FYS 3610

Exercise Week 37 due 21. September 2016

Questions as they might appear in the mid-term and/or oral exam

How is the solar wind formed? What are its major constituents?

What is the Parker spiral and what is its origin?

What are typical values of the solar wind at 1 AU?

Plot the radial solar wind velocity as a function of heliocentric distance, i.e., the solution to the gasdynamic model. Mark significant points on both axes. How does the velocity vary for different coronal temperatures?

Exercises

In this exercise I would like you to play around with real solar wind data. To be able to do that you will need to open a data file, read its contents into the computer's memory, plot the raw data, do some analysis, and plot the results of that analysis.

I leave the choice of program for reading and displaying the data up to you. Possible options are Matlab, sciPy (python), or any spreadsheet application (like MS Excel, LibreOffice Calc, Gnumeric, KSpread…) When importing the data into a spreadsheet application, you need to be careful that in the file, the decimal separator is a dot "." such that on some European computers something like "3943.23" will not be recognized as a number (depending on your locale). If that is the case, replace all "." with "," before you open the data file.

At http://folk.uio.no/lbnc/helios/ you will find two files: he1mgd.txt and helios1_daily.dat. In the latter file you will find solar wind data from the Helios 1 satellite that was launched into a heliocentric orbit in 1974. The former is a text files that contains descriptions about the contents and format of these data.

a) Read the data into your program of choice such that you are able to plot it.

b) Plot time on the x axis against radial distance of the satellite from the Sun (heliocentric distance).
c) Plot a time series of the temperature. Reminding yourself of the assumptions made for the Parker solar wind model, what do you observe?
d) Using the data from the file, calculate the speed of sound c_s from the available data.
e) Plot the sonic Mach number, i.e., the ratio v_{SW}/c_s, as a function of heliocentric distance on a double logarithmic scale. What do you observe? Do you expect these observations? Using either numerical tools or your artistic skills, try to estimate the heliocentric distance where the sonic Mach number drops below 1. What is the significance of that point?
f) Plot the total magnetic field strength multiplied by the heliocentric distance raised to its third power against the heliocentric distance, i.e., plot $B(r)r^3$. What do you observe? (Hint: for a dipole magnetic field the magnetic magnitude decays as $1/r^3$)
g) What happens if you plot $B(r)r^{3/2}$ as a function of heliocentric distance? Can you explain these results by considering the expressions for the magnetic field components derived from the Parker spiral?