MANDATORY ASSIGNMENT I

Candidate # X

Please note that this is assignment will not be graded but **delivery is mandatory** in order to qualify for submission of the final (graded) project assignment.

1. Preparatory exercises

Instructions. *The exercises in this section will help you getting started with tasks that are essential for working with the next mandatory and the final project assignments.*

1.1. Literature search and bibliography

Instructions. *Use the **Astrophysics Data System (ADS) Science Explorer** to find the right references. You should retrieve the bibTeχ items from ADS and build up a bibliography file (.bib). Please answer the questions below by specifying the **bibcode**[a] and using the **cite command**.*

[a] A correct bibcode is similar to `1999xxxxx.123.....A`.

1.1.1. **Which is the most cited paper that contains the word "Sun" in the title?**

Answer: - title of the paper — Bibcode:

1.1.2. **Which of the papers that do cite the paper referred to above in exercise 1.1.1 and was published after the year 2000 has itself received the most citations?**

Answer: - title of the paper — Bibcode:

1.1.3. **Which is the most cited paper of the author Parker, E that contains the word "solar" in the title?**

Answer: - title of the paper — Bibcode:

1.1.4. **In their paper on simulations of solar granulation, which the authors Stein, R. F. & Nordlund, Å published in the Astrophysical Journal (ApJ) in 1998, they refer to another paper on magnetic elements. Which is that paper?**

Answer: - title of the paper — Bibcode:

1.1.5. **Which is the most cited paper that contains the words "solar metallicity low-mass stars" in the title and/or abstract?**

Answer: - title of the paper — Bibcode:

1.2. A first look at relevant data sets and tools

1.2.1. Plotting and analysing a reference atmosphere model

Instructions. *Load the data file* `val81c.h5`*, which contains the model atmosphere VAL C (Vernazza et al. 1981). Reproduce the plot in Fig. 1, save it to a file (e.g., PNG), and replace the file name in the includegraphics command with your own file. In addition, please answer the questions below using the same data.*

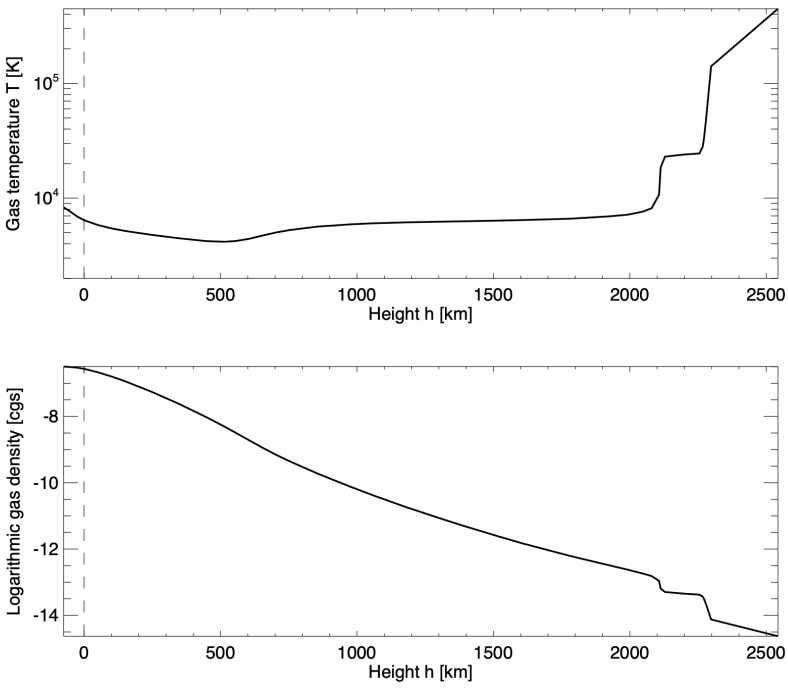

Fig. 1. The plot shows the semi-empirical atmosphere model C by Vernazza et al. (1981). *Top:* Gas temperature as function of height. *Bottom:* Logarithmic gas density as function of height. The vertical dashed line marks the height at which the optical depth $\tau_{500\,\mathrm{nm}}$ is unity, marking the bottom of the photosphere.

The VAL C model (see Fig. 1) shows that the gas temperature T decreases with height h in the photosphere until it reaches a minimum and then increases again with height.

1. At what height h do you find the temperature minimum and what value has the temperature there?
2. At what height h in the upper atmosphere does the temperature suddenly jump to temperatures $T > 10^4$ K?

1.2.2. Context data for the Sun.

Instructions. *Use the interactive helioviewer tool (either the web-based version at* `https://helioviewer.org/` *or as downloadable application at* `https://www.jhelioviewer.org/`*). The latter may have more functions. Provide context images for an observation that was carried out on January 10, 2022, at 08:57:42 UTC. The target is the trailing sunspot of an Active Region in the southern hemisphere with the (helioprojective) coordinates* $[x, y] = [+180'', -480'']$*. Generate figure files (e.g., via helioviewer's screenshot function) for the SDO/HMI Continuum, SDO/HMI Magnetogram, and SDO/AIA 171 and show them in Fig. 2. The shown field of view should include both magnetic polarities.*

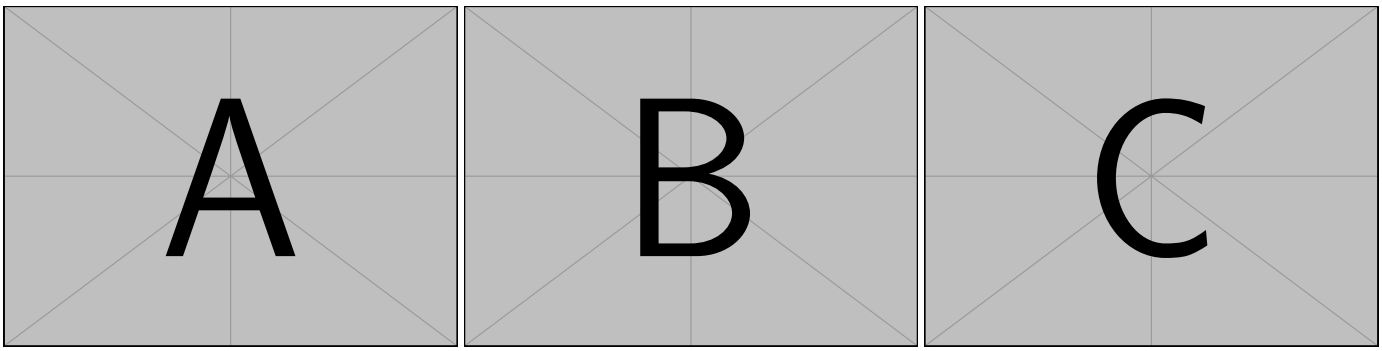

Fig. 2.

1.2.3. A first look at simulation data

Instructions. *Load the files* `simsts_K8V/simsts_K8V_0G.h5` *and* `simsts_K8V/simsts_K8V_0G_continuumintensity.h5` *and answer the questions below.*

1. What is the total extent of the computational domain in all three dimensions in units of km?
2. What is the average gas temperature and density at the lower boundary of the model?
3. What is the average absolute velocity amplitude ($< |\boldsymbol{v}| >_{x,y,z}$) in the model?
4. What is the ratio of the horizontally averaged continuum intensity at $\lambda = 4.0\,\mu$m with respect to $\lambda = 500$ nm ($\frac{<I\,(\lambda=4.0\,\mu\mathrm{m})>_{x,y}}{<I\,(\lambda=500\,\mathrm{nm})>_{x,y}}$)?

1.2.4. A first look at observational data

Instructions. *Load the file* `obssun_sst3/obssun_sst3.h5`*, which contains the observation of a sunspot in the Hα line ($\lambda_0 = 656.28$ nm), and answer the questions below.*

1. Look at the first time step at a wavelength of 656.15 nm. What is the horizontally averaged intensity value for that time step at that wavelength?
2. Now look at the intensity as function of time for the pixel with the coordinates $[x, y] = [2.204'', -3.480'']$ at the central wavelength λ_0 for the observed spectral line. What is the minimum value in this time series and at what time is that value reached?
3. Average the images for the continuum (shortest wavelength in this data set) over time and measure the extent of the sunspot umbra in arcseconds. You can measure along the x and y axes or, preferably, along the minor and major axis of an ellipse fitted to the umbra.
4. What is the measured extent in units of kilometres?
5. Look at all images for the shortest contained wavelength (λ_{min}) and calculate a histogram for these intensity values ($I_{\lambda_{\mathrm{min}}}(x, y, t)$). Describe in a few words the distribution that you see (e.g., has a Gaussian form, several peaks, maxima etc.). Explain why the histogram looks like that by comparing it to what you would expect when looking at these images directly.

References

Vernazza, J. E., Avrett, E. H., & Loeser, R. 1981, ApJS, 45, 635