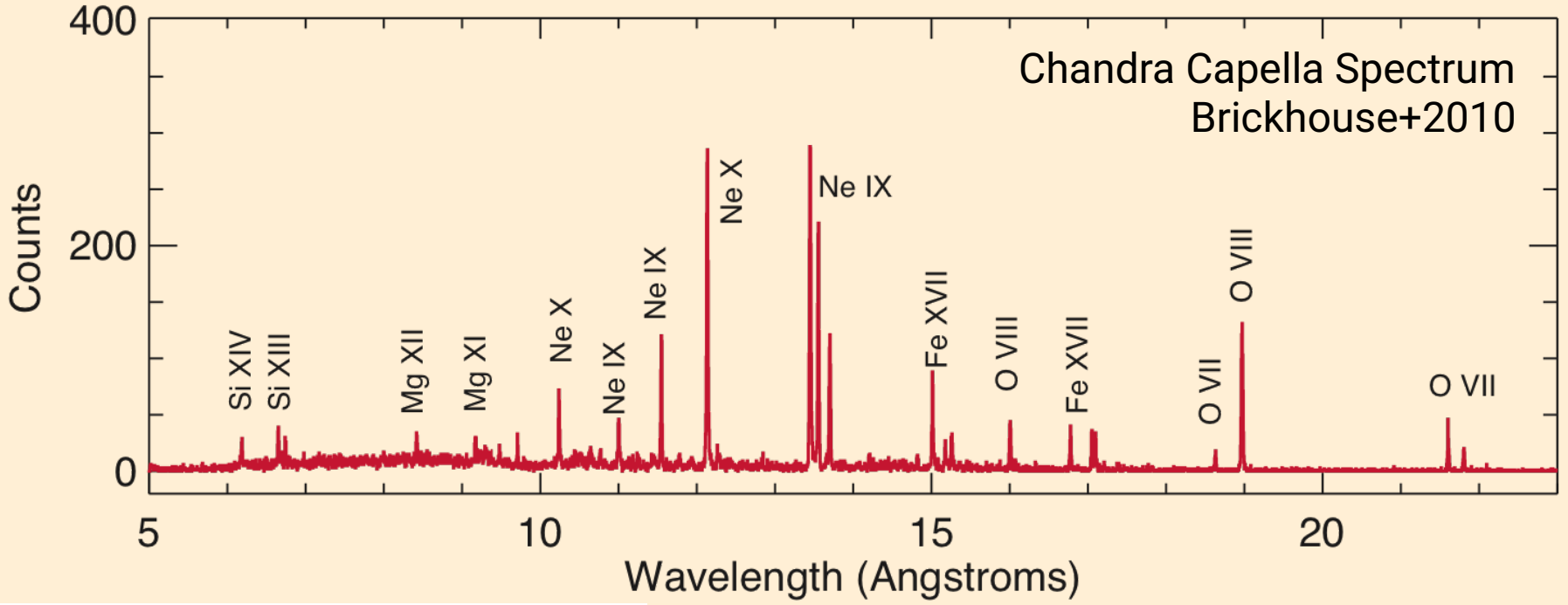
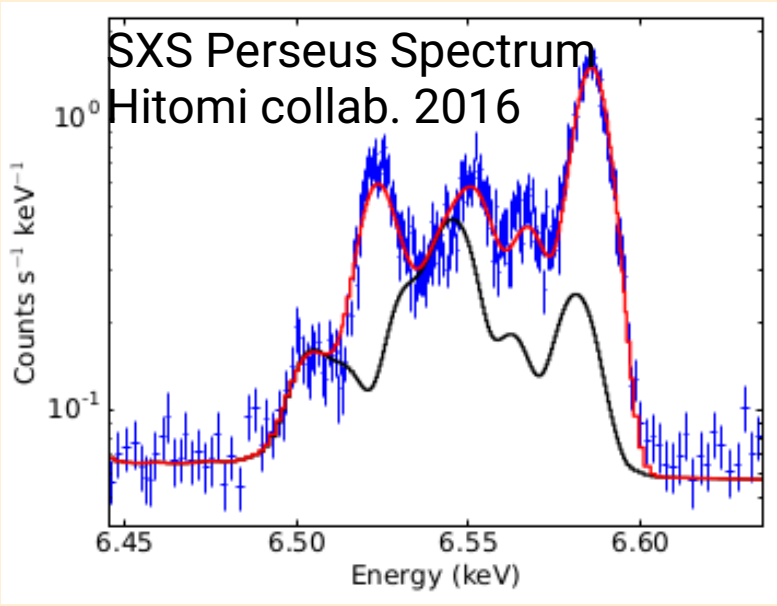
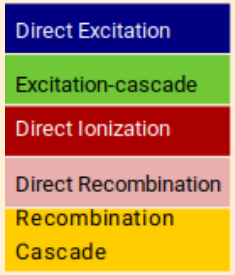
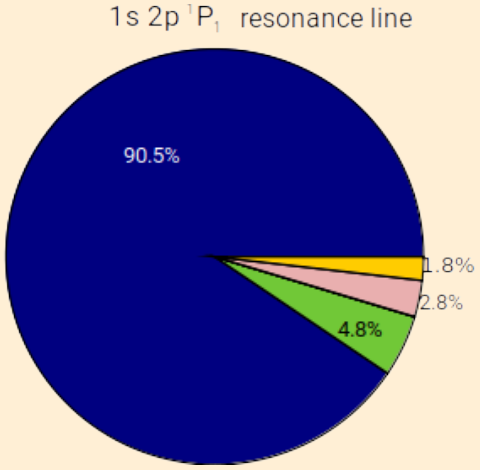
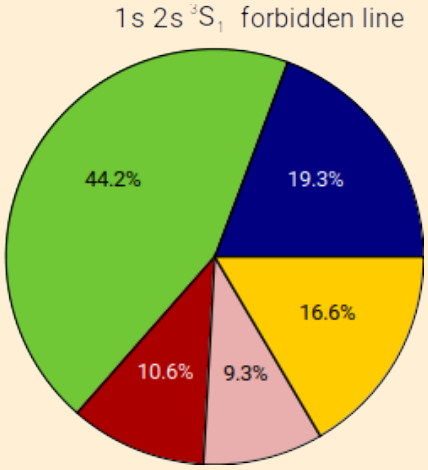
What Does X-ray Astronomy Need?



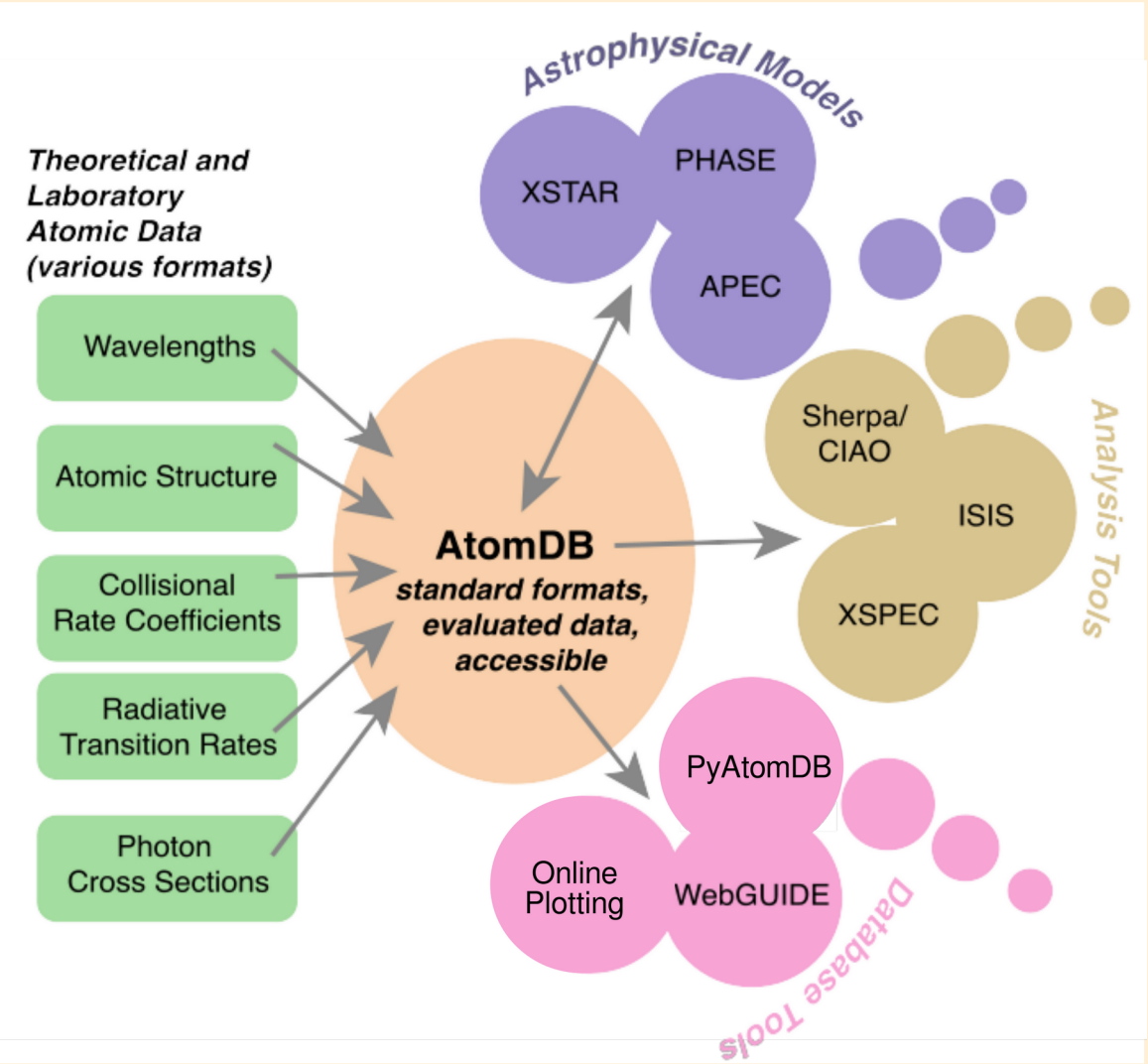








AtomDB in the X-ray World



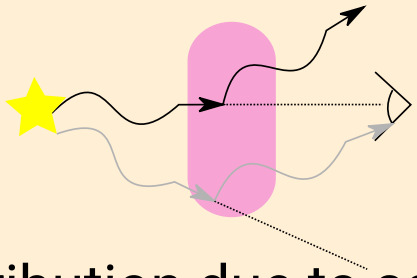
Large collection of atomic data used to model a range of X-ray emitting plasmas

- Create **useful** spectra for data analysis
- Ensure tight **integration** into modeling tools
- Provide **open access** to all the data and the models
- Ingest and **update** models with new atomic data
- Identify atomic data needs and **communicate** them to data producers

Resonance Scattering (RSApec)

RS occurs when emission with a sufficiently large oscillator strength travels through a material. It is resonantly absorbed and re-emitted in a different direction, leading to a deprecation of the line intensity.

$$\frac{I_{RS}}{I_0} = \frac{1 - e^{-\tau_0}}{\tau_0}$$



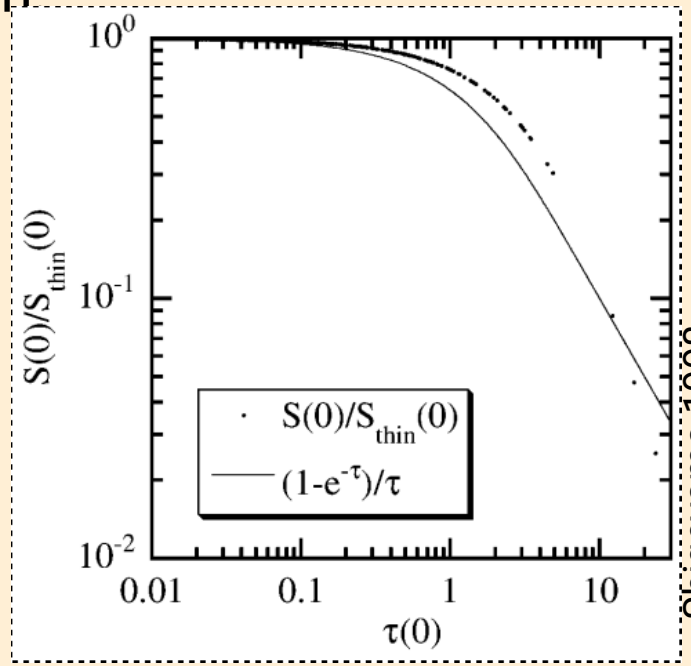
Bar model assumes redistribution due to scattering by thermally distributed ions, so scattering loss is also Gaussian.

Shigeyama showed scattering from a sphere (e.g. a galaxy) is different: scattering factor can be much more reduced.

Both models integrated into new RSAPEC model.

$$nL = \int_0^\infty n_e \, dr$$

Fit parameter is line of sight integral of emission electron density

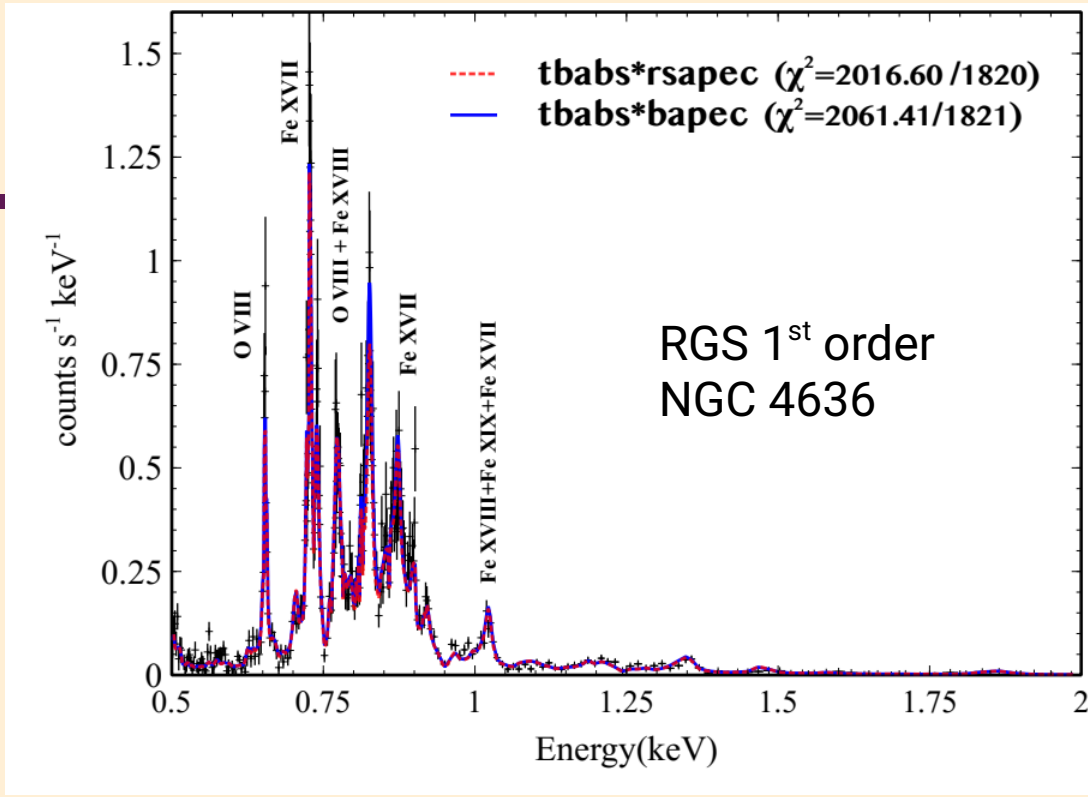


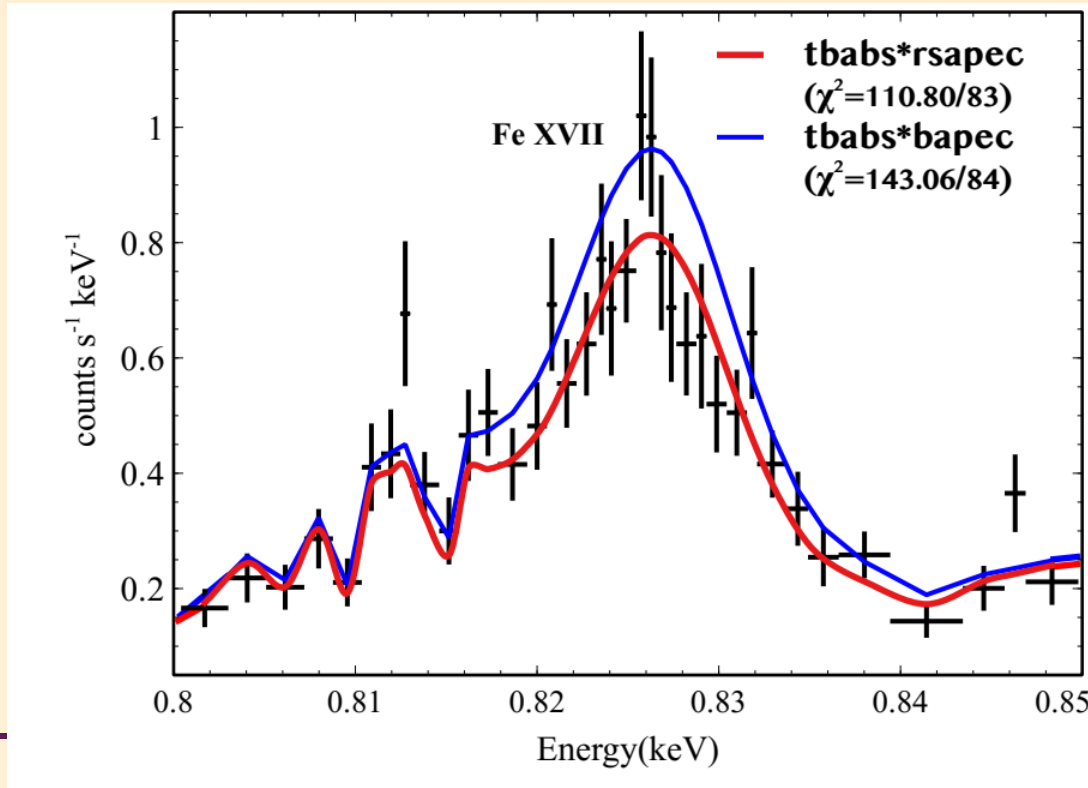
Shigeyama 1998

RSApec improves global fit by modeling RS in the Fe XVII (and other) lines.

Obtains nL value comparable to literature values: $1.43\pm0.12\times10^{21}$ vs 1.22×10^{21} cm^{-2}

Submitted to ApJ (Chakraborty+)
XSPEC model available at atomdb.org once accepted



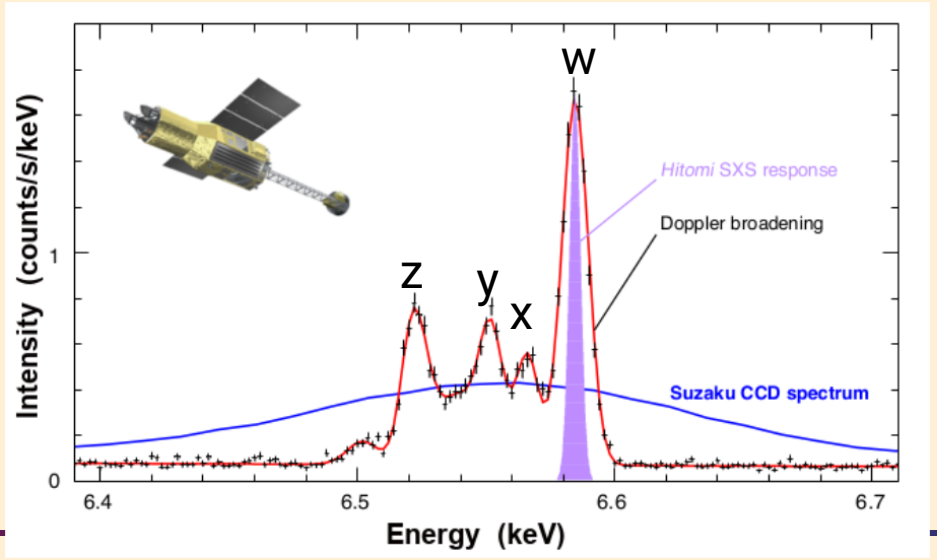


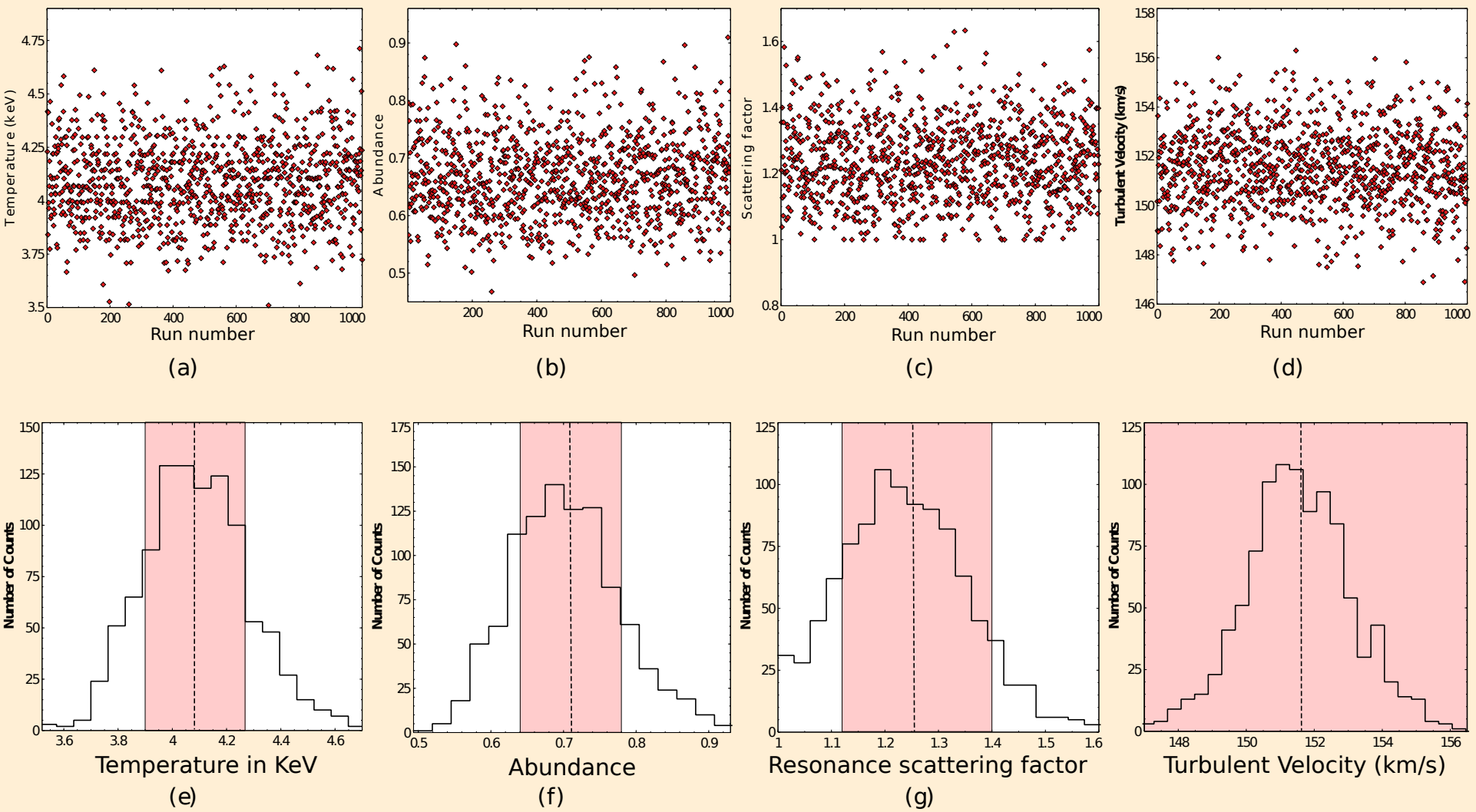
Uncertainties on Atomic Data

How well do we need to know atomic data?

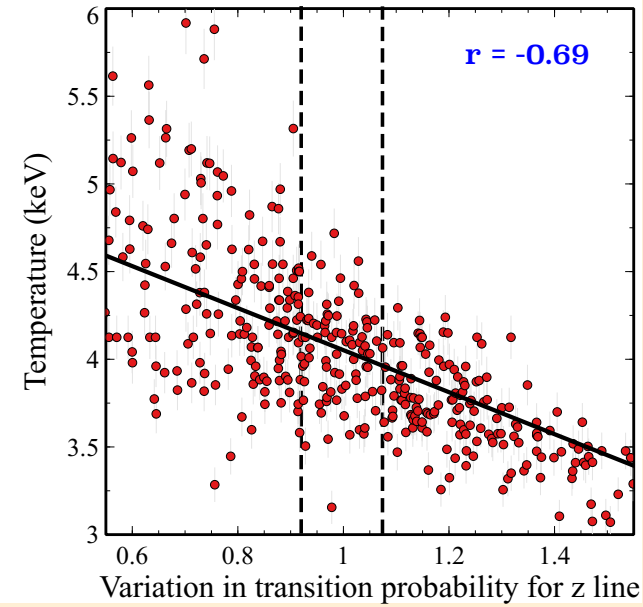
Developed Variableapec, a tool for investigating the effects of uncertainties on spectral fits.

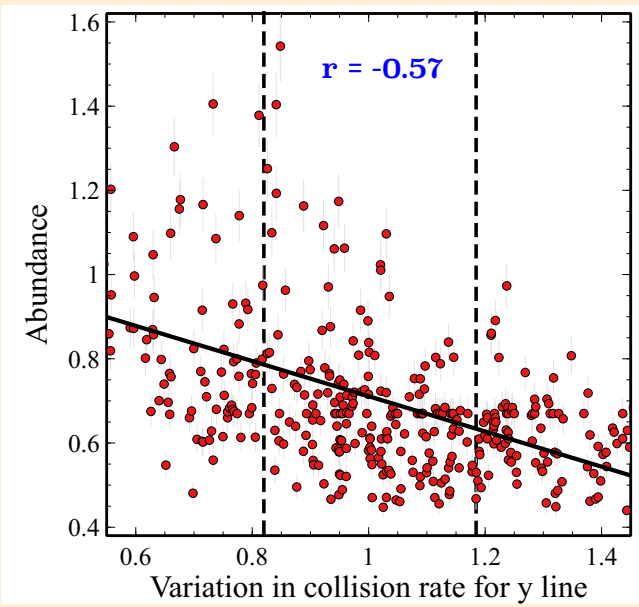
Ion	Label†	Transition	Wavelength	Error(transition probability)	Error(Collision strengths)
Fe XXV	x	$1s.2p\ (^3P_2) \rightarrow 1s^2$	1.85541	1%	6%
Fe XXV	y	$1s.2p\ (^3P_1) \rightarrow 1s^2$	1.85951	14%	18%
Fe XXV	z	$1s.2s\ (^3S_1) \rightarrow 1s^2$	1.86819	7%	42%
Fe XXV	w	$1s.2p\ (^1P_1) \rightarrow 1s^2$	1.85040	2%	7%
Fe XXIV	s	$1s.2s.2p\ (^3P_{3/2}) \rightarrow 1s^2.2s\ (^2S_{1/2})$	1.86110	25%	20%
Fe XXIV	r	$1s.2s.2p\ (^1P_{1/2}) \rightarrow 1s^2.2s\ (^2S_{1/2})$	1.85700	,,	,,
Fe XXIV	t	$1s.2s.2p\ (^3P_{1/2}) \rightarrow 1s^2.2s\ (^2S_{1/2})$	1.86350	,,	,,





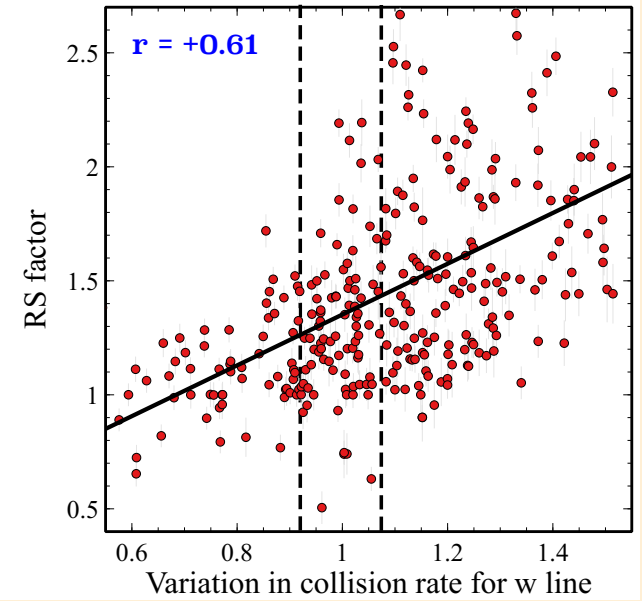
1000 runs of VariableApec with Hitomi Perseus Data.

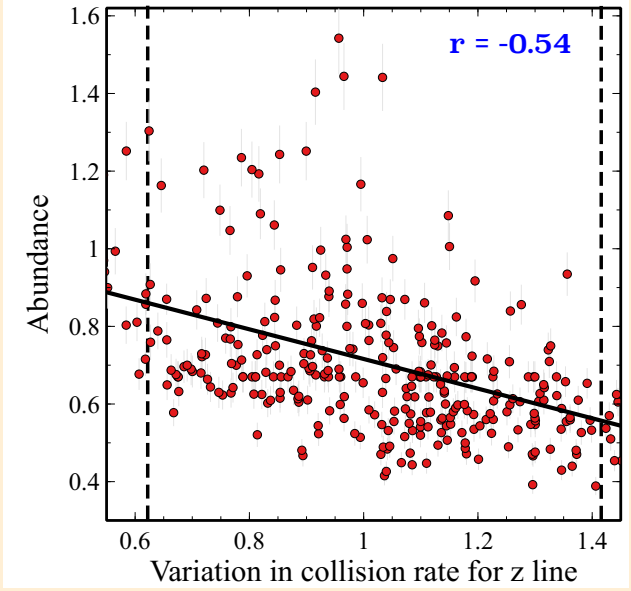


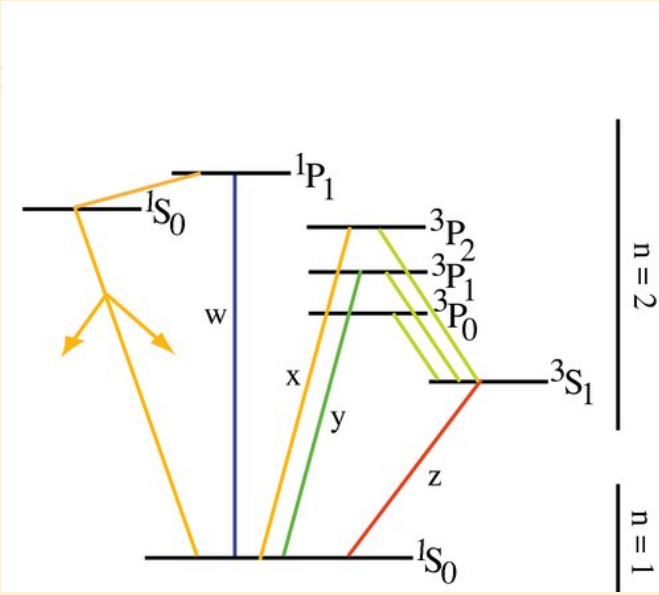


Temperature and abundance show correlation with collision strengths

Systematic study of upcoming results and their sensitivity to atomic data achievable





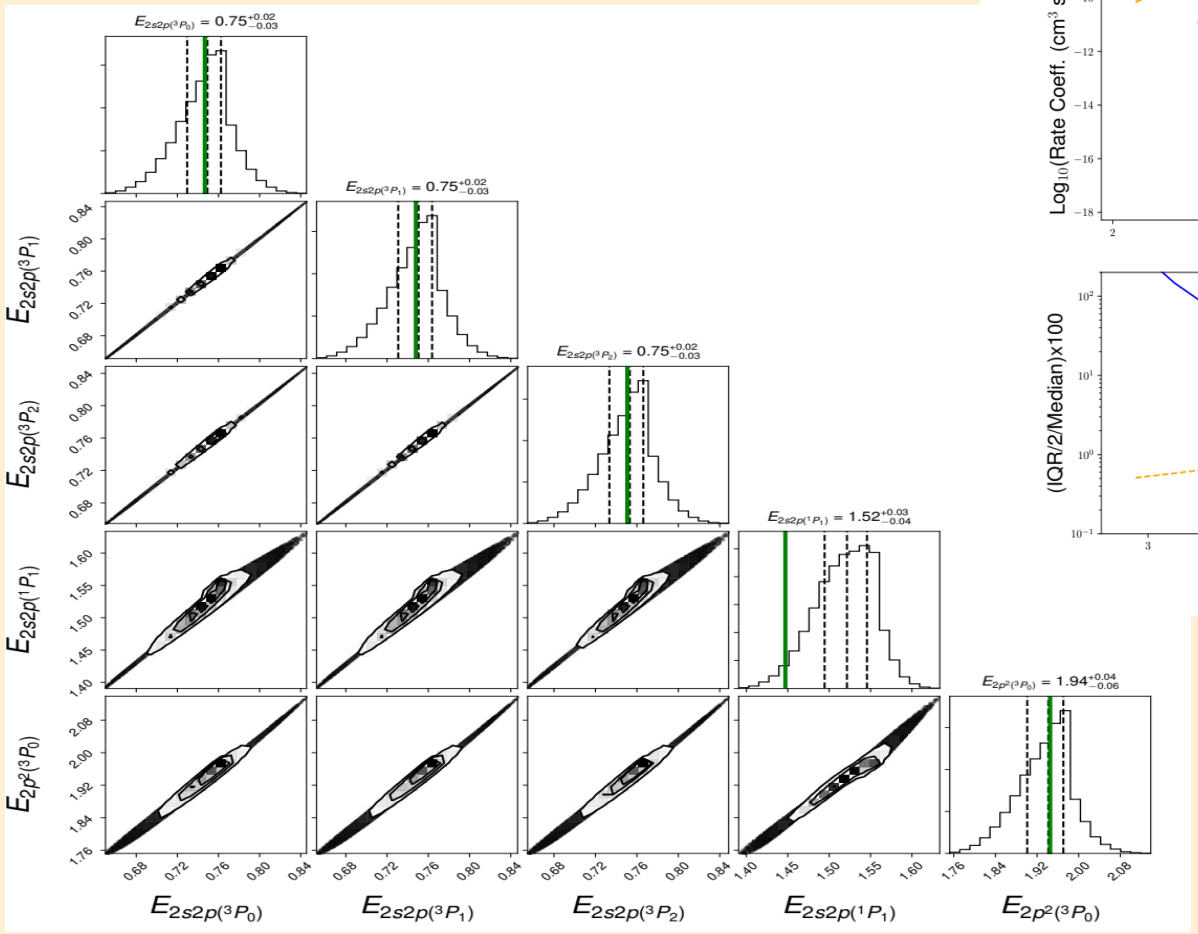


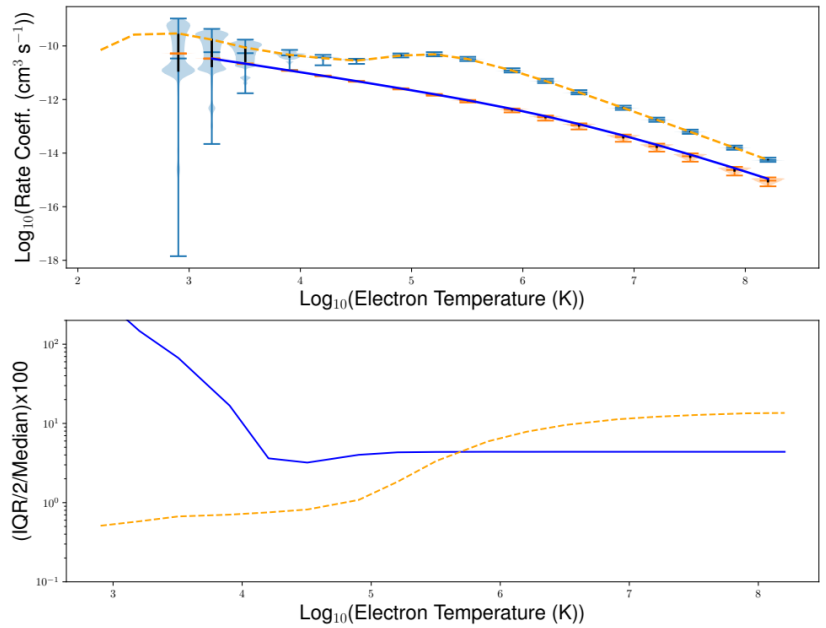
Chakraborty, Hemmer et al, submitted

Underlying Uncertainties on Atomic Data

Uncertainties in atomic data have a series of (sometimes not obvious!) correlations

If we start by varying the atomic structure, and continue on to calculation of all coefficients, we preserve these correlations



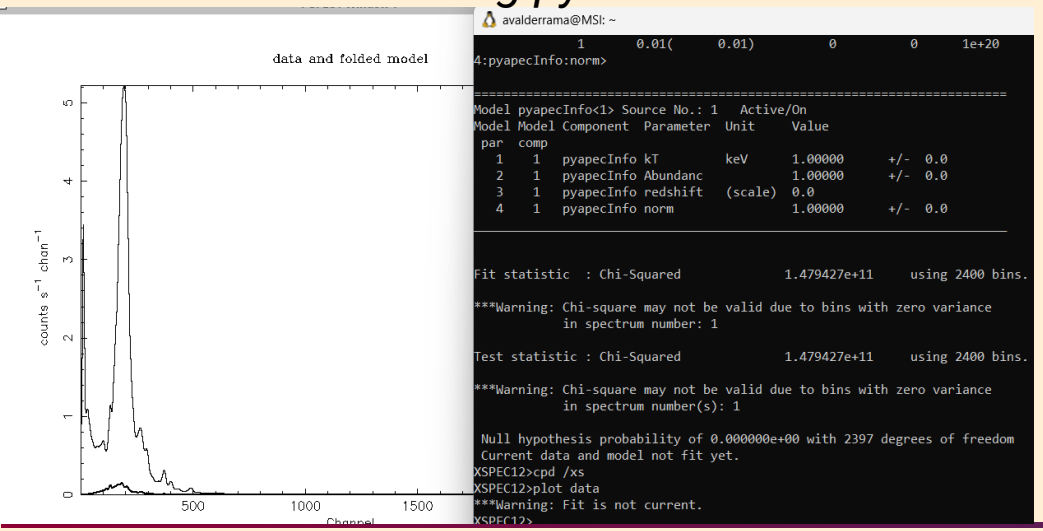


Large, complicated datasets, Need careful though on presentation and use!

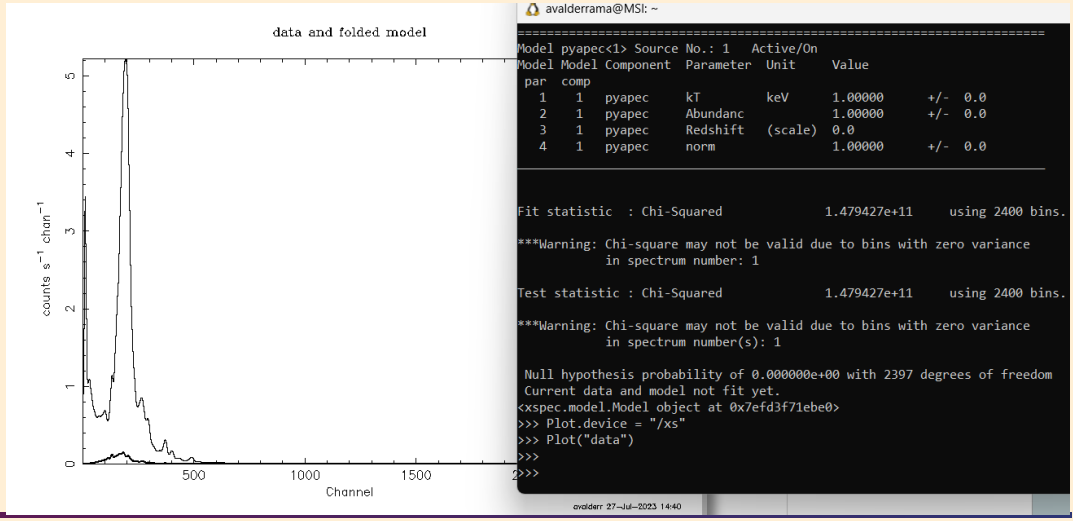
Loading Python Models in XSPEC

- APEC/AtomDB models are written in python, only legacy models have C++ versions in XSPEC
- New models (ACX2, resonant scattering, electron-electron bremsstrahlung, non-Maxwellian electrons etc) have no C version.
- We have designed wrappers to **allow use of python models in regular XSPEC**
  - **Generally applicable: works for all python-only models**

XSPEC calling python model

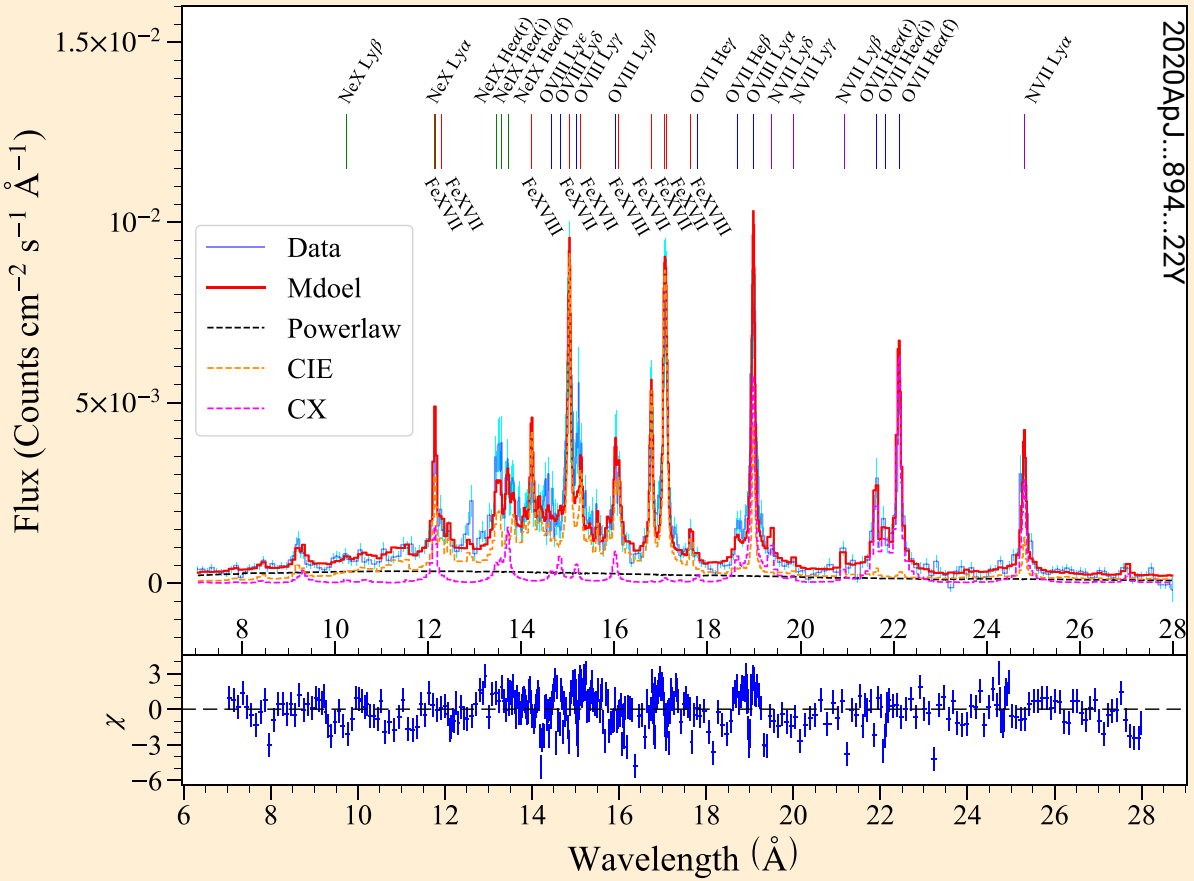


PyXspec calling python model



AtomDB Charge Exchange

M51 galaxy shows a curious ratio of the forbidden to resonance lines in RGS spectrum – explained using charge exchange



Updates to the python ACX2 model improve speed and reliability, allow for line broadening, easier maintenance and addition of new data.

McKenna Blake

Future Plans

- Redevelopment of apec code (almost complete) – more flexibility, allows us to do all of the below….
- Dielectronic Recombination line inclusion up to higher *n* & more ions (Hiromichi Okon, Nigel Badnell, Martin O'Mullane).
- Inclusion of density dependent effects
- Updates of L-shell ion data
- Updates of M-shell ion data (?)
- Continue collaboration with other projects, e.g. SPEX, ADAS, CHIANTI
- Work on SAO EBIT

DR Satellite lines

Autostructure vs literature