Astrophysical Applications Based on Updated Atomic Databases

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Abstract

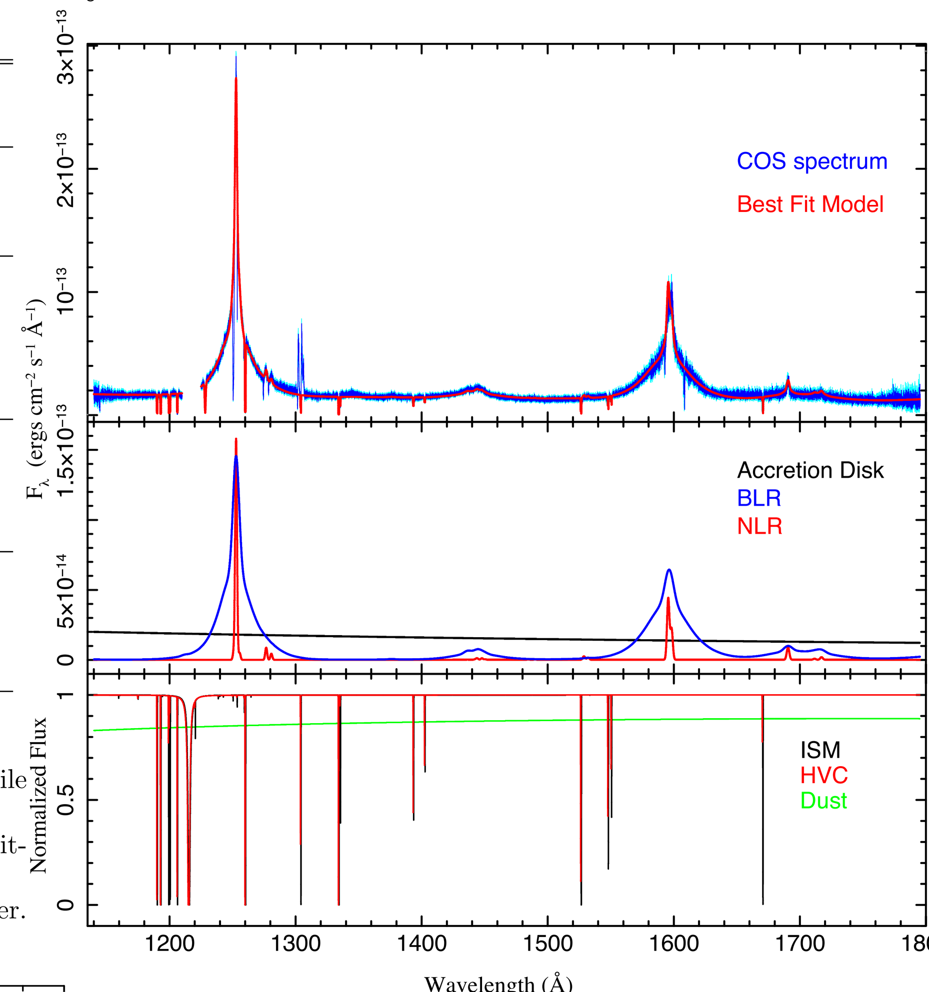
Taking advantage of the updated atomic database and codes, we present some astrophysical applications of our group. 1) The first application is based on AtomDB 3.0, we present the radiative cooling rates of optically thin collisionally dominated plasma in various collisional ionization equilibrium (CIE) and non-equilibrium ionization (NEI) cases. Our calculations are performed in a density range of 0.1–10^{14}cm^{-3}, in a temperature range of $10^4 - 10^9$K, and in an ionization timescale range of 1–10^{13}s for NEI plasma, which cover most kinds of cosmic X-ray bright plasma. The plasma with different metalicities, including hydrogen and helium free plasma (e.g. the ejecta in supernova remnants), are also examined. 2) The second application is based on the newly updated XSTAR, we generated photoionization models for the intrinsic absorption from the AGN outflow, the line emission from the AGN broad and narrow line regions, and the local absorption from high velocity clouds and Galactic interstellar medium. We show the combination of these physical models fit a HST/COS spectrum of Mrk 290.

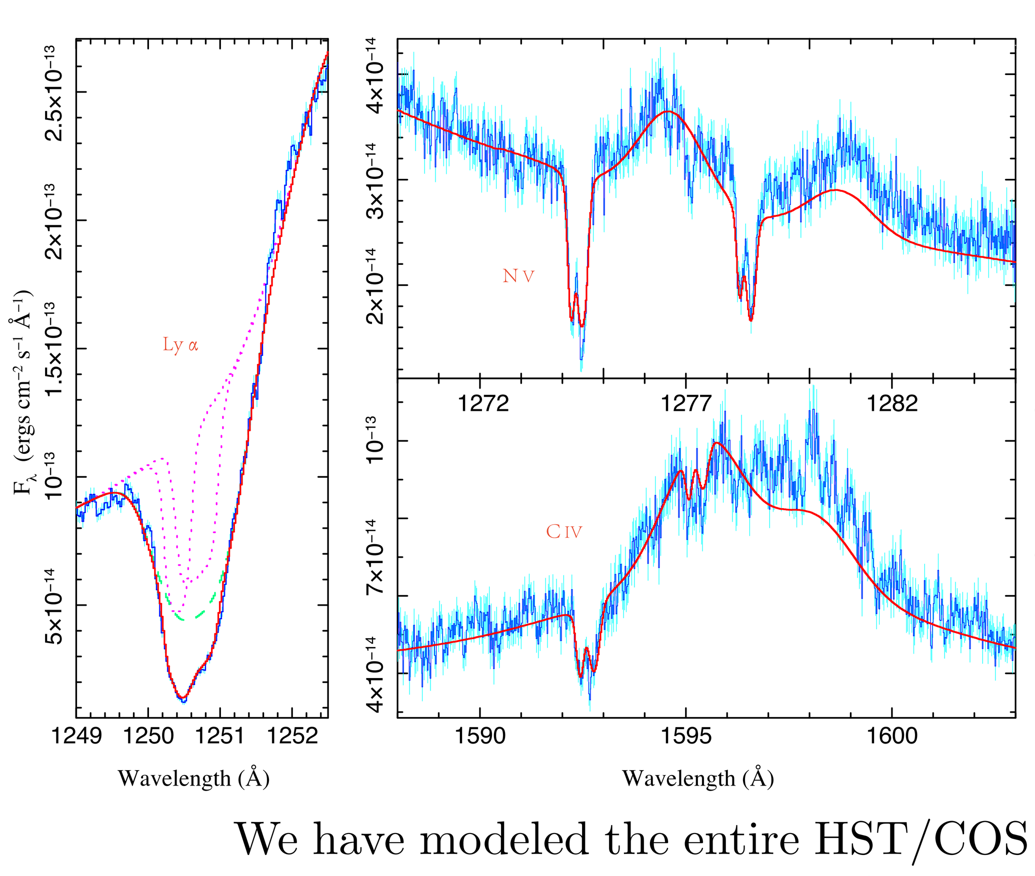
XSTAR Application

- Modifications in XSTAR (2.2 lbn19 & newer):
- allows the synthesis of spectra with resolving power up to 8×10^4
- the spectral resolution is an input parameter, controlled by the user
- update line database to include several low ionization lines which are observed from the Milky Way and its halo.
- cover the UV & X-ray bands simultaneously

	Log(ξ) (erg s cm^{-1})	N_H (10^{20} cm^{-2})	redshift	velocity* (km s^{-1})	
Local Absorption:					
HVC	-0.74±0.04	1.12 (fixed)	-0.000430±0.000001	-129.0±0.3	
ISM	-1.29±0.01	0.57±0.01	-0.000121±0.000001	-36.3±0.3	
AGN Radiation:					R_{norm}[a]
BLR I	-0.601±0.007	-	0.030546±0.000013	1.8±3.9	5.0±0.4
BLR II	0.659±0.004	-	0.029855±0.000035	-205.5±10.5	1.2±0.1
BLR III	0.125±0.009	-	0.029872±0.000052	-200.3±15.6	20.7±1.9
NLR	0.592±0.028	-	0.030540±0.000005	0±1.5	-
Intrinsic Outflow Absorption:					C_f[b]
WA I	1.13 ± 0.10	0.5 ± 0.2	0.028570 ± 0.000005	-591.0±1.5	66±3(%)
WA II	1.39 ± 0.04	4.8 ± 1.4	0.028789 ± 0.000006	-525.3±1.8	56±3(%)
WA III	2.2 (fixed)	36.0 ± 0.8	0.028811 ± 0.000005	-518.7±1.5	72±3(%)
X-ray WAs from *Chandra* observations (Z11):					
LI WA	1.62 ± 0.15	5.4 ± 1.8	-	-570±150	-
MI WA	2.42 ± 0.04	40.6 ± 6.2	-	-480±30	-
HI WA	3.20 ± 0.14	35 ± 15	-	-390±60	-

- The velocities of HVC & ISM are relative to heliocentric coordinates while other components are relative to AGN rest frame
- R_{norm}: the ratio of 'normalization' values of the two spectra for the transmitted and reflected emission by the BLR clouds
- C_f: the covering fraction to the continuum & BLR emission by each absorber.



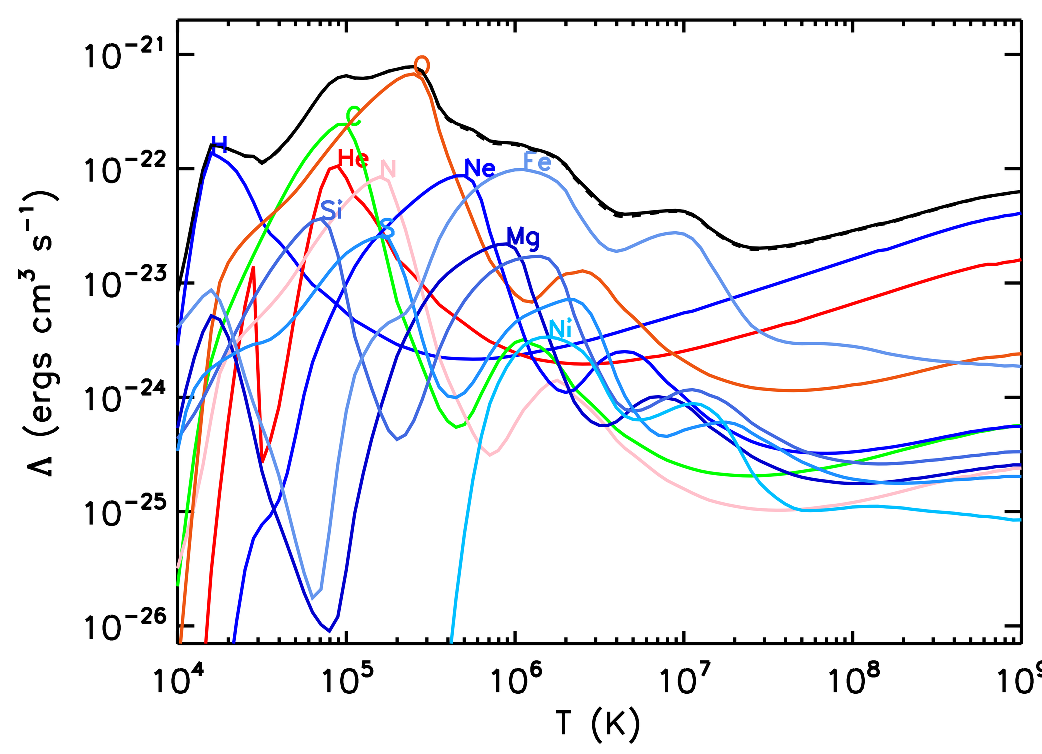


- red-solid:
  best fit by three photoionized absorption models
- purple-dotted:
  contribution from the two lower ionized absorbers that absorb the N V & C IV lines
- green-dash:
  the higher ionized absorber only affects Lyα

We have modeled the entire HST/COS spectrum of Mrk 290 with photoionization models generated by XSTAR. Three intrinsic UV absorbers outflowing with a radial velocity ~ 500 km s^{-1} are identified, which are consistent with the two WAs obtained in the X-ray band. The WAs are likely in the geometry of clouds rather than flat and thin layers. Their small turbulent velocities (100 km s^{-1}) also support the scenario that the WAs are from the torus due to thermal evaporation.

Credit: Zhang, S. et al. 2014 in review

AtomDB: Cooling Functions

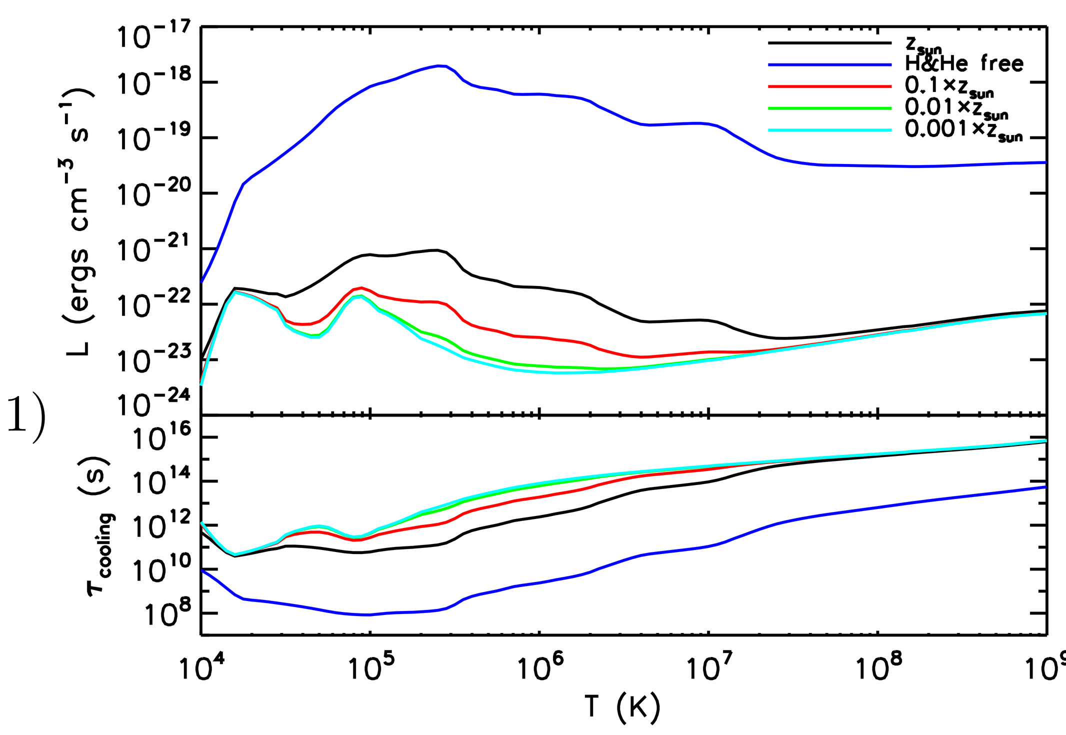


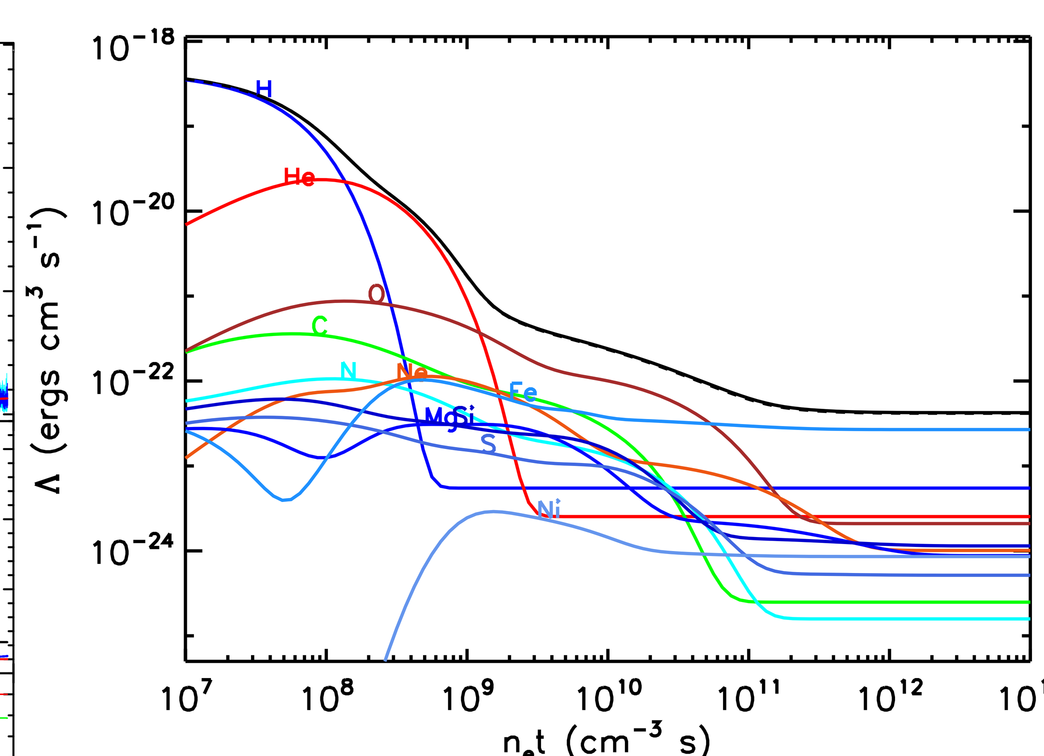
AtomDB 3.0 (www.atomdb.org)

- CIE case:
- 0.01 - 100 keV band
- Solar abundance
- $n_e = 0.1$ cm^{-3}

Total cooling efficiency: black line
- H : $T < 3 \times 10^4$K & $T > 10^7$K
- O : $T \sim 3 \times 10^5$K
- Fe : $T \sim 10^6$K & $T \sim 10^7$K

- CIE for different abundances:
-10^{-3}Z$_\odot$, 10^{-2}Z$_\odot$, 10^{-1}Z$_\odot$, Z$_\odot$
  $L = \Lambda n_e n_{nucleon}$
- H, He-free plasmas
  $L = \Lambda n_e n_H$
- Cooling time:
$\tau_{cooling} = (n_e + n_{nucleon})kT/(\gamma - 1)$
Assume:
  $n_H = n_{nucleon} = 1$cm^{-3}
  $\gamma = 5/3$

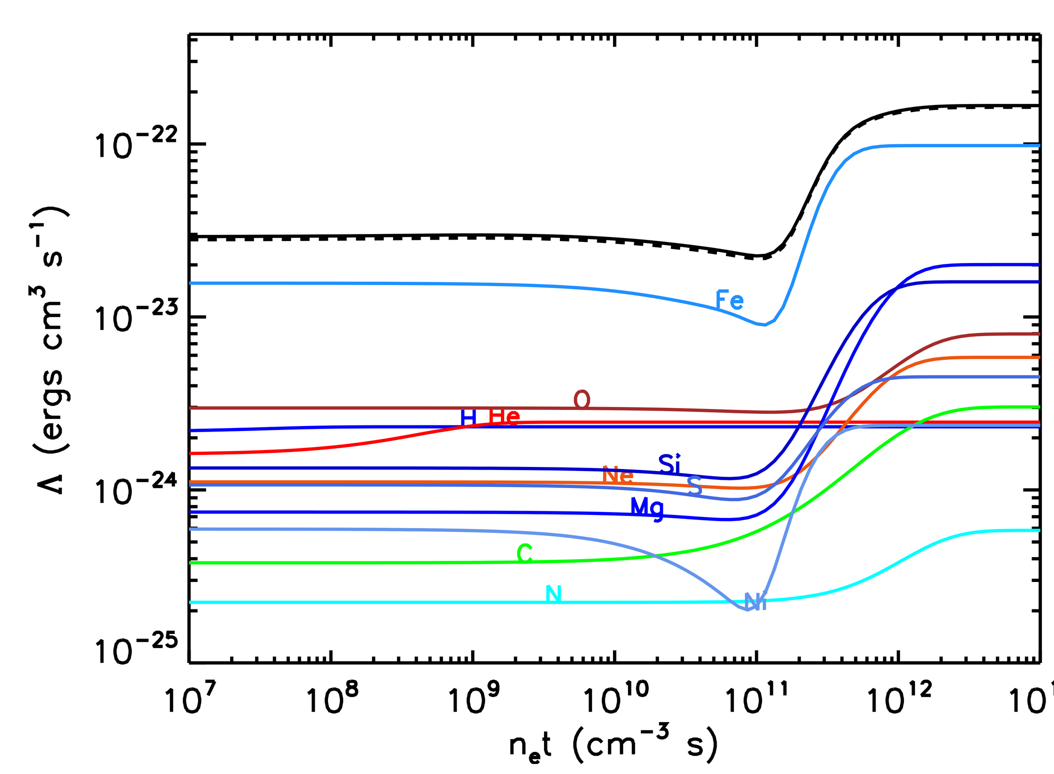




- Ionizing plasma:
- $T_i = 10^4$K
- $T_e = 10^7$K
- 0.01 - 100 keV band
- Solar abundance
- $n_e = 0.1$ cm^{-3}

The emission is dominated by: H, He, O& Fe.

- Recombining plasma:
- $T_i = 10^8$K
- $T_e = 10^6$K
- 0.01 - 100 keV band
- Solar abundance
- $n_e = 0.1$ cm^{-3}



- Ionisation state of CIE plasma is approximately independent of density
- The pure metal gas endures a rapid radiative cooling
- The radiative cooling rate of ionizing plasma is higher than that in CIE plasma, and it smoothly approaches the CIE case
- There is a stage where many ions with different ionisation levels coexist in recombining plasma
- The radiative cooling rate of recombining plasma is lower than that in CIE plasma, RRC emission could be dominant over line emission in a recombining plasma

Credit: Zhou, X. et al. 2014 in-preparation

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