Mission Space Lab Phase 4 report

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Chosen theme: Life in Space

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1. Introduction

The main goal of the experiment was to analyse dependencies such as: gravitational acceleration, magnetic field strength and air pressure inside the station referring to the station's position relative to the Earth - Sun axis. The second goal was to find out whether tectonic faults affect the Earth’s magnetic field. This question was considered interesting because the values of these factors have a significant influence on the operation of the ISS, including the magnetic field strength which may affect the behaviour of electronic devices, and the air pressure in the station is related to the air temperature and the volume of gases in the station, the dependence of

$$\frac{pV}{T} = nR, \tag{1}$$

where p for pressure, V for volume, T for temperature, n for molar number, R for molar gas constant. It was expected that the location of the station would have an impact on the values of these parameters.

2. Method

The experiment used: acceleration sensor, barometer, magnetometer, temperature and humidity sensor. The collected data was stored in text files with the csv extension and then analysed with Excel and OriginPro to visualise the results. Some characteristics showed linear relations, therefore the obtained results were approximated with linear functions in order to obtain the following coefficients: directional and shift.

3. Experiment results

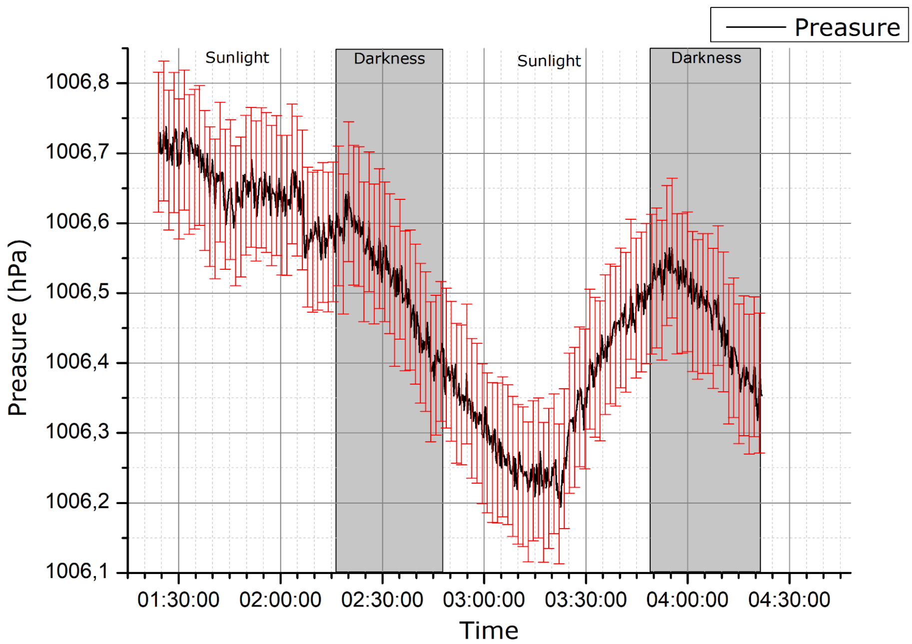

Figure 1: Dependence of the pressure in the station on time

The pressure measurement uncertainty, according to the documentation, is 0.1 hPa. On the basis of Fig. 1, a thesis can be made that the insolation of the station influences the pressure change inside the station. The shift of the minima and maxima results from the thermal inertia of the station.

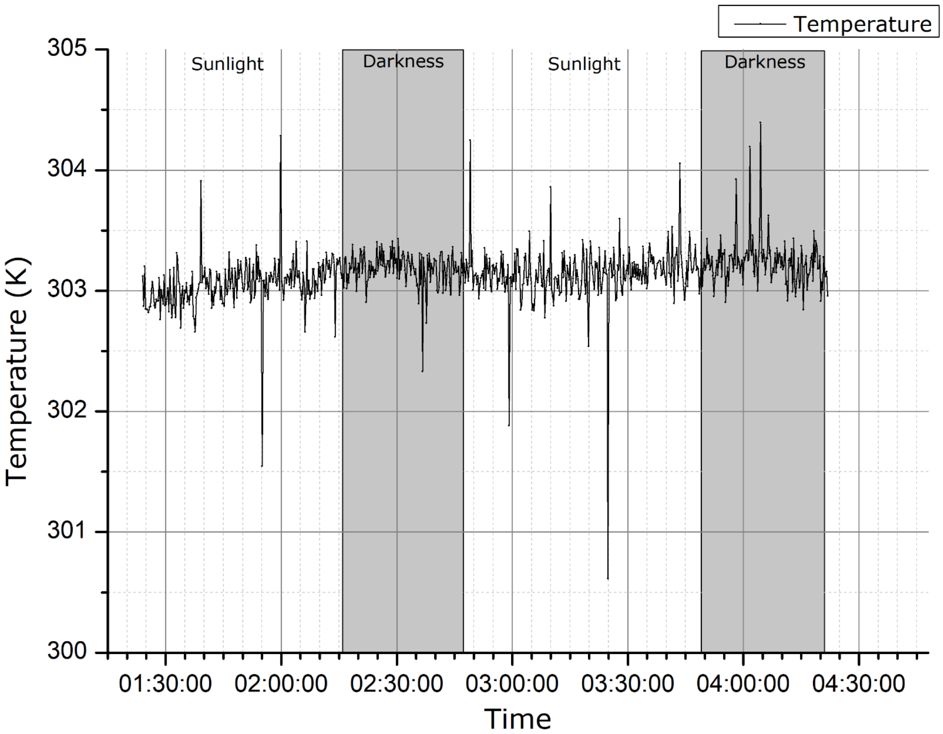

Figure 2: Dependence of the temperature in the station on time

Based on the data, the relation:

$$f = \frac{p}{T}(t) \qquad (2)$$

was determined and presented as a time chart Fig. 3

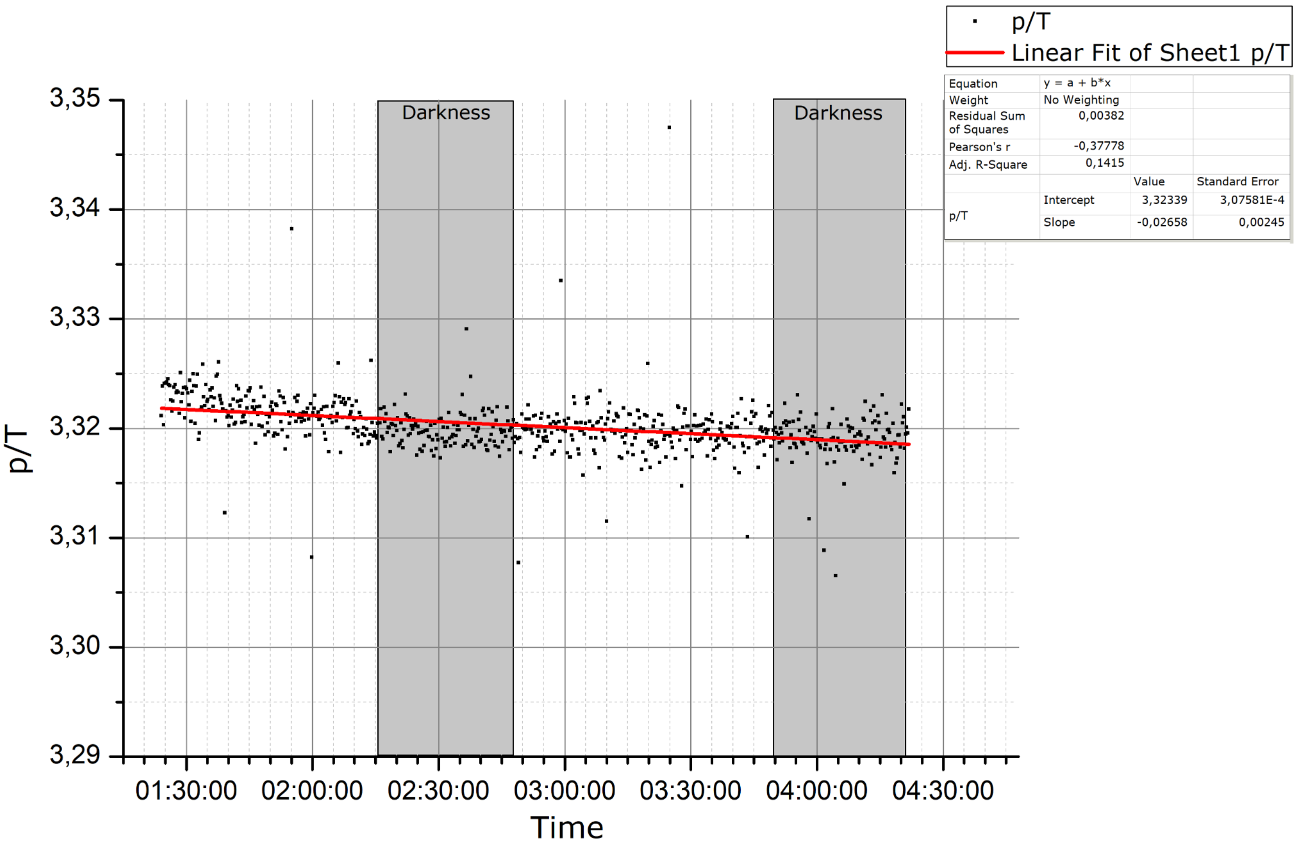

Figure 3: Dependence of $\frac{p}{T}$ on the station on time

The distribution of points in the diagram shows the linear alignment of the obtained results. The Origin tools have determined a linear relation in the form $y = a + bx$, which confirms the calculated results with $a = (3,32339 \pm 3,07581\,E - 4)[\frac{hPa}{K}]$, $b = (-0,02568 \pm 0,00245)[\frac{hPa}{K \cdot h}]$. The type of curve indicates that the station sheathing of the station may have leaks, since without leaks b should equal zero.

Another factor that was investigated was the induction of the magnetic field. The magnetometer recorded the induction values in three axes. On the basis of the values determined, the total induction value was calculated according to the following formula (3):

$$B_R = \sqrt{B_x^2 + B_y^2 + B_z^2} \quad (3)$$

According to the documentation, the measurement uncertainty of the individual measured values of magnetic induction is 4 μT. The uncertainty of the composite quantity was determined on the basis of the ratio (4).

$$u(B_R) = \sqrt{\left(\frac{\partial B_R}{\partial B_x}u(B_x)\right)^2 + \left(\frac{\partial B_R}{\partial B_y}u(B_y)\right)^2 + \left(\frac{\partial B_R}{\partial B_z}u(B_z)\right)^2} \quad (4)$$

where

$$\frac{\partial B_R}{\partial B_x} = \frac{B_x}{\sqrt{B_x^2 + B_y^2 + B_z^2}} \; ; \; \frac{\partial B_R}{\partial B_y} = \frac{B_y}{\sqrt{B_x^2 + B_y^2 + B_z^2}} \; ; \; \frac{\partial B_R}{\partial B_z} = \frac{B_z}{\sqrt{B_x^2 + B_y^2 + B_z^2}}$$

The determined dependencies were used in Fig 4.

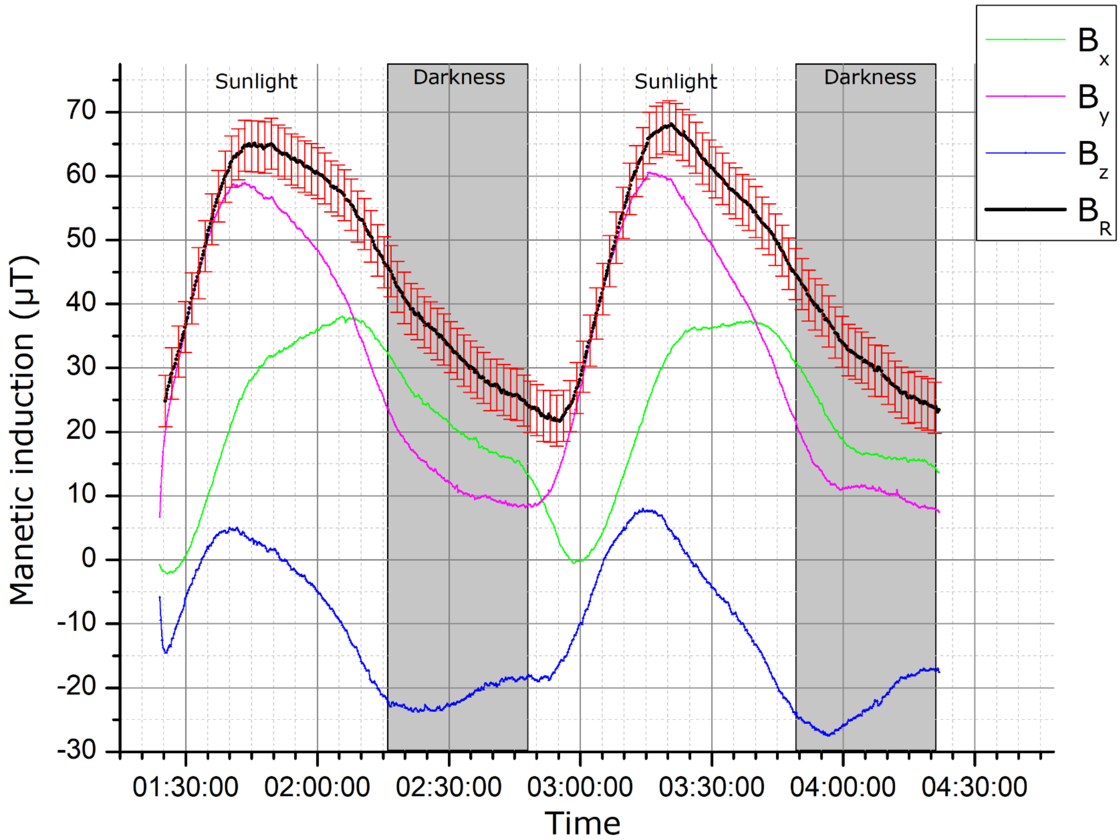

Figure 4: Dependence of magnetic induction in the station on time

From the given properties, it can be seen that maxima of the total magnetic induction occurs when the station is closest to the Sun (centre of the bright graph).

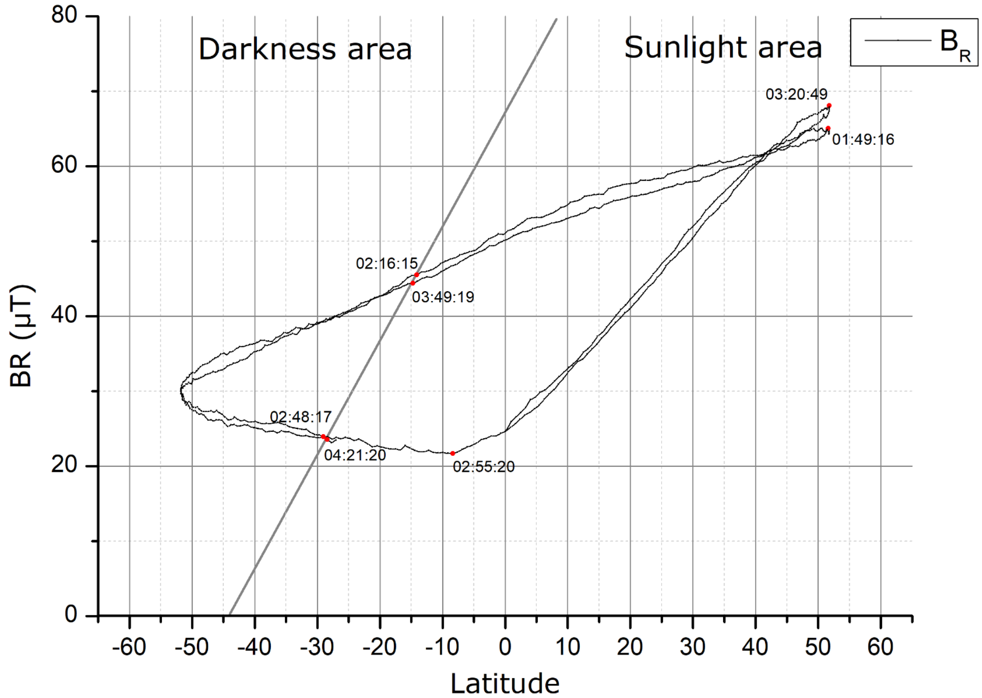

Figure 5: Total induction of the magnetic field recorded as a function of the geographic latitude

Fig. 5 shows that the maximum magnetic field induction was reached when the station was in extreme latitude and not obscured by the Earth. It was found that the minimum was recorded near the Equator. On the basis of the attached properties, it can be assumed that the Sun's magnetic field has a significant influence on the total magnetic field measured by a magnetometer.

4. Learnings

At the beginning, we planned individual stages of work. Then we divided the responsibilities. No major difficulties were encountered during implementation. Thanks to participation in this project, we have learned to work better in a group, to communicate about the need for support and enjoy well-completed tasks together, as well as to use software for data analysis and visualisation. Working on the project was also an opportunity to expand our knowledge of physics, mathematics and programming. We also learned how to use the Pandas library and the OriginPro program. The wide range of measured quantities resulted from the fact that we participated in the third phase of the experiment for the first time, and we wanted to know what the characteristics of all quantities look like, which allowed us to look at the processes taking place at the station as a whole.

5. Conclusion

The results of the experiment allowed the team to put forward a thesis concerning the influence of the station's insolation on the pressure inside the station: insolation causes changes in pressure. Based on the collected data, using the Clapeyron's ideal gas law, the relation $f = \frac{p}{T}(t)$ was expressed, which showed a possible leak in the station sheathing. The study of the magnetic field revealed that the maxima of the total magnetic induction are related to the station's location - they occur when the station is as close to the Sun as possible. It was also concluded that the solar magnetic field has a significant impact on the total magnetic field recorded with the magnetometer. The team found that depending on the flight path, the induction of the Earth's magnetic field has a different component in the total magnetic field recorded at the station. It turned out that tectonic faults didn't have enough influence on the magnetic field to be able to see the anomalies in the graphs. We also learned that the acceleration in the station is constant and the team wasn't able to register manoeuvres of orbit adjustments or to avoid larger space debris.