Status of Atomic Plasma Models

Randall Smith

…with assistance from many plasma modelers…

Codes Used for High-Energy Spectroscopy

- Collisional
  - AtomDB
  - Chianti
  - SASAL
  - SPEX

  - ADAS (Fusion)

- Photoionized
  - Cloudy
  - SPEX
  - XSTAR

  - Mocassin, others

Codes Used for High-Energy Spectroscopy

- Collisional
  - AtomDB (From Raymond-Smith 1977)
  - Chianti (From Landini & Monsignori-Fossi, 1970)
  - SASAL (2010's Blend of Chianti, ADAS)
  - SPEX (From Meka code; Mewe 1972)
  - ADAS (Fusion) (Begun with JET experiment In ~1982…)

- Photoionized
  - Cloudy Ferland, 1980s or before
  - SPEX (From Meka code; Mewe 1972)
  - XSTAR (Kallman & McCray 1982)
  - Mocassin, others

The 'Lorentz Meeting'

At this meeting, we developed recommendations for a baseline set of model calculations that could be performed by all or most plasma models, with clearly specified temperatures, densities, plasma compositions and output formats.

http://www.atomdb.org/Issues/lorentz.php

High Energy Astrophysical Model Comparison Workshop

Workshop: 8 – 12 August 2016, Leiden, the Netherlands

Scientific Organizers
- Adam Foster, CfA Cambridge
- Jelle Kaastra, SRON Utrecht
- Randall Smith, CfA Cambridge

Topics
- Inullorae ommo cus dit moluptatium
- Sunteni mporporem doluptas
- Reprehe nditatu rerspis sinctemquam lab ilitiatiasin pliantest moluptat
- Demod que isquatem aut lab iunt abor ma atem aut estorporem
- Et volor sum quo et et, tem re sim
- Corionem reptatusamus et ut denda dellendae andunt quam et pa

The Lorentz Center is an international center for scientific workshops. Its aim is to organize workshops for researchers in an atmosphere that fosters collaborative work, discussions and interactions. For registration see: www.lorentzcenter.nl

Wouldn't it be nice to have a short explanation here of the chosen image, and it's relevance to the scientific subject? Poster design: SuperNova Studios . NL

Universiteit Leiden The Netherlands

FOM

STW

NWO Netherlands Organisation for Scientific Research Physical Sciences

Lorentz center

www.lorentzcenter.nl

Lorentz Tests (Equilibrium)

- **CIE-CSD** Charge State Distribution in equilibrium with electron density 10^6 m^{-3} and three temperatures: 10^6K, 6×10^6K, and 4.642×10^7K (=4 keV). These temperatures correspond to typical values for the Sun, Capella, and Perseus cluster.

- **Power** Total radiative power in ergs/s from a 1 m^3 plasma with $n_e = 10^6$m^{-3} for proto-Solar gas over the range 13.6 eV to 13.6 keV. Done per element, over T=10^4-10^9K in 51 log steps.

- **StrongLines** The 100 strongest lines with $\lambda<1000$Å, in photons/s, from a 1 m^3 plasma in the same state as CIE-CSD
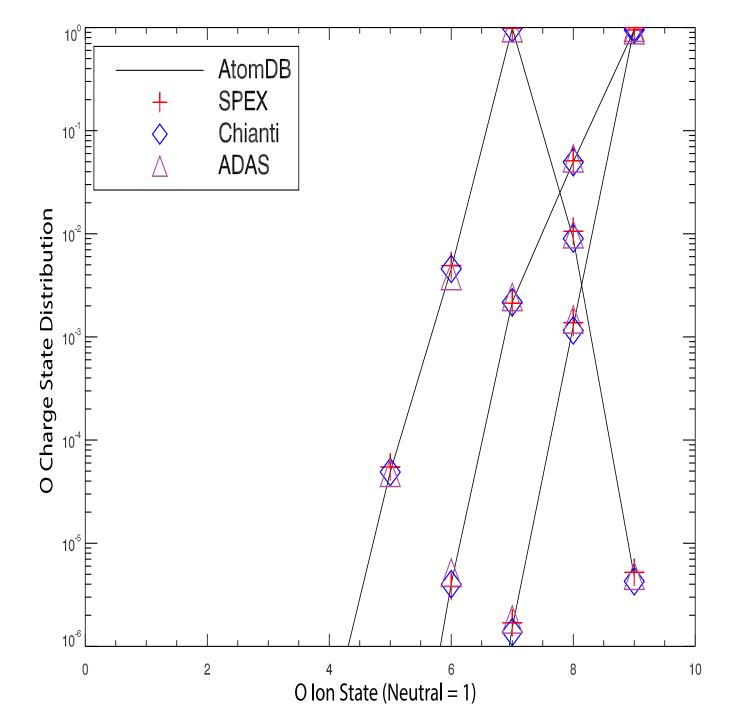
- **PI-CSD** The CSD and electron temperature at log(ξ) =1, 2, 3 for an optically thin 10^8 cm^{-3} proto-Solar plasma excited by a single power law ionizing continuum with Γ=2 and low and high energy cutoffs are 0.1 eV and 1 MeV, with a central source with L_{bol} = 2.76×10^{43} erg/s.

- **PI-Lines** The lines with the largest optical depth from each ion at log(ξ) =1, 2, 3 for the same case as PI-CSD

- **PI-HeatCool** The heating and cooling rates (both total and broken down by contributing process) at log(ξ) =1, 2, 3 for the same case as PI-CSD.

- **PI-Abs** The absorption spectra at log(ξ) =1, 2, 3 for the same case as PI-CSD.
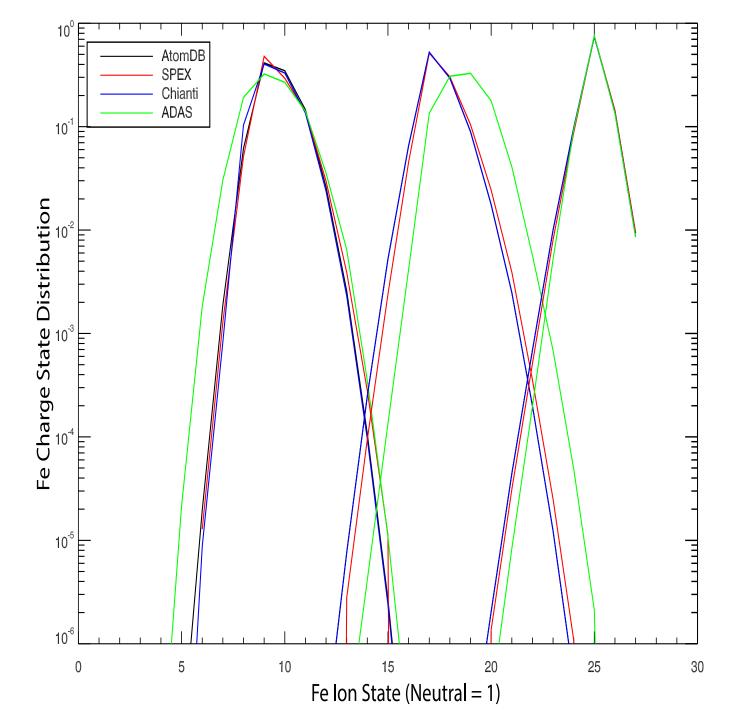
Lorentz Tests (Non-Equilibrium)

- **NEI-CSD** Charge State Distribution of a proto-Solar gas from a non-equilibrium plasma at constant volume and $n_e=10^6 m^{-3}$ at $10^4 K$, raised to $2.32 \times 10^7 K$ (=2 keV) and allowed to evolve for a fluence n_e x t = $10^{10} cm^{-3}s$. This corresponds, roughly, to a Cas A-type supernova remnant.

- **NEI-Lines** The 100 strongest lines with $\lambda < 1000$Å from a 1 m^3 plasma with $n_e=10^6 m^{-3}$ for proto-Solar gas and allowed to evolve as per NEI-CSD.
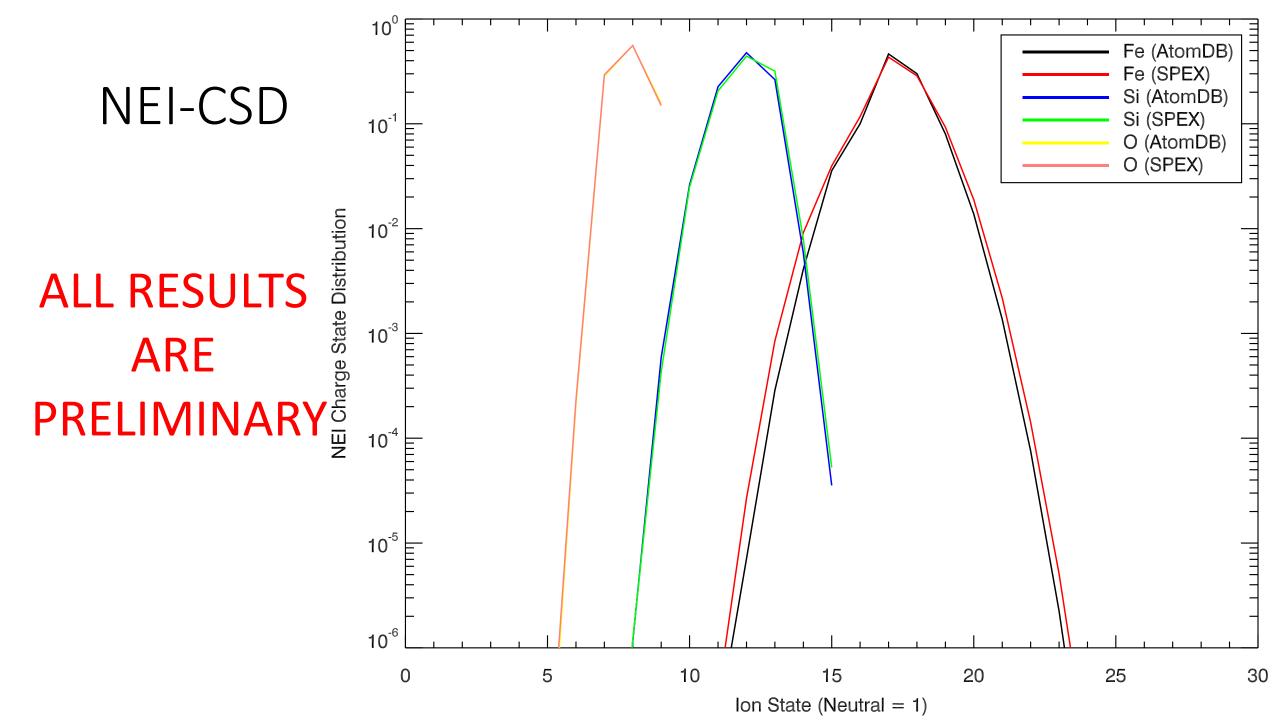
- **NEI-Cont** The spectrum from 10 eV to 10 keV of a 1 m^3 plasma $n_e=10^6 m^{-3}$ for proto-Solar gas that starts in equilibrium at T_e = 3.5 keV, then jumps to T_e = 1.5 keV and the plasma evolves to a fluence n_e x t = $10^{10} cm^{-3}s$. This model corresponds, roughly, to the recombining SNR W49B.

- **LevelPop** For 17 'key' X-ray lines, the line flux and formation method in photons/s, from a 1 m^3 proto-Solar gas plasma with densities $10^6 m^{-3}$ and $10^{18} m^{-3}$ (=$10^{12} cm^{-3}$) at 10^6, $6 \times 10^6 K$, and $4.642 \times 10^7 K$ (=4keV). Formation methods include electron [de-]excitation, proton [de-]excitation, radiative decay into/out of the level, radiative recombination into the level, dielectronic recombination into the level, and inner shell ionization/excitation into the level.
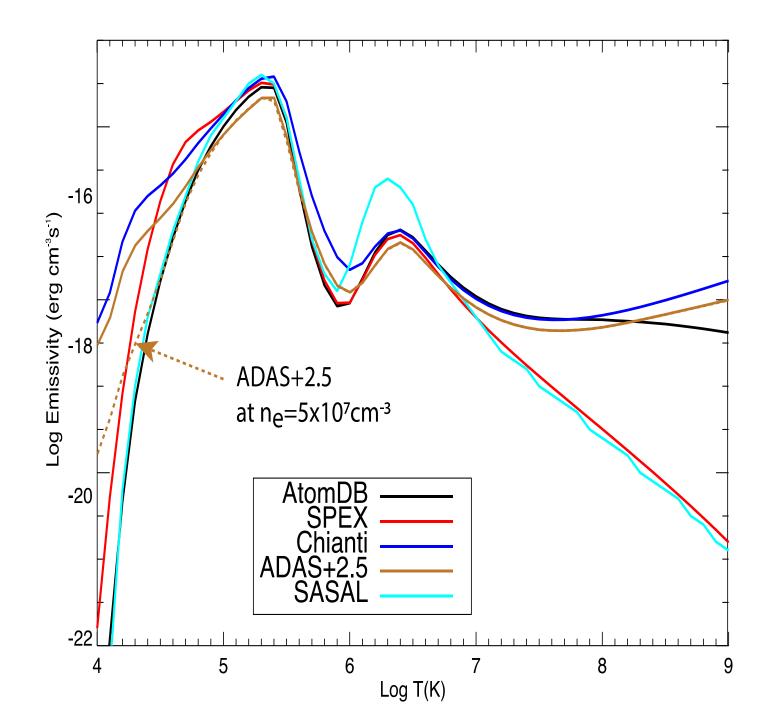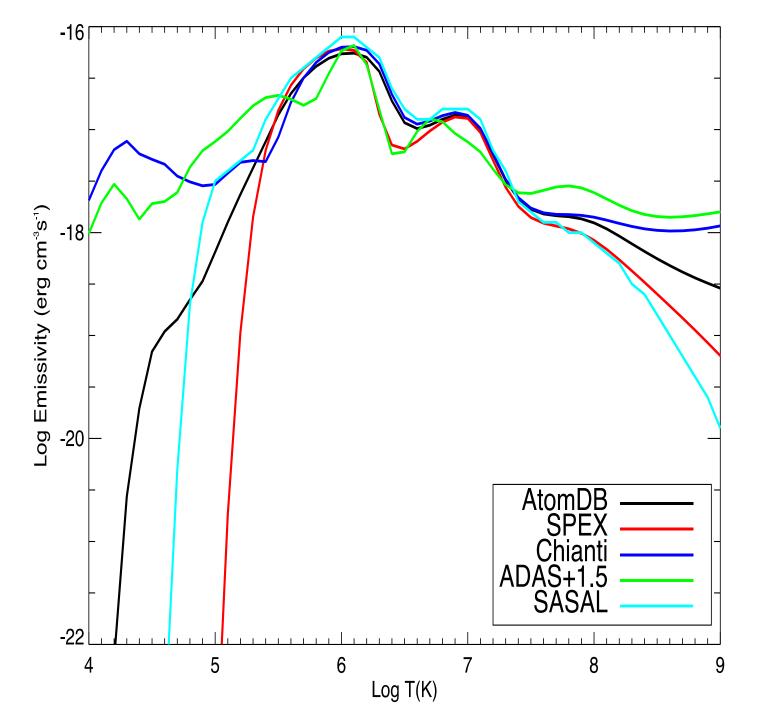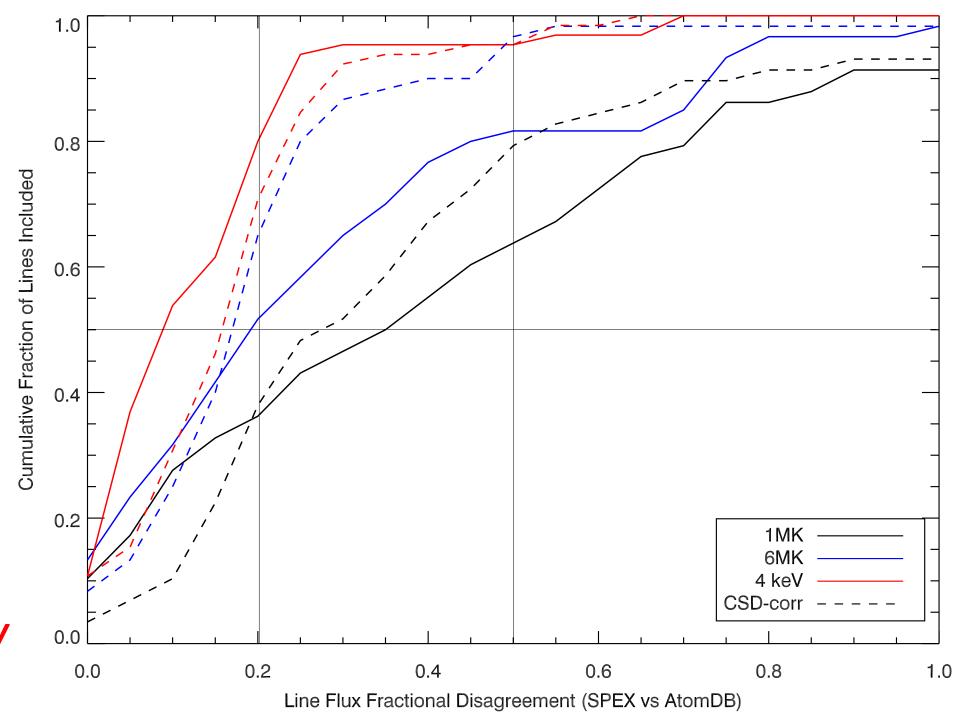
CIE-CSD

ALL RESULTS
ARE
PRELIMINARY

POWER (Oxygen)

ALL RESULTS ARE PRELIMINARY

ADAS+2.5 at $n_e = 5 \times 10^7 cm^{-3}$

Log Emissivity (erg cm^{-3}s^{-1})

Log T(K)

AtomDB
SPEX
Chianti
ADAS+2.5
SASAL

POWER
(Iron)

ALL RESULTS
ARE
PRELIMINARY
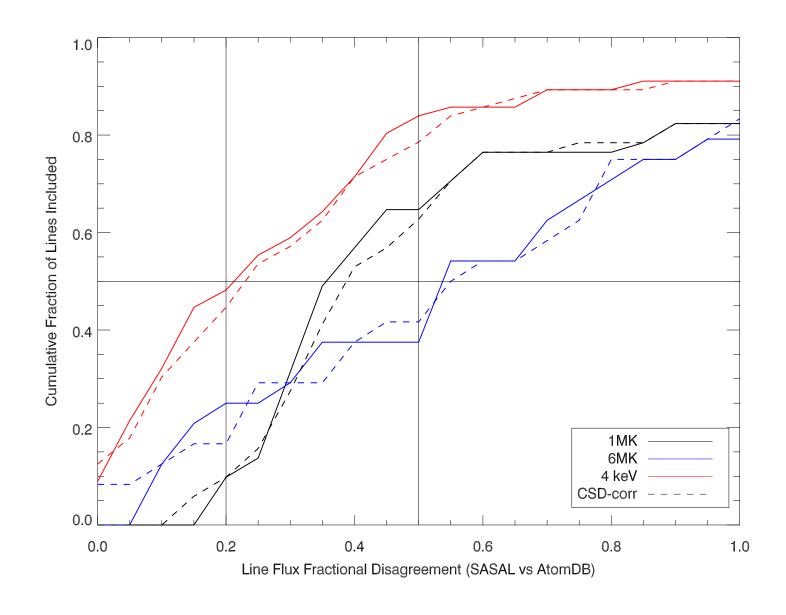
Strong Lines

Comparing SPEX to AtomDB

ALL RESULTS ARE PRELIMINARY

Strong Lines

Comparing SASAL to AtomDB

ALL RESULTS ARE PRELIMINARY