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# **CHIANTI**

**An Astrophysical Database for Emission Line Spectroscopy**

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**CHIANTI TECHNICAL REPORT No. 1**

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**The CHIANTI energy level files (elvlc)**

Ver 1.2, 31 July 2017, Peter Young

Ver 1.1, 6 February 2017, Peter Young

Ver 1.0, 14 January 2013, Peter Young

This document describes the format for the CHIANTI elvlc file, which contains the level index for all levels in the CHIANTI model for an ion and assigns an energy to each level.

## 1 General information

The format for the elvlc file remained the same from CHIANTI 1 through to CHIANTI 7.1. Between CHIANTI 7.1 and 8, the format was changed, principally to allow level indices to go beyond 999. The present document describes the format of the new files.

Only fine structure levels are considered in CHIANTI, and for each level the configuration, L, S and J-values are given to describe the level. Energies are given in units of  $\text{cm}^{-1}$  and both an observed energy and a theoretical energy are given. If an observed energy does not exist, then the CHIANTI software uses the theoretical energy for that level. If an energy is not available for a level, then a “missing value” of -1 is assigned to that level.

The elvlc file contains columns with a fixed number of characters, and the data entries are terminated by a line containing only a “-1”. All subsequent lines are considered to be comments.

## 2 Data columns

There are eight data columns and each is described below. The format for the column is indicated by Fortran-style notation: *\*i7\**, *\*a30\**, etc.

### Column 1 - level index *\*i7\**

Levels can be arranged in any order, although following the observed or theoretical energy ordering is recommended. Level 1 is recommended to be the ground level, although this is not essential.

### Column 2 - configuration description *\*a30\**

The recommended configuration format is, e.g., “3s2.3p2(2P).3d”. That is, orbitals are separated by a “.” and parent terms are placed in brackets. However, separating orbitals by white space is also acceptable, e.g., “3s2 3p2(2P) 3d”.

### Column 3 - level label string *\*a5\**

This can be used to attach a label to a level. An example is for Fe II for which the common multiplets are identified by a single letter.

### Column 4 - 2S+1 value *\*i5\**

### Column 5 - L value *\*a5\**

Takes values of S, P, D, F, G, etc.

### Column 6 - J value *\*f5.1\**

### Column 7 - observed energies, $\text{cm}^{-1}$ *\*f15.3\**

If a level does not have an observed energy, then a value of -1 should be given.

### Column 8 - “best-guess” theoretical energies, $\text{cm}^{-1}$ *\*f15.3\**

Any level that does not have an observed energy must have an energy in this column. For levels that do have an observed energy, a value in this column is optional.

### Comments section

The comments section will be free format. It is recommended that, in addition to specifying the citation to a data source, the data assessor should also specify a URL to the ADS page for the paper. For example:

```
%collision strengths:  
Mason, H.E., 1975, MNRAS, 170, 651  
http://adsabs.harvard.edu/abs/1975MNRAS.170..651M
```

### 3 Reading the elvlc file

The elvlc file is read by the routine read\_elvlc.pro, which was completely revised between CHIANTI 7.1 and CHIANTI 8 in order to read the new file format. In order to maintain compatibility with the previous version of the routine, the new version of read\_elvlc can be called in the identical manner to the old routine, i.e.,

```
IDL> read_elvlc, filename, l1,term,conf,ss,ll,jj,ecm,eryd,ecmth,erydth,ref
```

However, it is recommended that the CHIANTI software be modified in the future to call read\_elvlc with:

```
IDL> read_elvlc, filename, elvlc=elvlc
```

where ELVLC is an IDL structure containing the data. ELVLC has two tags, INFO and DATA, that are both structures. The tags of ELVLC.INFO are listed in Table 1, and the tags of ELVLC.DATA are listed in Table 2.

Note that ELVLC.DATA.ENERGY contains the best energy for a level, i.e., it will be the observed energy if this exists otherwise it will be the theoretical energy. It is recommended that this tag be used when the software needs to access a level's energy.

**Table 1. Tags for the elvlc.info structure.**

Tag	Data	Type
ION_NAME	Ion name (CHIANTI format)	String*1
ION_Z	Atomic number	Integer*1
ION_N	Spectroscopic number	Integer*1
ION_ROMAN	Ion name (Roman numerals)	String*1
ION_LATEX	Ion name (latex format)	String*1
ION_LATEX_ALT	Ion name (alternative latex format)	String*1
COMMENTS	File comments	String array
CHIANTI_VER	Chianti version number	String*1
TIME_STAMP	Time file was made	String*1
FILENAME	Filename (including path)	String*1

**Table 2. Tags for the elvlc.data structure.**

Tag	Data	Type
INDEX	Level index	Integer*1
CONF	Configuration of the level	String*1
CONF_LATEX	Configuration identifier in Latex format	String*1

CONF_INDEX	Index of configuration	String*1
TERM	Spectroscopic term	String*1
TERM_LATEX	Spectroscopic term in Latex format	String*1
LEVEL	Spectroscopic level	String*1
LEVEL_LATEX	Spectroscopic level in Latex format	String*1
FULL_LEVEL	Full level description (incl. configuration)	String*1
FULL_LEVEL_LATEX	Full level description in Latex format	String*1
LABEL	A label for the level	String*1
MULT	Multiplicity (i.e., 2S+1)	Integer*1
S	Spin	Float*1
L	Orbital angular momentum	Integer*1
L_SYM	Symbol for orbital angular momentum (S,P, etc)	String*1
J	Total angular momentum	Float*1
J_STR	J as fractional string (e.g., '1/2')	String*1
PARITY	Parity (0 or 1)	Integer*1
PARITY_STR	Parity ('e', or 'o')	String*1
WEIGHT	Weight (2J+1)	Float*1
OBS_ENERGY	Observed energy in cm <sup>-1</sup>	Double*1
THEORY_ENERGY	Theoretical energy in cm <sup>-1</sup>	Double*1
ENERGY	"Best" energy in cm <sup>-1</sup>	Double*1
ENERGY_UNITS	Units of energy	String*1
EXTRA_INFO	Unused tag	String*1

## Appendix

### 1 Update history

*Ver. 1.2, 31-Jul-2017: added Appendix 3.*

*Ver. 1.1, 6-Feb-2017: added Table 1 and Table 2; added Appendix 2.*

### 2 ELVLC format prior to CHIANTI 8

Prior to CHIANTI 8, the ELVLC file had 12 columns, which are listed below. The contents of the columns are mostly the same as those in the new files so please check Section 2 for more information.

Some files had an additional two columns in formats e15.3 and e15.6 that contained energies in  $\text{cm}^{-1}$  and Rydbergs. These columns were not read by the CHIANTI software but they contained energies that had been used to compile the model atom. For example, there may be observed energies, theoretical energies from the scattering model, and then “best-guess” energies that are not experimental values but have a higher accuracy than the scattering model energies. The comments section should give detailed information on the origins of the energies.

**Column 1 - level index \*i3\***

**Column 2 - configuration index \*i6\***

Configurations are indexed sequentially beginning from the ground level.

**Column 3 – configuration string \*a15\***

**Column 4 - 2S+1 value \*i3\***

**Column 5 - L value(integer) \*i3\***

**Column 6 - L value (string) \*a3\***

Takes values ‘S’, ‘P’, ‘D’, etc.

**Column 7 - J value \*f4.1\***

**Column 8 – Statistical weight \*i3\***

**Column 9 - observed energy,  $\text{cm}^{-1}$  \*f15.3\***

Levels that do not have an observed energy will have a value of zero.

**Column 10 – observed energy, Ryd \*f15.6\***

**Column 11 - theoretical energy,  $\text{cm}^{-1}$  \*f15.3\***

**Column 12 - theoretical energy, Ryd \*f15.6\***

#### Comments section

The comments section begins with a ‘-1’ on a single line, and ends with another ‘-1’ on a single line. Otherwise the comments have a free text format.

### **3 Converting an old format file to the new format (CHIANTI team only)**

To convert an old format ELVLC file to the new format, the procedure is, for example,

```
IDL> convert_elvlc, 'ne_6.elvlc'
```

which will create a new file called 'ne\_6.elvlc\_new' in the current directory.