D1 - Interstellar absorption spectroscopy

Task

A UV spectrum of Delta Orionis (a nearby star) is given, showing several interstellar absorption lines of different ions and molecules. These lines arise from interstellar gas clouds between the emitting star and the earth. Using computer programs, the properties of these lines are examined and the column density of the contributing ions and molecules are calculated. With the column densities the element abundances and further physical properties are deduced.

Evaluation: Metal abundances in the interstellar gas

Search for a UV spectrum of Delta Orionis in the [IUE database](#) (use a radius of a few arc second). By clicking on the `dataID`, a preview will open, offering the possibility to download the spectrum as an ASCII file. The data needs to be converted to final spectra (flux over wavelength) with the script `iue-makelambdascale.plot` that can be found in `~/scripts/d1/`. The header of the downloaded file needs to be commented out (with * in *WRplot*) before it can be read by the script. Moreover, the corresponding file name needs to be stated in the script. The script can be run with

```
wrplot filename.plot
```

or

```
wrpdf filename.plot
```

The resolution of the IUE spectrograph in the high dispersion mode is $R = \frac{\Delta \lambda}{\lambda} = 10000$. Identify the lines by of the line list (`lines.txt`), which also can be found in the scripts directory. Determine the line center of several lines and calculate the shifts with respect to values given in the line list. Determine the radial velocity of the absorbing cloud by means of the Doppler formula. Measure the equivalent width of the absorption lines of the following ions: FeII, SiII, OI, AlI, SI, and NI. Create a curve of growth and determine the (logarithmic) column density for the elements listed before, i.e. log N(FeII), log N(SiII), etc. What is the Doppler parameter (b value) of the curve of growth?

Evaluation

Assume that the column density of neutral hydrogen in the cloud is log N(HI) = 19.92. Estimate the relative abundances of elements X in comparison to the sun,

$$\left[\frac{X}{H}\right] = \log \left(\frac{N(X)}{N(HI)} \right) - \left(\frac{X}{H}\right)_\mathrm{sun},$$

where the solar abundances are given by $(Fe/H)_{\mathrm{sun}} = -4.49$, $(Si/H)_{\mathrm{sun}} = -4.45$, $(Ar/H)_{\mathrm{sun}} = -5.35$, $(O/H)_{\mathrm{sun}} =$

−3.13$, und $(N/H)_{\mathrm{sun}} = −4.03$ [Asplund 2009 (The chemical composition of the Sun)](#).

The evaluation shall be done using the ESO software package *Midas* which is installed at the [Laboratory course computer](#) or can be [installed](#) at the own computer. The required data and scripts are being provided by the instructors.

Report

First, describe the background of this experiment. Estimate the wavelength shifts, the resulting velocity including the error margins (non-linear error propagation!). Determine the b parameters of the curve of growths and the column densities of the different elements. Use the above formula to calculate the relative abundances in respect to solar values and their deviation from those values in percent.

[Overview: Laboratory Courses](#)