ADVANCED SOLAR PHYSICS AND SPACE WEATHER List 4

1. What is the mean free path of particles in plasma? How can the mean free path of particles in plasma be described mathematically? Discussing this topic, provide also a detailed explanation of concepts such as the Landau radius and the Debye length. Attempt to calculate the value of the mean free path for electrons in the photosphere and in the lower corona. The necessary values for the calculation should be determined independently.

2. What is the plasma β -parameter? What does this parameter represent, and what do its different values signify? The β -parameter can be described in several ways, using various mathematical equations, and may also be presented in a graph depicting the variation of the plasma β -parameter with height in the solar atmosphere.

Parameter	Photosphere	Cool corona	Hot corona	Outer corona
Electron density n_e (cm ⁻³)	2×10^{17}	1×10^9	1×10^9	1×10^7
Temperature T (K)	5×10^3	1×10^6	3×10^6	1×10^6
Pressure p (dyne cm ⁻²)	1.4×10^5	0.3	0.9	0.02
Magnetic field B (G)	500	10	10	0.1

Using the data presented in the table above for four layers of the solar atmosphere (representing average, characteristic values for each individual layer):

a) calculate the β -parameter;

b) interpret the resulting β -parameter values for each layer;

c) discuss the appropriate degree of ionisation to be assumed for the photosphere, and the corresponding value for the solar corona.

3. During spectroscopic observations of the Sun, the recorded spectrum is affected by solar rotation. How much is the hydrogen H α spectral line (656.3 nm) shifted in the solar spectrum when we observe structures located at the eastern limb of the solar disk in relation to the line obtained during observations at the centre of the disk? The measurements were made at the solar equator. The equatorial rotation period of the Sun is assumed to be P = 25.38 days, and the solar radius is R_{\odot} = 700 000 km. What is the linear velocity (measured along the line of sight) of structures located on the solar limb?

4. With what lineal velocity (in km/s) the Sun rotates on the equator and at 30° and 60° of heliographic latitude (the observational graph of rotation velocity relative to the heliographic latitude presented in Fig.1 should be used). What is the centripetal acceleration (caused by the rotational movement of the Sun) on the equator and at 30° and 60° of heliographic latitude. Compare the acceleration values to gravitational acceleration on the surface of the Sun. Compare the result of the rotation velocity on equator to the value obtained in exercise 3.



Fig.1. Solar rotation velocity versus heliographic width.