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# CHIANTI – An Atomic Database for UV and X-ray Cool star spectroscopy

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**Abstract.** The CHIANTI atomic database was first released in 1996 and has since become the standard resource for the interpretation of UV spectra from the transition regions and coronae of the Sun and other cool stars. We describe the contents of the most recent release (v.3) and some of the uses that have been found for the database.

## 1. Introduction

The first version of CHIANTI is described in Dere et al. (1997) and the key features are: (i) coverage of virtually all astrophysically important ions; (ii) assessed, up-to-date atomic data; and (iii) a freely-available database, transparent to the user. Further releases have included minor ions and continuum emission (v.2, Landi et al. 1999), and an extension to X-ray wavelengths (v.3, Dere et al. 2001).

The database contains both atomic data and a set of IDL routines from which one can construct synthetic spectra or study plasma diagnostics. The atomic data consist of: (i) energy levels; (ii) electron excitation rates; and (iii) radiative decay rates. These allow the level balance equations of the ion to be solved in the 'coronal approximation'. Figure 1 shows the ions we have in the database and the number of levels we model each ion with. The IDL routines allow the user to construct synthetic spectra, study plasma diagnostics, derive $G(T)$ functions, and compute the radiative loss function amongst other things. Examples of radiative loss functions derived with CHIANTI are shown in Fig. 2.

## 2. Other Databases/Software Packages That Use CHIANTI

The high quality of the CHIANTI database has been recognized by teams working on other spectral codes and in order not to duplicate the efforts of the

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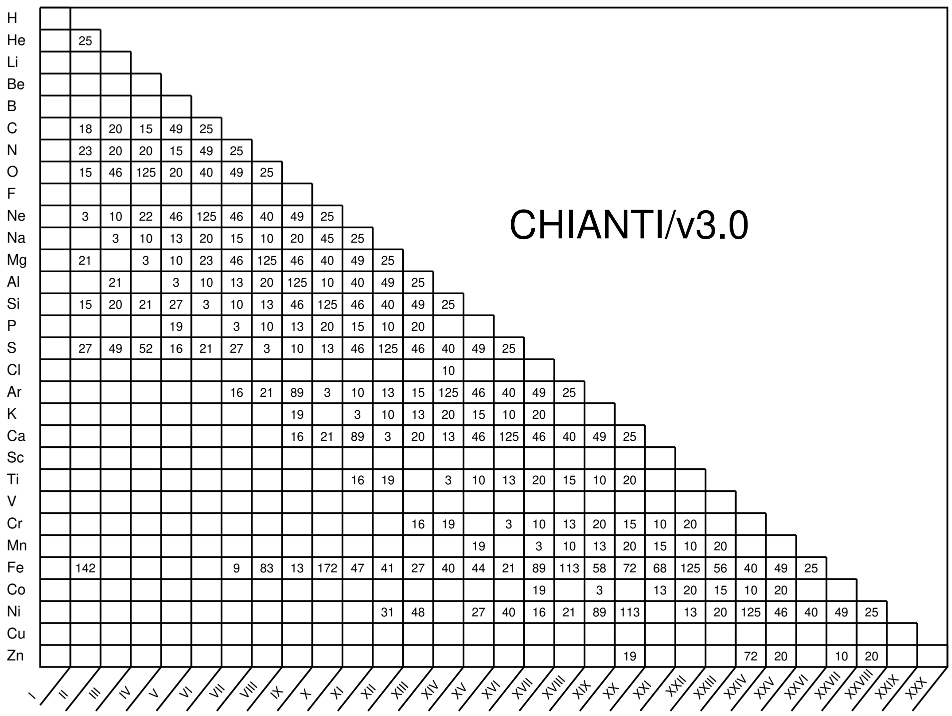


Figure 1. Ions contained in v.3 of CHIANTI. The numbers indicate the number of levels included in the model of the ion.

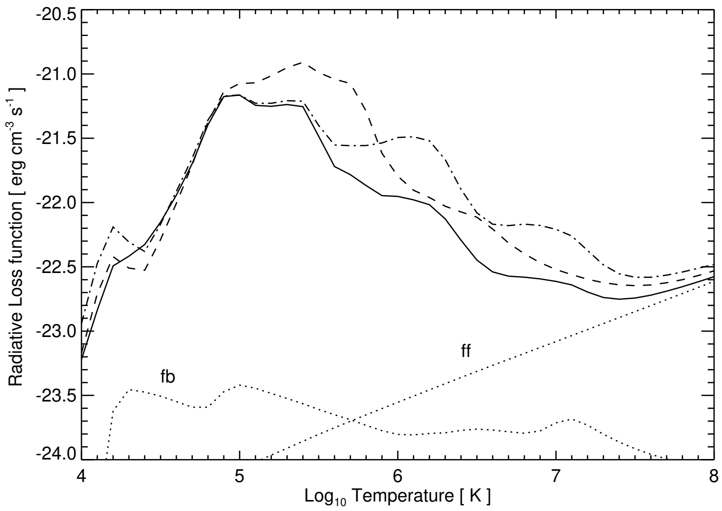


Figure 2. Radiative loss curves derived with CHIANTI assuming different abundances. The solid line is for solar photospheric abundances (Anders & Grevesse 1989), the dashed line noble gas enhanced abundances (Drake et al. 2001), and the dash-dot line solar coronal abundances (Feldman et al. 1992). The dotted lines indicate the contributions of free-free (ff) and free-bound (fb) continua.

CHIANTI team, they have incorporated CHIANTI into their codes. They include

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| XSTAR | Designed principally for the modeling of photoionized plasmas, XSTAR (Bautista & Kallman 2001) uses CHIANTI data for electron excitation and radiative decays – crucial for determining emission line fluxes from the plasma. |
| APED | The Astrophysical Plasma Emission Database (Smith et al. 2001) combines CHIANTI with data from other sources to model X-ray spectra. APED is included within the *Chandra* and XSPEC software packages. |
| Arcetri Spectral Code | A code for calculating theoretical spectra in the range 1–2000 Å (Landi & Landini 1998). |
| PINTofALE | This is an IDL-based software package to aid in the analysis of UV and X-ray spectra (Kashyap & Drake 2000). Emissivities from CHIANTI are provided to aid in spectral analysis. |

## 3. Uses of CHIANTI: TRACE and EIT

The EIT and TRACE instruments have provided spectacular images of the Sun in extreme ultraviolet radiation, revealing the huge range of dynamic phenomena taking place on the Sun. In order to determine quantitative information from the EIT and TRACE images it is necessary to understand precisely the spectrum that is covered by the instruments' filters. For this, the scientists of both instruments turned to CHIANTI. The standard EIT and TRACE software convert measured count rates into temperature and emission measure maps through the synthetic spectra calculated by CHIANTI.

With this data, many important results have come from EIT and TRACE including the derivation of uniform temperature along coronal loops (Lenz et al. 1999), which has led to advances in coronal loop modelling (e.g., Aschwanden et al. 2000).

## 4. Uses of CHIANTI: Spectrometer Calibration

A common method for checking the flux calibration of spectrometers is to study ratios of emission lines known to be insensitive to the plasma temperature and density. The software and data in CHIANTI allow such ratios to be quickly found and recent UV spectrometers have made use of CHIANTI to determine or check calibration curves.

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| SERTS | Spectra from the 1989, 1991, 1993 and 1995 flights of SERTS have flux calibrations that have been determined or modified through the application of insensitive line ratios from CHIANTI (Brosius et al. 1998, Young et al. 1998). |
| SOHO/CDS | The calibration of both the NIS and GIS channels have been extensively checked by Landi et al. (1999) and Del Zanna et al. (2001) using CHIANTI. |

## 5. Summary

The CHIANTI database continues to evolve both in terms of its content and its applications. Future updates include the addition of proton excitation rates and photoexcitation, and in the longer term ionization and recombination rates. These updates can be monitored by accessing the web-page at http://wwwsolar.nrl.navy.mil/chianti.html. A recent development has been the addition of the complete database and routines as a package to the SOLAR-SOFT distribution (http://www.lmsal.com/solarsoft/) allowing updates to be handled automatically through a MIRROR process.

If you make use of CHIANTI in your research, please indicate which version you have used, and reference both the original CHIANTI paper (Dere et al. 1997) and the paper describing the version you are using (e.g., for v.3 cite Dere et al. 2001).

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