Stellar Atmospheres in Cloudy

Peter van Hoof
Royal Observatory of Belgium

Cloudy Workshop
Lexington, August 2025

Royal Observatory
of Belgium

Stellar Atmospheres in Cloudy (1)

Cloudy allows you to incorporate a set of spectral energy distributions (SEDs), interpolate between the models, and use the result as input for your simulations.

- This was originally set up for grids of stellar SEDs, such as the Kurucz ATLAS models.

- The grid can have up to 4 dimensions, typically including T_{eff} and log(g), but possibly also metallicity, mass loss rate, or other parameters.

- Several popular grids are available for download from the Cloudy web site (see next slide).

- After downloading, the ascii file needs to be uncompressed and placed in the search path. Optionally they can be compiled into an index file for efficient use.

- Some grids need to be compiled into ascii form first, such as the Rauch atmosphere grids and Starburst99 models. This step is mandatory.

- The compiled SED index file is in principle platform dependent, but should in practice work on most platforms.

Stellar Atmospheres in Cloudy (2)

https://gitlab.nublado.org/cloudy/cloudy/-/wikis/StellarAtmospheres

Details about individual stellar grids

The following subsections describe details of each of the standard grids now in the code. People who wish to install all the available grids should download all the ascii files in our ➦stars directory as well as visit the links shown below in the Tlusty, Rauch, and CoStar sections.

Atlas grids

➦atlas_fp05k2_odfnew.ascii.gz (log Z = +0.5)
➦atlas_fp02k2_odfnew.ascii.gz (log Z = +0.2)
➦atlas_fp00k2_odfnew.ascii.gz (log Z = +0.0)
➦atlas_fm05k2_odfnew.ascii.gz (log Z = -0.5)
➦atlas_fm10k2_odfnew.ascii.gz (log Z = -1.0)
➦atlas_fm15k2_odfnew.ascii.gz (log Z = -1.5)
➦atlas_fm20k2_odfnew.ascii.gz (log Z = -2.0)
➦atlas_fm25k2_odfnew.ascii.gz (log Z = -2.5)

➦atlas_3d_odfnew.ascii.gz (all metallicities)

These are the Castelli & Kurucz (➦Castelli, F., Kurucz R. L. 2004, astro-ph/0405087) LTE, plane-parallel, hydrostatic model atmospheres using the newest opacity distribution functions. The original versions of the files are from the ➦Kurucz web site. These grids come in various metallicities, ranging from log Z = +0.5 to -2.5, all with a turbulent velocity of 2 km/s. There is also a single file atlas_3d_odfnew.ascii.gz which contains all metallicities and which enables interpolation in log Z. If you download the latter file, *you do not need any of the other odfnew files*, unless you want to run the entire test suite. **The ODFNEW models are the most up-to-date and preferred versions of the Atlas models.**

You don't need to download all the files! Simply choose what you need, or skip all of them if you don't need them. Adding files later is also easy.

If you use one of these grids in a publication, cite the original author!

Stellar Atmospheres in Cloudy (3)

- Available are Kurucz grids (LTE, plane-parallel), Tlusty O & B stars grids (non-LTE, plane-parallel), various grids of PN central star SEDs by Thomas Rauch (non-LTE, plane-parallel), and two small grids of non-LTE wind-blanketed models (CoStar and WMbasic).

- You can also include grids of other types of SEDs this way! Most notably this is the case for stellar population synthesis models such as Starburst99 models. Such grids typically have either one dimension (age only) or two dimensions (age and metallicity).

- You can create your own atmosphere grids. The syntax of the file is pretty simple and is described in appendix B of Hazy 1. But beware that all the individual SEDs need to be on the same frequency mesh!

- This is convenient if you want to interpolate between various SEDs. The interpolation will be done automatically by Cloudy.

- The command **table star available** will list all the grids you have installed (since C25 this also includes custom grids). This will also show the syntax to use in your script.

- The command **table star <grid> list** will list all the models included in a single grid. This works directly on the ascii file.

Stellar Atmospheres in Cloudy (4)

- The ascii atmosphere files and optional index files need to be stored in the search path. The easiest options are to store them either in the data directory or in the local directory where you plan to run your sims.

- If you want to keep the standard data directory clean, you can use a custom search path to add local data directories. See:

  https://gitlab.nublado.org/cloudy/cloudy/-/wikis/EditPath

  as well as section 3.4 of Hazy 1 for more detail.

- The **table stars** command is set up for interpolating between various SEDs, but this is not strictly necessary. You could even set up a grid of a single model, but the **table SED** command would be more convenient for that.

- You can find the location of a specific file with the **print path "filename"** command.