D2 - Estimating the mass loss rate of OB stars

Task

Massive, hot stars (spectral types O and B) emit parts of their radiation in the Radio band. Wright & Barlow (1975) developed a simple model to calculate free-free-emission of stellar winds (see the script of the stellar atmospheres lecture!). At least of three OB stars (e.g. HD66811 (ζ Puppis), HD152408, HD169454) there are Radio measurements at different frequencies that show the predicted frequency profile. Multiple measurements show similar results (i.e. no variation with time). Both combined suggest that the model of Wright & Barlow is valid for these stars. A number of such measurements were undertaken with the most powerful Radio telescope in the world, the VLA (Very Large Array). (Data can e.g. be found in the Wendker 1995 catalog.)

Estimate the mass loss rate $\dot{M}$ of the three stars mentioned before from the free-free Radio emission follwing the formula given by Wright & Barlow. Get the needed measurements from the acquainted databases in the internet (Simbad, VizieR).

Operation

The formula has three **input parameters**: The Radio flux at a given frequency, the distance and the “terminal velocity” of the stellar wind.

Radio flux

First, find the Radio data for the given stars. See the database ViZieR of the *Centre de Données astronomiques de Strasbourg*, France. Select the wavelength/frequency range (Radio!) and enter the name of the star (Target field), mission and keyword don't need to be given. View the data by clicking “Go!”. Also, think about useful wavelength ranges to look for Radio fluxes in order to select the most useful catalog from the long list of catalogs.

Distance

The distance (approximations) can be found at the SIMBAD database. On which basis were the given distances confined, what are their error margins? Discuss the reliability of the distance values.

Terminal velocity

The terminal velocity of the stellar wind is the third parameter needed. This is the (maximum) velocity of the radially expanding stellar wind. To simplify, it may be assumed that (a) the wind reaches its “terminal velocity” v_{∞} already in those layers where the saturated UV resonance lines form, and (b) this velocity remains constant up to the distances (several stellar radii from the star) where the free-free Radio emission forms. So the value of v_{∞} can be estimated from the UV spectrum.

A large number of UV spectra were obtained with the International Ultraviolet Explorer (IUE). Find the IUE database at VisieR or get the data directly. There are spectra in two wavelength ranges (SWP: $1150–1980 \mathrm{\AA}$ and LWP or LWR: $1850–3350 \mathrm{\AA}$). Futhermore there are spectra in high and low resolution while the former has been rebinned to the lower resolution in the database. The C IV resonance doublett in the SWP range can serve as the saturated resonance line for in this laboratory course. The rest-frame wavelengths are $1548.188 \mathrm{\AA}$ and $1550.762 \mathrm{\AA}$. The middle of the steep blue wing of the P-Cygni absorption part shows the maximum blueshift, i.e. the maximum velocity, that can be used to calculate the “terminal velocity” by the Doppler formula v_{∞}.

Either get the complete spectrum of the star (in column `Plot` click `Rebin`), then zoom in to measure the wavelength of the blue wing, or download the spectrum (in column `Plot` click `Fetch`). The data are then present in the Fits format and need to prepared for further reduction: Open the Fits file with the tool Fits-Viewer

```
fv filename
```

and select representation `All` below the button “Table”. The Fits file opens a table, select the rows that are of no further need here (all but wavelength and flux) and remove them “Edit - Delete - Selected Column”. Then export the table as text file (“File - Export as Text - Fixed Width Colums”) as X-Y table. Attention, to plot the data with WRplot, delete the first three lines (or mark them as comment lines with an asterisk, *, as first character).

See the WRplot script `~prakdata/sternwinde05/spectrum.plot` and copy it to the own directory as usual. Execute the script (change filenames as needed) by

```
wrps spectrum.plot
```

which will plot the spectrum in a ps file that can be used to measure the blue wing..

Correlation with the X-Ray luminosity

It's interesting to note, that OB stars also emit X Rays. X Ray count rates can also be found at Simbad. Also check (under the assumption of the distance used for the $\dot{M}$ estimation to convert brightness to luminosity) if the X Ray luminosity scales with the mass loss rate.

Prepare a laboratory course protocol, as usual.

Overview: Laboratory Courses