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Student Number: 110190704 **Report Date:** Jan. 03, 2021

1. Purpose of LabWork03:

Understanding the characteristics of magnetopause, calculating magnetopause distance (R_{mp}) and auroral latitudes (Λ) through the values from magnetosheath data. Showing the correlation between magnetosheath data and R_{mp}.

Themis C

Event Interval: 2009/09/15 12.30.00.000 - 2009/09/15 19.30.00.000
Magnetopause Time: 2009/09/15 17.12.00.000

Magnetopause

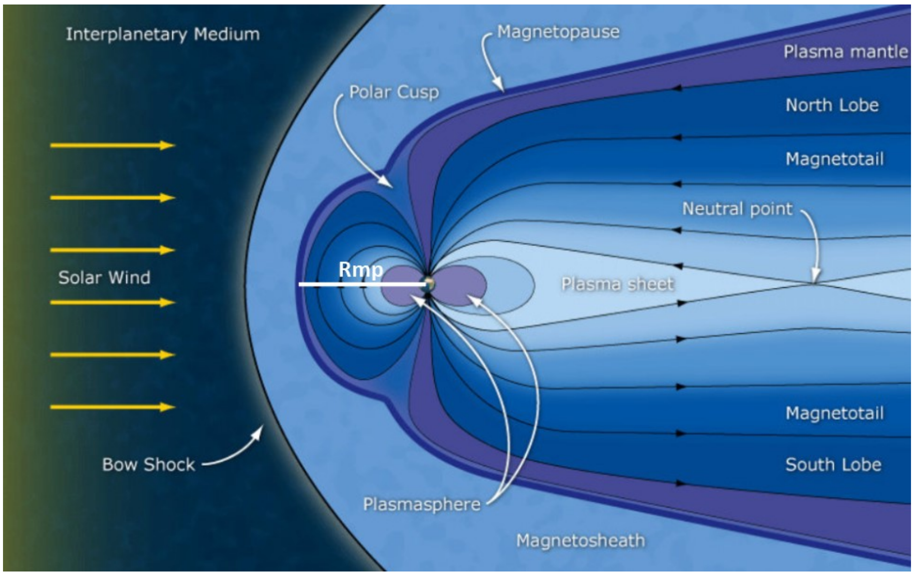

Figure 1: Demonstration of magnetopause and R_{mp} on XY plane

The magnetopause is the shell that covers the magnetosphere. Solar wind particles that pass through the bow shock enter magnetosheath region. At the point where the dynamic pressure of solar wind particles (P_{dyn}) and the magnetic pressure (P_{mag}) are equal, magnetopause occurs.

The sensor data in the magnetosheath region are highly fluctuating. The data become stable after the magnetopause. Since the velocity of the solar wind particles decreases dramatically in the magnetopause, V_{total} data could be an indicator.

R_{mp} is the magnetopause distance from Earth. Density, velocity and angle of the solar wind particles control the magnetopause distance. In this experiment, the angle is taken as 0 (subsolar point), and therefore only density and velocity values from magnetosheath data are used.

$$P_{dyn} = P_{mag} \tag{1}$$

$$R_{mp} = (R_e)\sqrt[6]{\frac{B_0^2}{(\mu_0 n m_p V_{sw}^2 cos^2(\psi))}} \tag{2}$$

$$P_{dyn} = n m_p V_{sw}^2 \tag{3}$$

$$B_0 = 0.3 * 10^{-4}T,\ \mu_0 = 4 * \pi * 10^{-7} mkgs^{-2}A^{-2},\ m_p = 1.68 * 10^{-27}kg,\ cos(\psi) = 1 \tag{4}$$

2. Time Series Plots :

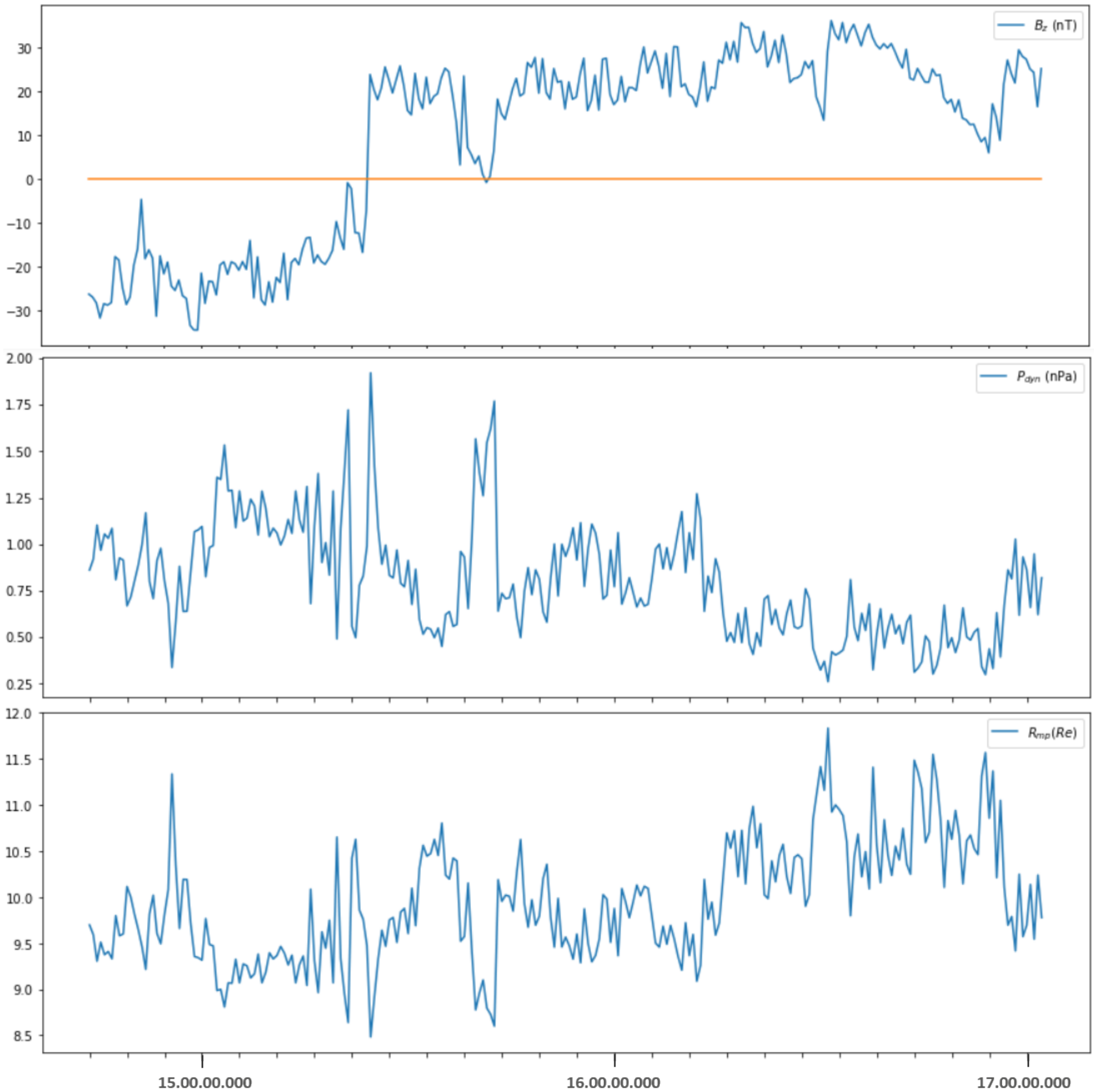

Figure 2: Time series plots of B_z (nT), P_{dyn} (nPa) and R_{mp} (Re)

In Figure 2, it is obvious that R_{mp} is inverse proportionate to P_{dyn}. This result is expected from the formula (2). In the region where IMF B_z is negative, R_{mp} values are slightly small. However, it is inaccurate to state that there is a direct correlation between R_{mp} and IMF B_z in Figure 2.

Since the magnetopause occurs when $P_{dyn} = P_{mag}$, P_{dyn} is dominant in the motion of the magnetopause (R_{mp}).

3. Scatter Plot of P_{dyn} vs R_{mp} :

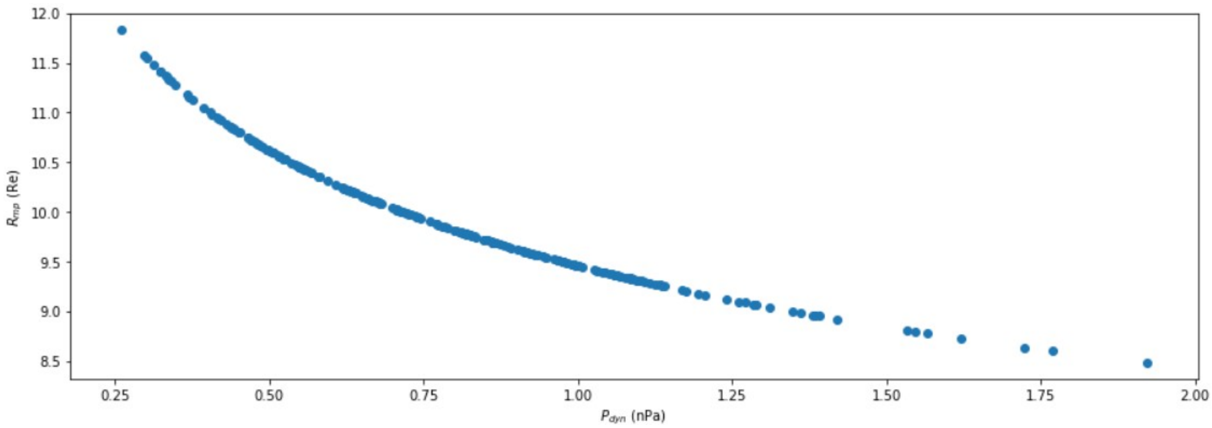

Figure 3: Scatter plot of P_{dyn} (nPa) vs R_{mp} (Re)

As it is expected from the formula (2), higher P_{dyn} causes lower R_{mp}. Since P_{mag} is higher close to Earth and the magnetopause occurs when $P_{dyn} = P_{mag}$, increase in the dynamic pressure of the solar wind decreases the magnetopause distance and makes it closer to Earth.

4. Scatter Plot of IMF B_z vs R_{mp} :

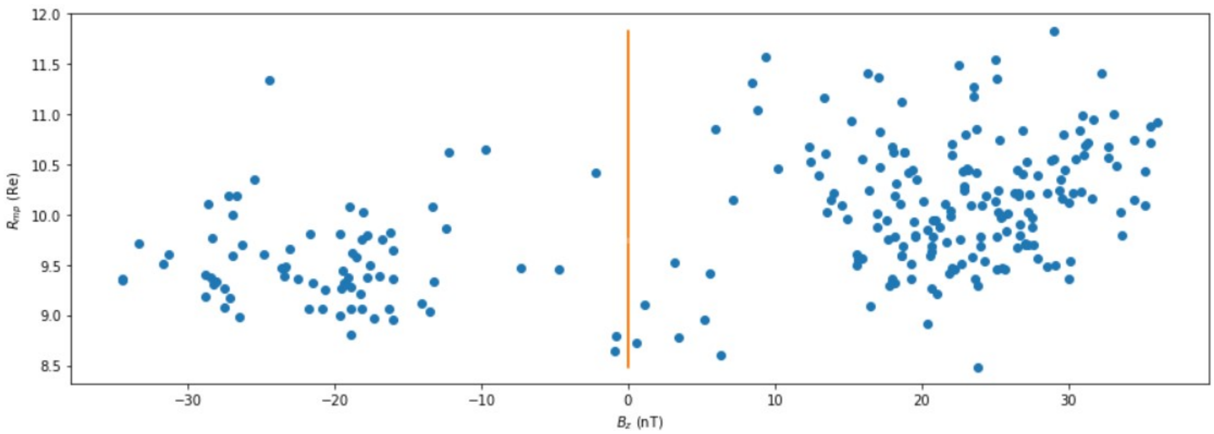

Figure 4: Scatter plot of IMF B_z (nT) vs R_{mp} (Re)

The avarage R_{mp} is lower when IMF B_z is negative. However, the effect is not dominant and there is no direct correlation. In the formula (2), IMF B_z is not used. Negative IMF B_z indicates magnetic storm.

5. Scatter Plot of R_{mp} vs Auroral Latitude (Λ) :

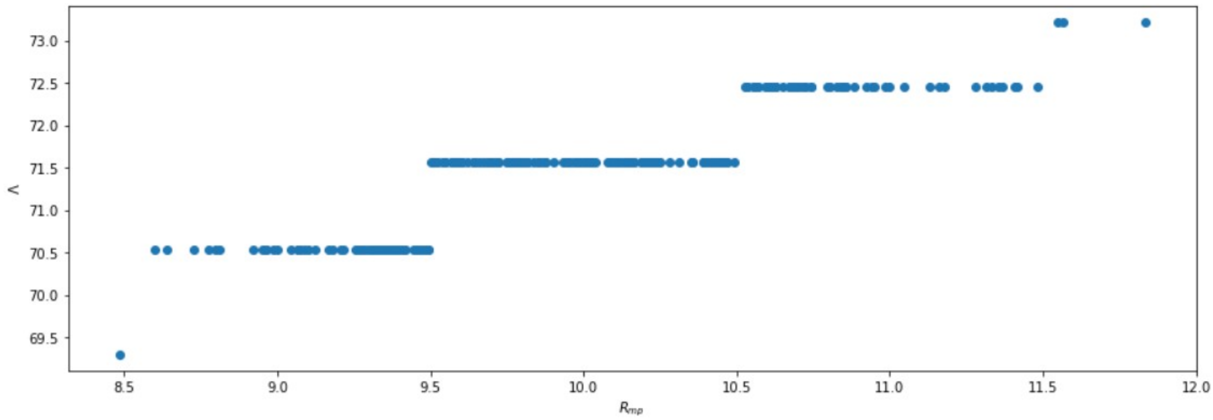

Figure 5: Scatter plot of R_{mp} (Re) vs Λ (deg)

$$cos(\Lambda) = \frac{1}{\sqrt{L}} \tag{5}$$

$$\Lambda = \arccos\frac{1}{\sqrt{L}} \tag{6}$$

$$L = int(R_{mp}) \tag{7}$$

In the subsolar point, L is equal to integer form of R_{mp}, and therefore according to formula (6) when R_{mp} increases, auroral latitude (Λ) increases as well. This increase can be seen in Figure 5. Since L is an integer value, there are jumps in the Figure 5 and 6.

6. Scatter Plot of P_{dyn} vs Auroral Latitude (Λ) :

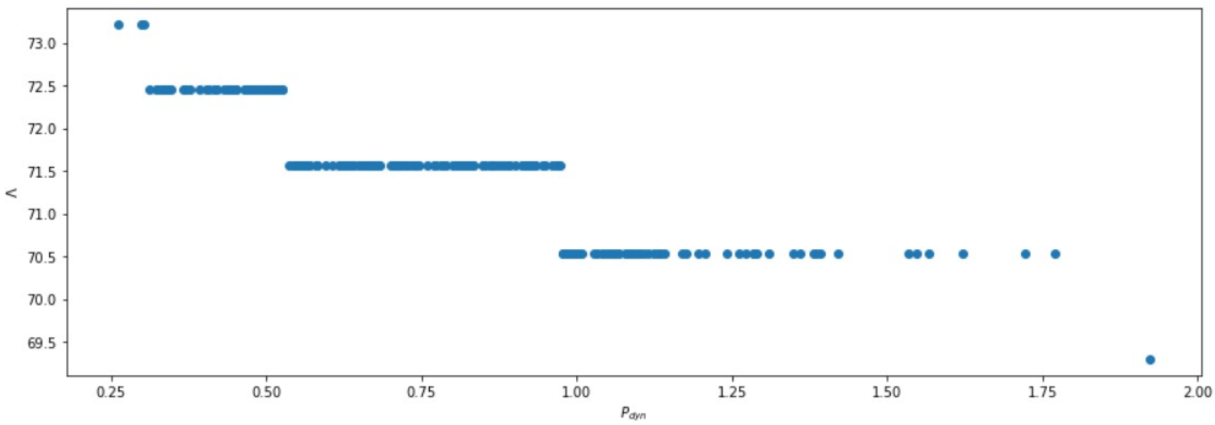

Figure 6: Scatter plot of P_{dyn} (nPa) vs Λ (deg)

According the formulas (6) and (7), R_{mp} is directly proportional to Λ. Besides, the inverse proportion between R_{mp} and P_{dyn} is obtained in the Figure 3, and thus increase in P_{dyn} decreases Λ.

7. Table :

	Mean	Median	Max	Min	Standard Deviation
$B_z \geq 0$	22.390947	22.884050	36.143600	0.151969	6.945174
$B_z < 0$	-20.372610	-20.616900	-0.007792	-37.123800	6.991760
P_{dyn}	0.806091	0.768505	3.167741	0.177174	0.316562
R_{mp}	9.949871	9.883139	12.621340	7.805136	0.656513
Λ	71.463809	71.565051	73.897886	69.295189	0.703261

Table 1: Statistic Table of Magnetosheath Data

8. Learning Outcomes :

Summary:
Firstly, the characteristics of magnetopause are determined, and therefore magnetopause time is found from the same data in Lab Work 2. Using the formula for magnetopause distance, the parameters that control the motion of the magnetopause are found. Time series plots are used to show the change in magnetopause distance over time. The scatter plots indicate inverse and direct proportionality of magnetosheath data to R_{mp}. Since the data are considered from the subsolar point, auroral latitude (Λ) is easily calculated using the formula (6) and (7). The statistical values are shown in Table 1. The report is written in LaTeX.

Project Code: `https://github.com/kadirkilicnet/magnetopause-uzb411e`

In this Labwork03, I learned the followings:

- The characteristics of the magnetopause
- Calculation of the magnetopause distance R_{mp}
- Calculation of the auroral latitude Λ
- Understanding what controls the magnetopause distance R_{mp}
- Understanding what controls the auroral latitude Λ
- The benefits of scatter plots to show the correlation between parameters