Constellation-X/ IXO
Facility Science Team Meeting
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Constellation-X FST Science Panel Plasma Diagnostics and Atomic Astrophysics

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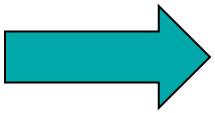
Panel Members: G. Brown, J. Li, V. Kashyap, M. Sako, D. Savin, D. Schultz, W. Waldron, B . Wargelin

Outline

- Theoretical and Experimental Atomic Physics -> Plasma Modeling
- Examples of Plasma Diagnostics for Con-X/IXO
  - Charge Exchange
  - Collisionally Ionized Plasmas
    * Case Study: Mn/Cr Ratios in SNR from Type Ia SNe
  - Photoionized Plasmas
    * Case Study: Time-Dependent Photoionization to Study Feedback in AGN
- Conclusions

Data -> Models -> Interpretation

- Collisional ionization rate coefficients
- Photoionization rate coefficients
- Radiative recombination rate coefficients
- Dielectronic recombination rate coefficients
- Collisional excitation rate coefficients
- Oscillator strengths
- Wavelengths
- All elements < Z=30
- All ionization states in X-ray regime
- Fluorescence yields
- Inner shell lines
- Charge exchange rate coefficients
- Brehmsstrahlung

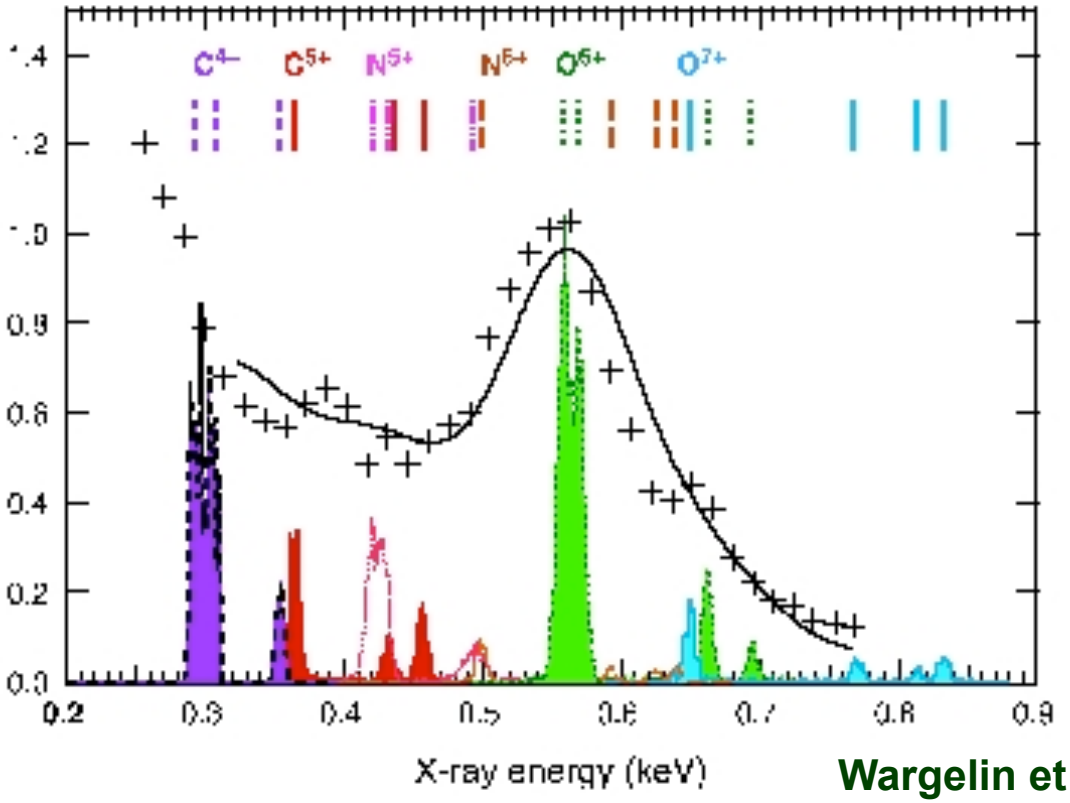


Charge State
Electron Temperature
Electron Density
Elemental Abundance
Absorbing Column
Optical Depth
Velocity

- Molecular/solid absorption cross sections
- Nuclear cross sections, r- and s- process
- MHD/Hydro simulations and experiments
- High power lasers/photoionization
- Particle physics

Charge Exchange Spectrum

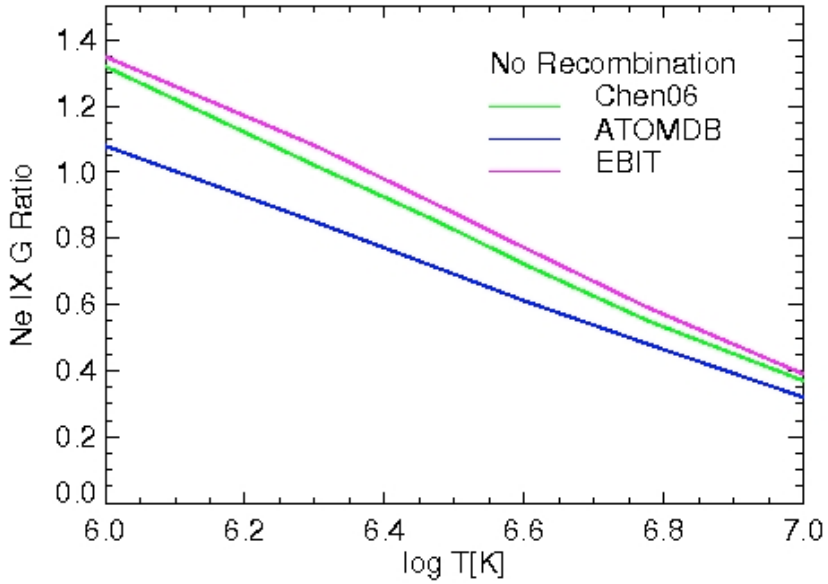
***Chandra* ACIS observations of Comet Linear compared with LLNL EBIT/ microcalorimeter measurements of slow solar wind species**

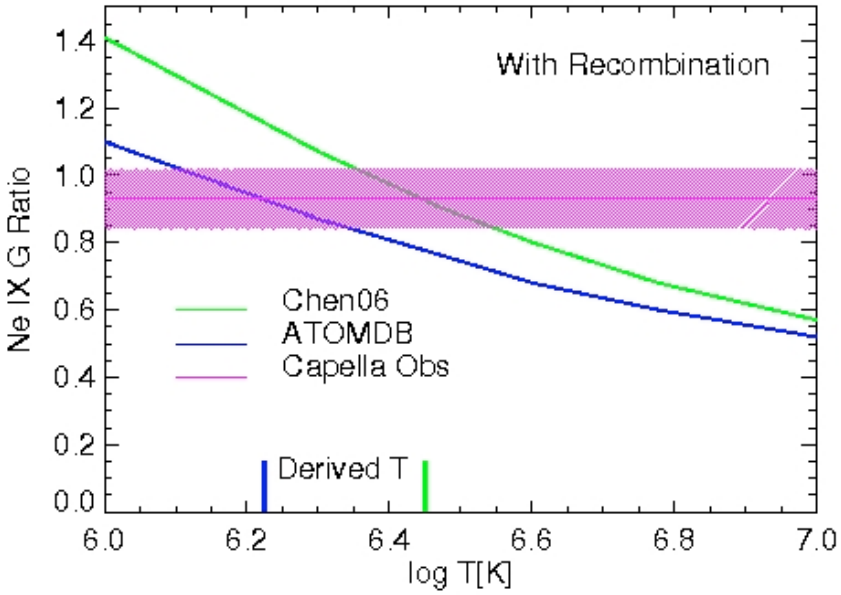


Wargelin et al. 2008

He-like Ne IX G-ratio Theory and Experiment

New calculations (Chen et al. 2006, PRA)



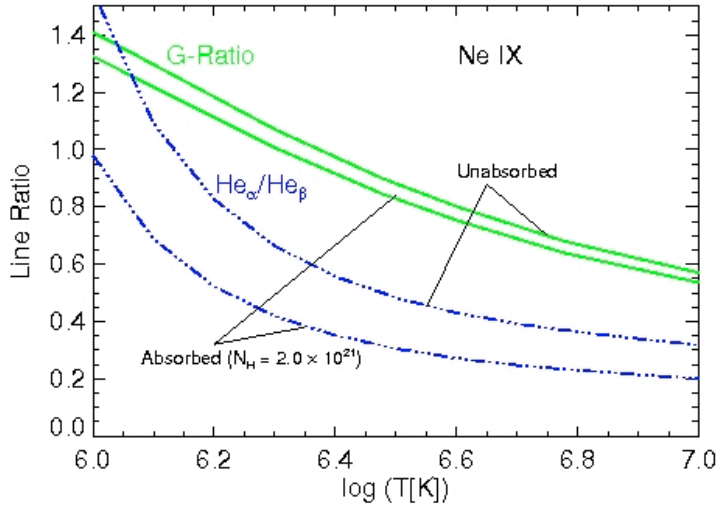


G-ratio agrees with LLNL EBIT measurements of Wargelin (PhD Thesis 1993)

Derived T from Capella in better agreement (Smith et al. in prep)

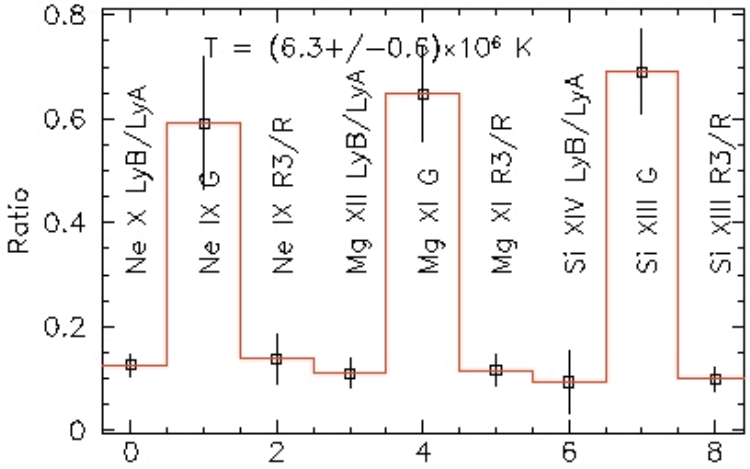
Diagnostics for T_e, N_e, N_H, R

He-like lines used to measure N_H



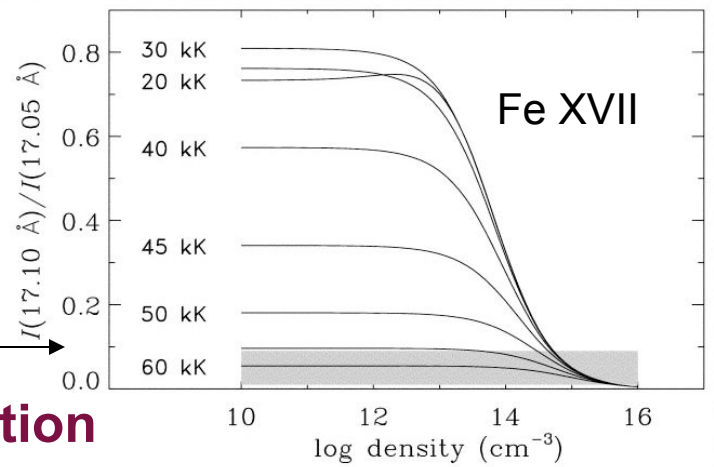
Brickhouse et al. 2008

Simulation for single T, using several line ratios



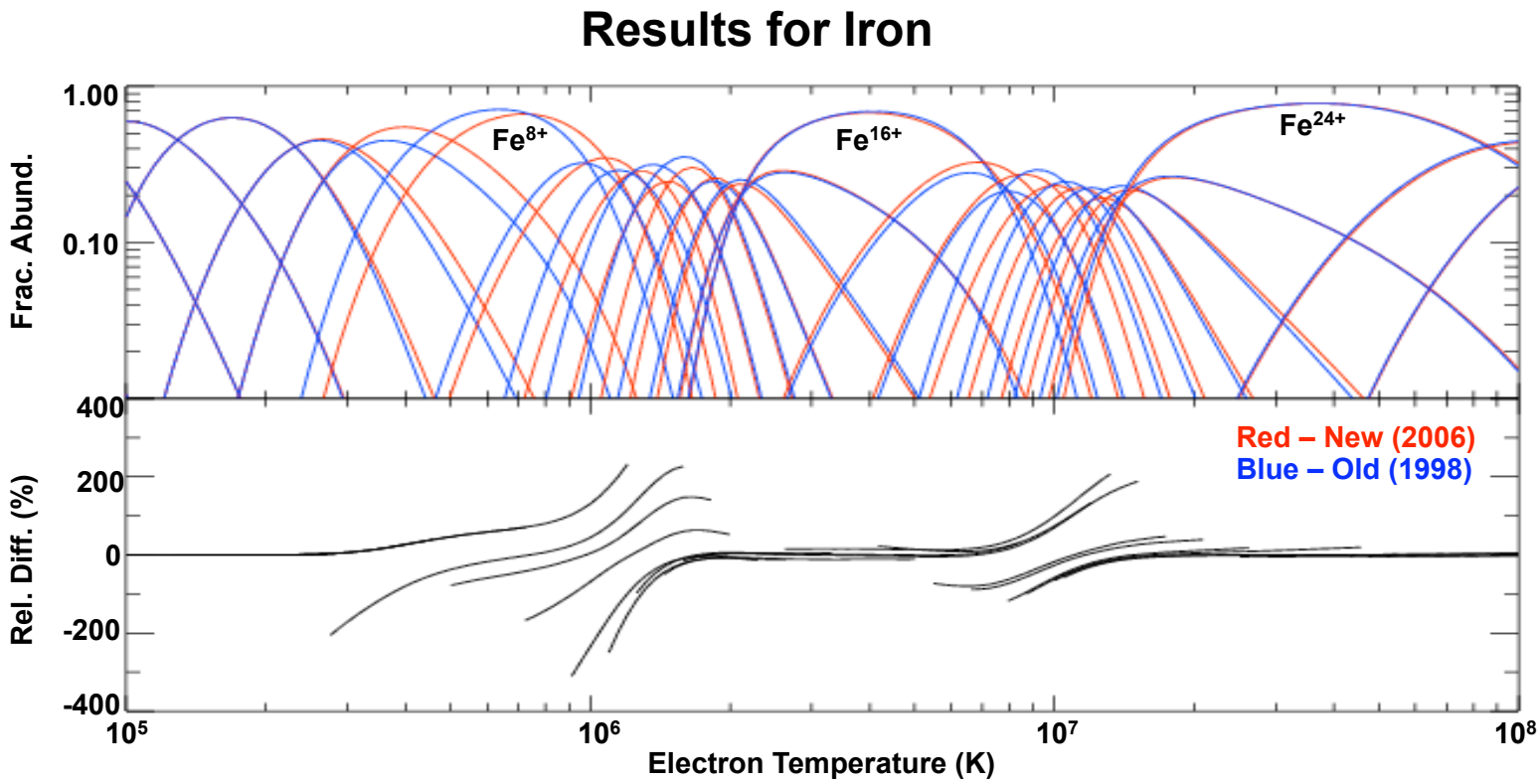
Courtesy R. Smith

Fe XVII lines used to infer N_e or photoexcitation



Mauche et al. 2001

Charge State Balance for Collisional Ionization Equilibrium



Bryans et al. 2007

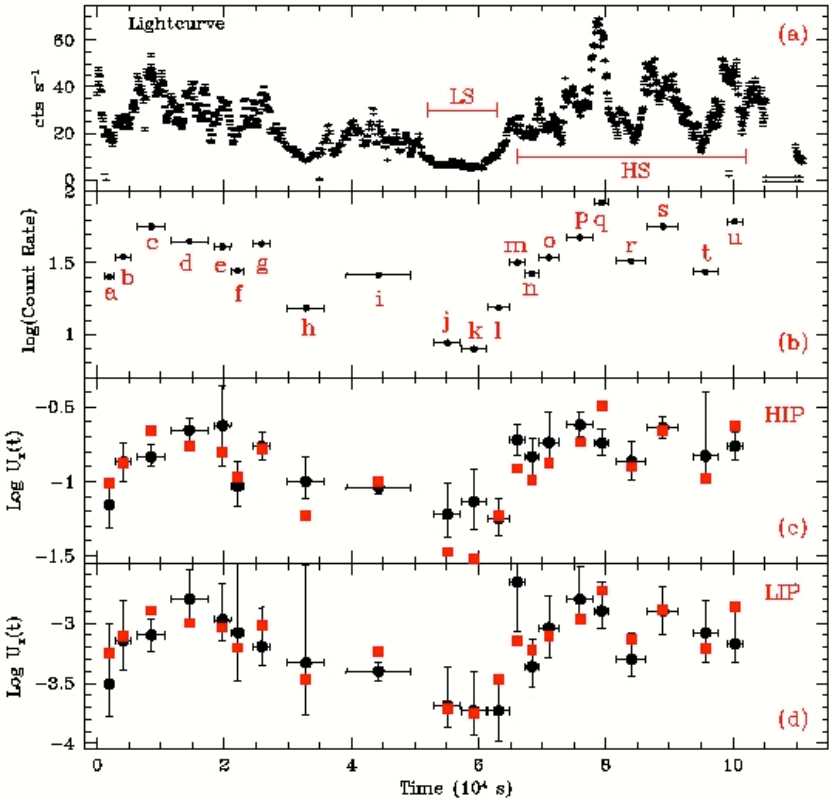
Relative Mn/Cr Abundances in Type Ia SNe to 10% Accuracy?

- T from H- and He-like line ratios and fluence ($n_e t$) from NEI charge state distribution of "uninteresting" ions
- NEI charge state distribution for Mn and Cr
- Kα fluorescence yields for Mn and Cr (or at least their spectral signatures)

- Fe experiments on LLNL EBIT demonstrate ability to produce Kα spectra during ionization
- Absolute normalization of Cr to Mn difficult
- Simulated spectra (e.g. Monte Carlo) to test systematic errors

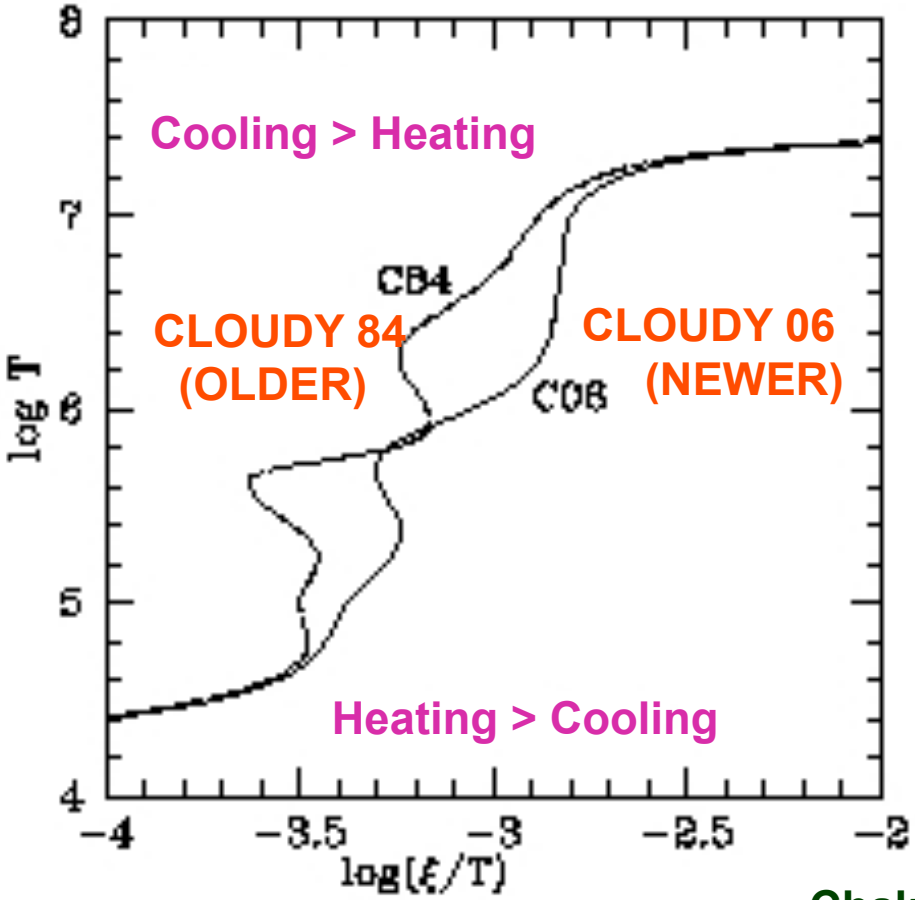
Time-Dependent Photoionization to Study Feedback in AGN

NGC 4051
XMM-Newton



Krongold et al. 2007

Effects of Atomic Data on Thermal Stability in Photoionized Plasmas



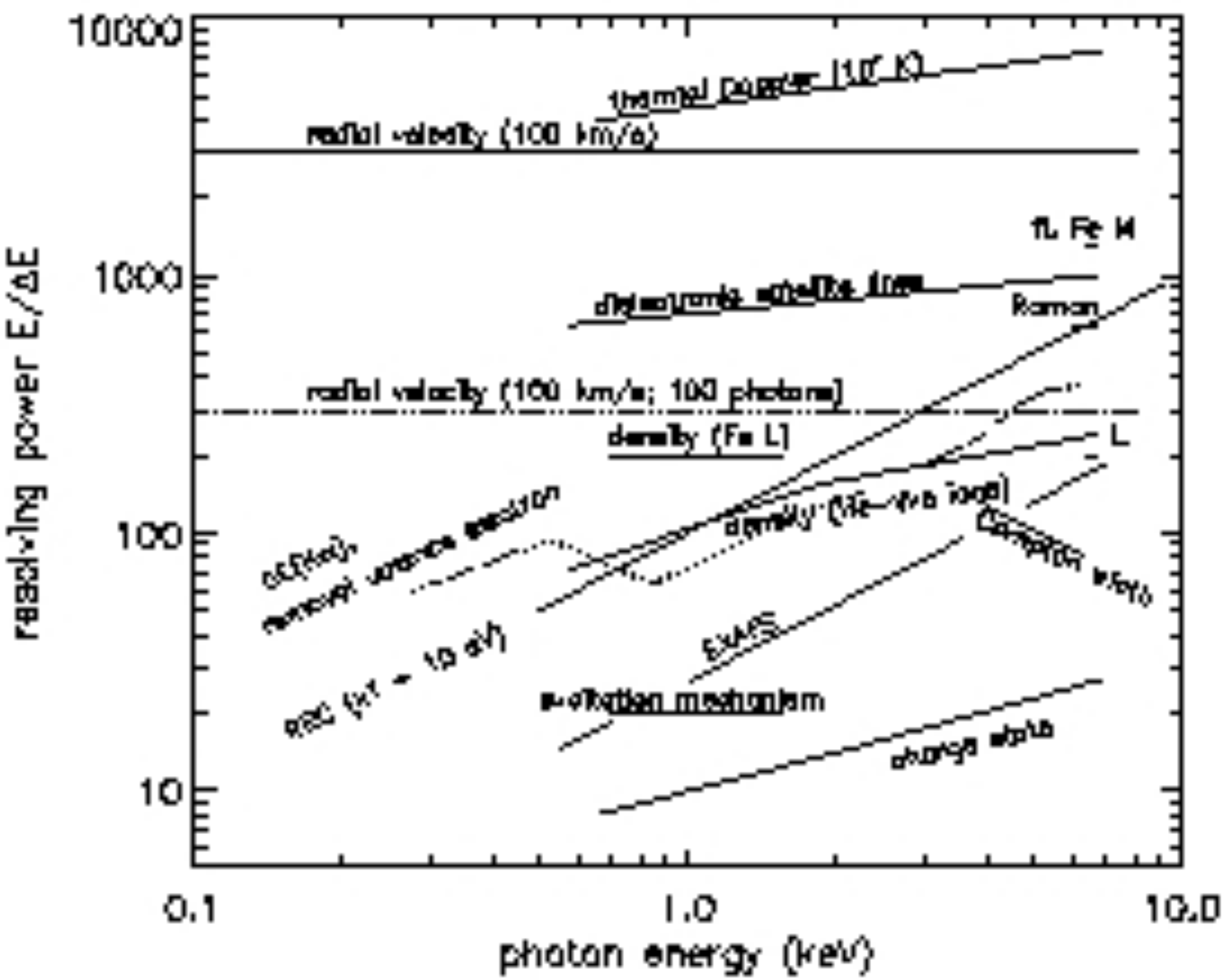
Chakravorty et al. 2008

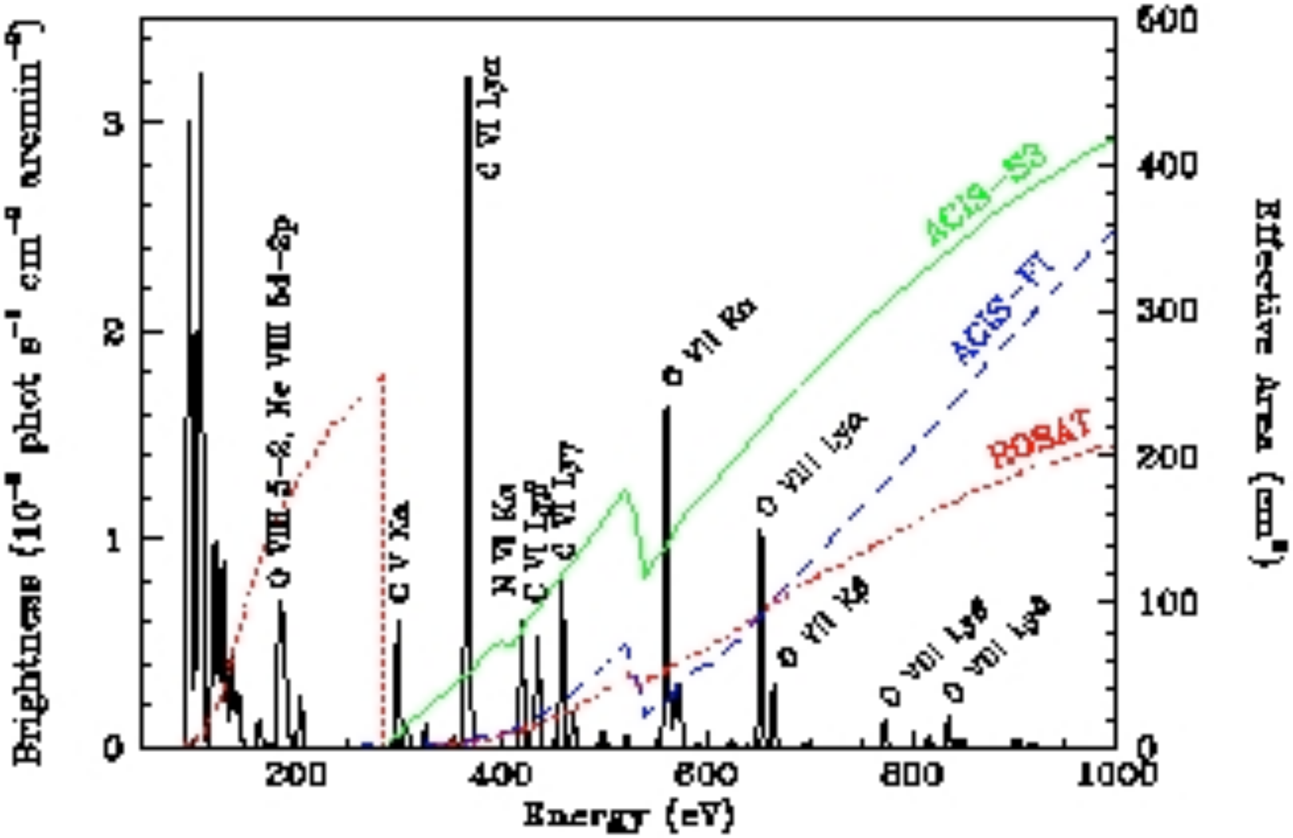
Locating the Warm Absorber

- Time-dependent photoionization models not yet self-consistent
- Radiative transfer?
- Low ionization species not well benchmarked (Fe M-shell Unresolved Transition Array)
- Accurate wavelengths for velocity studies
- Develop new density diagnostics

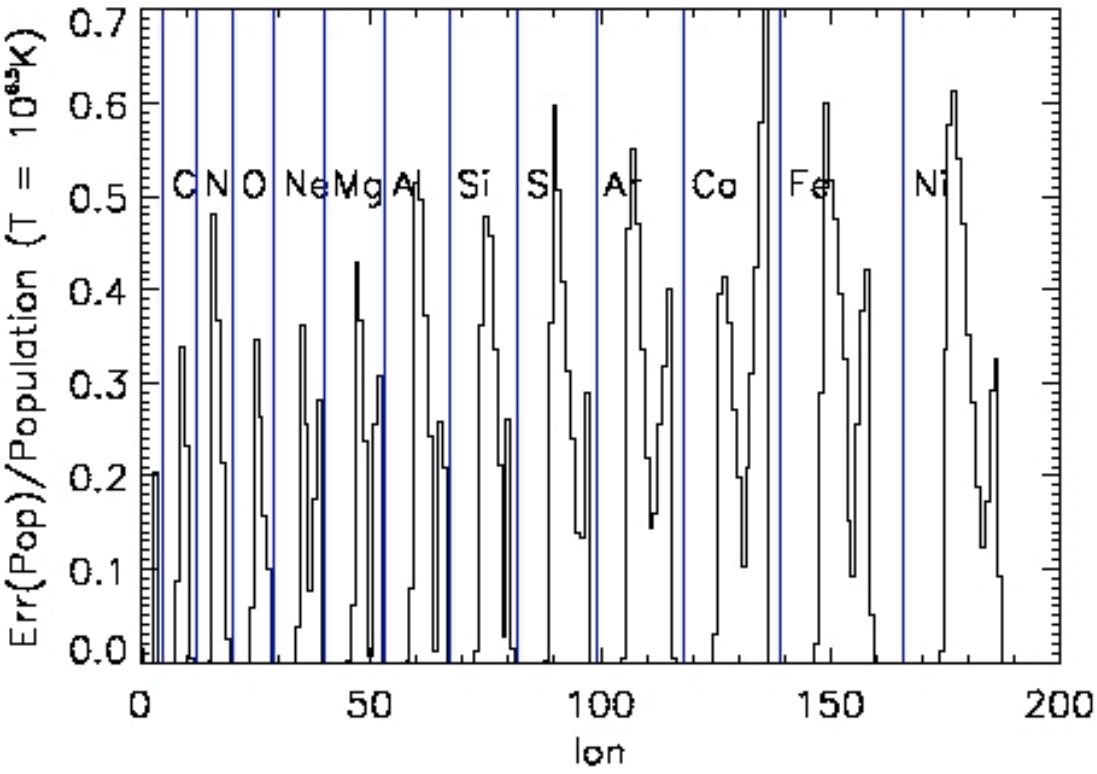
Conclusions

- Of atomic, molecular, solid/dust, plasma, particle, and nuclear, we focus on *atomic physics* because of its immediate impact on high resolution X-ray spectroscopy.
- Controlled experiments and complete, detailed theory is required to understand the atomic physics.
- X-ray astronomy is a model for interaction among astrophysics, plasma modeling and atomic physics.
- X-ray astronomy currently benefits from an active, responsive "laboratory astrophysics" effort. Stable funding, in particular for experimental groups with large infrastructure, needs to be in place.
- Planning for the future requires that we first identify areas of greatest uncertainty, highest science priority, and means for improvement.

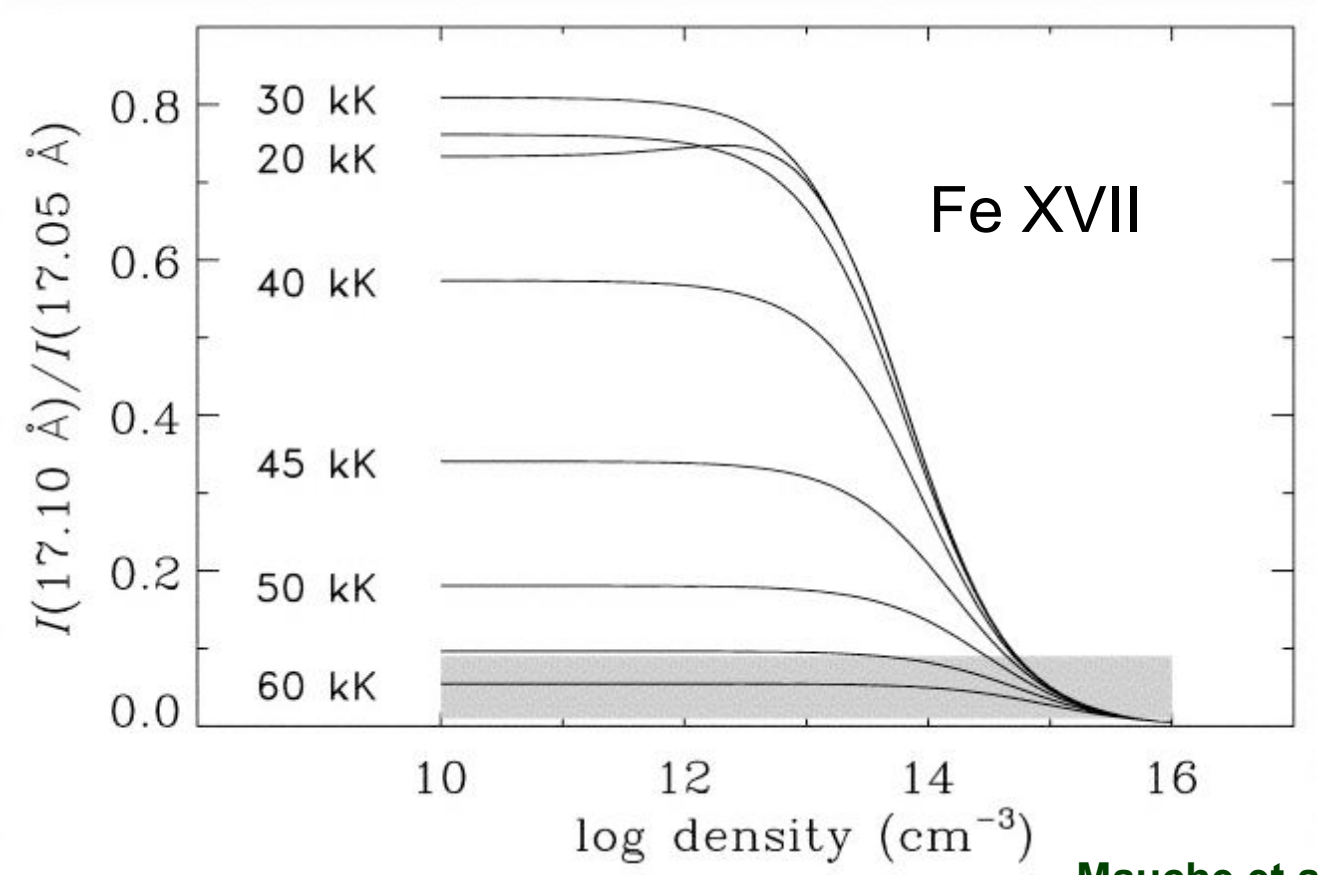

resolving power E/ΔE
photon energy (keV)
10000
1000
100
10
0.1
1.0
10.0
radial velocity (100 km/s)
dielectronic satellite lines
Raman
radial velocity (100 km/s; 100 photons)
density (Fe L)
L
EXAFS
excitation mechanism
charge state



Brightness (10^-8 phot s^-1 cm^-2 arcmin^-2)
Effective Area (cm^2)
Energy (eV)
C VI Lyα
O VIII 5-2, Ne VIII 3d-2p
C V Kα
N VI Kα
C VI Lyβ
C VI Lyγ
O VII Kα
O VIII Lyα
O VII Kβ
O VIII Lyβ
O VIII Lyδ
ACIS-S3
ACIS-FI
ROSAT
0
1
2
3
0
100
200
300
400
500
600
200
400
600
800
1000


Err(Pop)/Population (T = 10^6.5K)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
C
N
O
Ne
Mg
Al
Si
S
Ar
Ca
Fe
Ni
0
50
100
150
200
Ion

Electron Density and Photoexcitation



Mauche et al. 2001