CHIANTI

An Astrophysical Database for Emission Line Spectroscopy

CHIANTI TECHNICAL REPORT No. 9

The radiative loss function

Ver. 1.2, 11-Aug-2017, Peter Young
Ver. 1.1, 8-Aug-2017, Peter Young
Ver. 1.0, 4-Apr-2016, Peter Young

The radiative loss function, $Q(T)$, is defined through the expression (see, e.g., Priest, 2014)

$$L_{\rm r} = N_{\rm e} N_{\rm H} Q(T) \tag{1}$$

where $L_{\rm r}$ is the radiative loss, i.e., the energy lost per unit volume per unit second by radiation, $N_{\rm e}$ and $N_{\rm H}$ are the electron number densities of electrons and hydrogen, respectively.

Note that in astrophysics $Q(T)$ is often referred to as the radiative cooling curve and denoted by $\Lambda(T)$.

1 CHIANTI calculation

The radiative loss function is calculated by CHIANTI using the routine `rad_loss.pro`:

```
IDL> rad_loss, temp, loss_rate
```

which will assume a constant density of $N_{\rm e} = 10^{10}$ cm^{-3} and ask the user to select an abundance data-set and an ionization equilibrium file. Note that the temperature (`temp`) is not an input, it is only an output. Its values are taken from the ionization equilibrium file. Options exist to vary the density, or to assume a constant pressure.

The routine takes about 10 minutes to run, mainly due to the calculation of bound-bound radiative losses.

A plot of the radiative loss function is shown in Figure 1, which was computed with CHIANTI 8 (Del Zanna et al., 2015) with the `sun_photospheric_2011_caffau.abund` abundance file, the CHIANTI ion balance file, and a constant density of 10^{10} cm^{-3}.

1.1 Changing the temperature range

To change the temperature range for which the radiative loss function is defined, it is necessary to create a new ionization balance file. The example below shows how to create a new file covering the temperature range $\log T = 3.0$ to 5.0 at 0.02 dex intervals:

```
IDL> ltemp=findgen(101)/50.+3.0
IDL> make_ioneq_all,10.^ltemp,outname='new.ioneq'
```

Now when you call `rad_loss` you will be able to choose the new ion balance file from the widget menu.

1.2 Options

The routine `rad_loss` has the following options:

density Allows the electron number density to be varied from the default value (10^{10} cm^{-3}).

pressure If set, then a constant pressure is assumed. The units are K cm^{-3}.

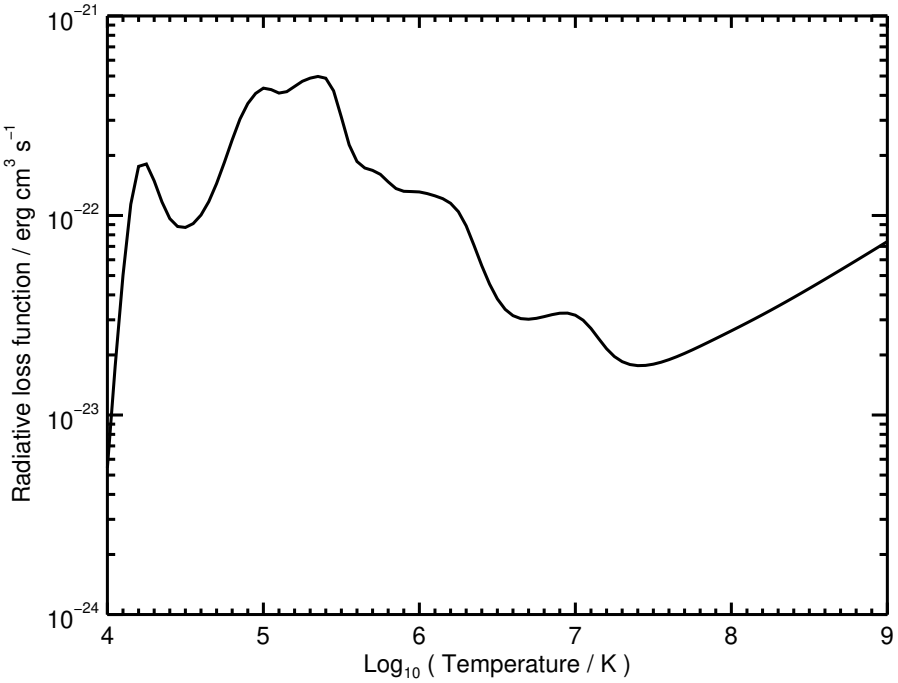

Figure 1: The radiative loss function computed with CHIANTI 8.

abund_file Allows the abundance file to be directly specified rather than using the widget.

radtemp, rphot These allow photoexcitation to be specified (see CHIANTI Technical Report No. 19).

noprot This switches off proton rates from level population processes for all ions.

outfile Specifies the name of a text file in which the radiative loss function will be tabulated.

2 Individual components

For the computation of the radiative losses, `rad_loss.pro` calls out to three other routines: `bb_rad_loss.pro`, `fb_rad_loss.pro` and `ff_rad_loss.pro` for bound-bound, free-bound and free-free radiative losses, respectively. (Note that losses due to two-photon emission are neglected.)

```
IDL> ff_rad_loss, temp, ff
IDL> fb_rad_loss, temp, fb
IDL> bb_rad_loss, temp, bb
```

For the bound-bound losses, a constant pressure or constant density across the temperature range can be specified. The default is a constant density of 10^{10} cm^{-3}.

The bound-bound losses for a single ion (or a subset of ions) can be computed by using the `sngl_ion=` keyword, for which ions can be specified in the CHIANTI format, e.g., `'o_6'` for O VI.

References

Del Zanna, G., Dere, K. P., Young, P. R., Landi, E., & Mason, H. E. 2015, A&A, 582, A56

Priest, E. 2014, Magnetohydrodynamics of the Sun (Cambridge: Cambridge University Press)

A Document history

Ver. 1.3, 23-Jul-2018. Added Sect. 1.2.
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