

S1 - Solar Rotation

Task

Calculate the rotational period of the sun from the Doppler shift of solar spectral lines at the eastern and western rim of the sun, respectively.

Observation

The observation will be performed with the solar telescope in the “Einsteinturm”.

Data reduction

Data reduction for data taken before 2016:

Login at the [laboratory computer](#). Copy the observational data (TIFF files) from the directory `~/data/<date>` to your own directory (see [name conventions](#)). Use the command `ls` to view the directory's content. After the copying there should be at least two TIFF files, possibly with names that represent the meaning of the image (i.e. eastern rim, western rim, date,...).

The TIFF images can be viewed in *ImageMagick* with the console command

```
display filename.TIF
```

(The default contrast settings are generally unfavorable, as the image appears extremely dark.)

We use [GDL](#) for the data reduction. The program need to do the following steps:

- Convert TIFF to FITS
- Read-in the FITS file
- Rearrange the byte order of the 16-bit numbers (First check if this is required for data from the Einsteinturm!)
- Rotate the images for further data reduction in Python (the dispersion must be oriented horizontally/in X direction), i.e. rotate the image matrix
- Save the converted and rotated image as FITS files

Luckily, the required program (`konvert.pro`) is already prepared and can be found in the scripts directory. Copy it to your own directory. At the end of this program a few lines need to be adjusted. Use a text editor, i.e.

```
kate konvert.pro &
```

to open the script and change the parameters that describe the input files (filenames, dimensions). To compile the program, start *GDL*

```
gdl
```

then compile the program via

```
gdl> .compile konvert.pro
```

The program itself is started in *GDL* by calling the program name, which in this case should be

```
gdl> konvert
```

The program converts and rotates the images, then saves the FITS files. They can be viewed (outside of *GDL*) with

```
ds9 filename.fits &
```

The image should be clearer and rotated in comparison to the TIFF file.

Analysis

The analysis can be done with a Python script (see `~/scripts/s1s2/comparespecs.py`) that needs to be copied to your own directory, too. This script allows to cut those lines from the image matrix that shall be displayed as a spectrum. Open the script with a text editor, e.g.

```
kate comparespecs.py
```

In the upper part of the script, find “Script Parameters”. Edit the names of the input files and the range of lines that shall be extracted. To find the latter, also open the image with *ds9* and select the coordinates of useful strips for the spectra. Choose those lines that are equally exposed and that contain as few (obvious) pixel errors as possible. Especially pay attention to the range where the spectral lines are situated. Once all required input parameters are set, save the script file and execute it by

```
./comparespecs.py
```

to obtain a PostScript file `speccmp.ps`, which can be opened with *GhostView*

```
gv speccmp.ps &
```

This figure should now show the spectrum of the lines previously selected from the image. From this figure the Doppler shift of the spectral lines can be determined. To do this, the best strategy is to shift the spectra (with the help of the Python script) against each other, so that (1) the solar iron lines are superimposed and (2) the telluric oxygen lines are superimposed. The dispersion (nm/pixel) can be determined from the given wavelengths (see the following Table).

	λ_0 [nm]
Fe	630.151

	λ_0 [nm]
Fe	630.250
O ₂	629.846
O ₂	629.923
O ₂	630.200
O ₂	630.276

Using the Doppler shift one can determine the rotational velocity of the sun and from that its rotational period. **Note, that the observation has not necessarily been performed at the sun's equator.**

Protocol

A usual protocol has to be prepared for both experiments, S1 and S2, together.

The protocol should give a short introduction to the "Einsteinurm", before the rotational velocity and period is calculated. It is also required to discuss and to utilize the geometrical corrections for the rotational velocity and period. The necessary data can be obtained from the sun ephemerides.

[Overview: Laboratory courses](#)

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