The 3rd International Earth Science Olympiad

Practical Test - Astronomy

18 September 2009

Taipei, Taiwan

Student Name:	Nationality:

Mentor's Signature:________________

希言自然，故飄風不終朝，驟雨不終日。孰爲此者？天地。

To seldom speak is the essence of nature. Why the winds and storm do not last whole day? Because the earth that manifests the winds and storm is constantly changing.

《老子道德經》第廿三章

Laozi Tao Te Chin 4^{th} Century BC

南方有倚人焉曰黃繚，問天地所以不墜不陷，風雨雷霆之故。惠施不辭而應，不慮而對，遍爲萬物說。

In the south, there was a man of extraordinary views, named Huang Liao, who asked Shi how it was that the sky did not fall nor the earth sink, and what was the cause of wind, rain, and the thunder's roll and crash. Shi made no attempt to evade the questions, and answered him without any exercise of thought, talking about all things.

《莊子雜篇》天下第三十三

Zhuangzi Tian Xia 4^{th} Century BC.

Instructions for the practical test (Astronomy):

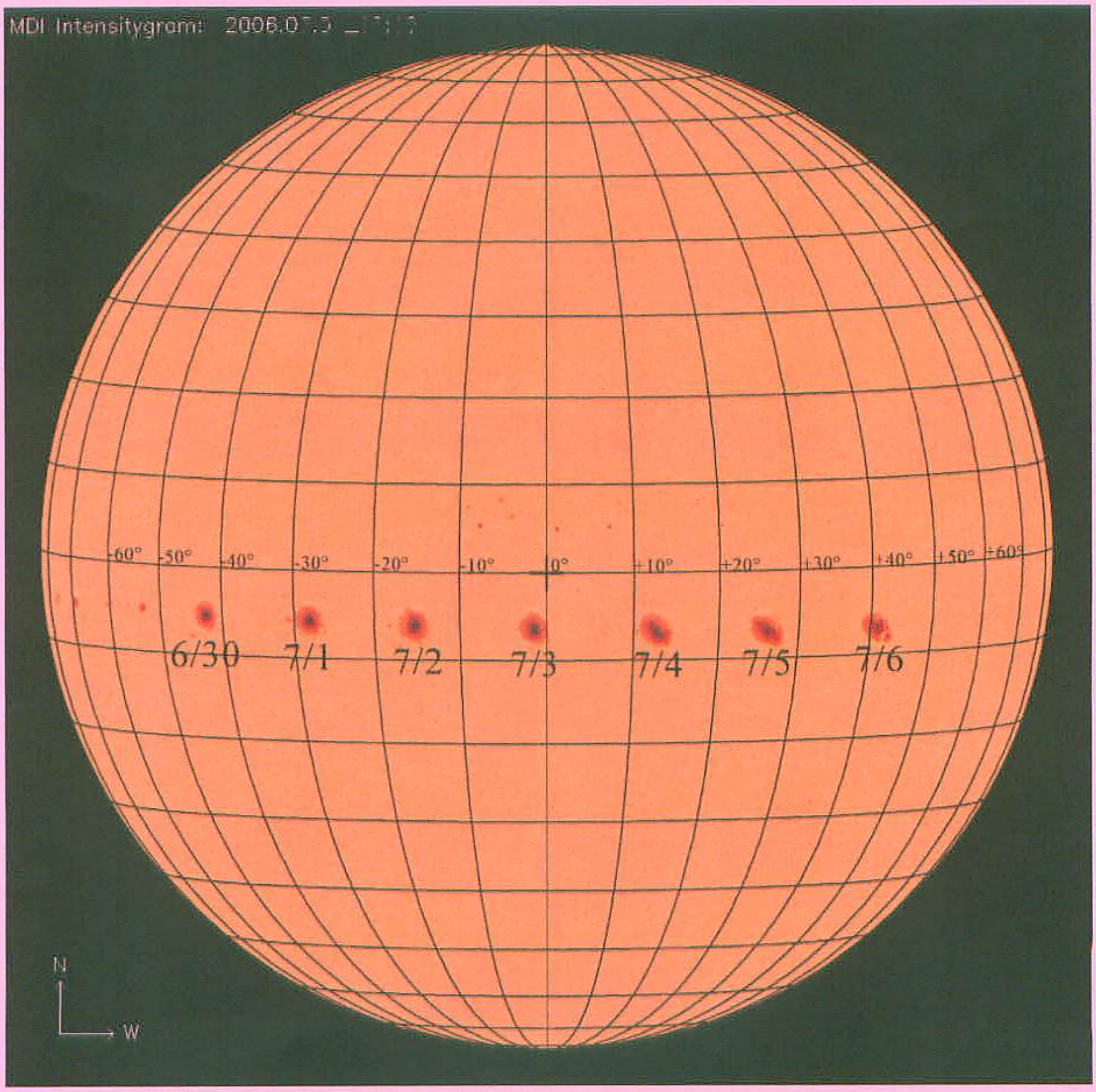
- Please write name and nationality in English on the cover page.
- The time allotted for this examination is 1.5 hours.
- Write your answers legibly. Illegible answers will not be graded.
- Keep your answers short and focus on the key points.
- Write your answers on the white test booklet provided. There is no separate answer sheet.
- You can use the calculator provided to perform the calculation.
- You may respond to questions either in English, your native language, or a combination of both.
- Read the entire question group carefully before starting to answer.

  Each question has a point value assigned, for example, (1 pt).
- For some questions, you may be asked to provide your answer on the figures. Please do so carefully.
- Any inappropriate examination behavior will result in your withdrawal from IESO.

1. The rotation of the Sun

There are sunspots on the solar surface. They can be used to calculate the rate of the solar rotation, based on a sunspot's motion on the surface. The following figure shows the sunspots during June 30 - July 6, 2006 taken from the SOHO satellite images (listed in the following table). The longitude is marked on the solar disc.

Date	Time(h:m)	Date	Time(h:m)
6/30	17:36	7/04	18:05
7/01	19:02	7/05	17:36
7/02	17:36	7/06	20:12
7/03	17:36		



(1) Let's set June 30, 00:00 to be day 0.000, i.e. Δt = 0.000 for June 30, 00:00. Record Δt in Table 1. (0.6 pts)

(2) Measure the longitude of the sunspot for each date marked, and record in Table 1. (1.2 pts)

Table 1					
Time	Δt(days)	Longitude	Time	Δt(days)	Longitude
6/30 17:36	0.733	-42.2°	7/04 18:05	4.753	12.4°
7/01 19:02	1.710	-28.0°	7/05 17:36	5.733	26.5°
7/02 17:36	2.733	-15.2°	7/06 20:12	6.842	41.1°
7/03 17:36	3.733	-1.6°			

(3) Using the data in Table 1, plot longitude (in degrees) vs. time (in days) on the graph paper – on the next page. (4.2 pts)

(4) Draw a line of best fit on the graph.

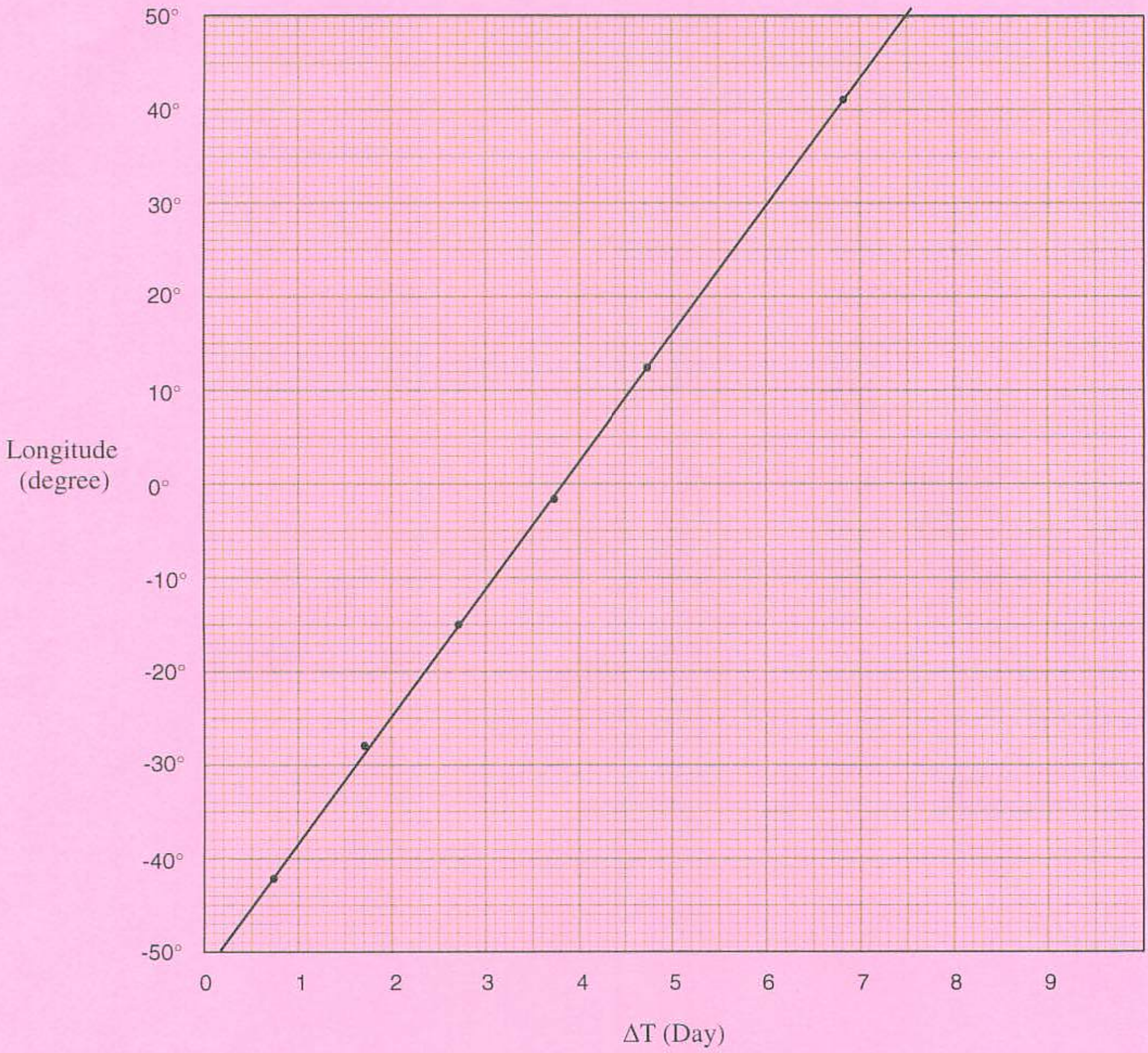
(i) Calculate the slope of the line of best fit (straight line). (2 pts)

Answer: 13.61 °/day

(ii) Calculate the rotation period of the Sun. (2 pts)

Answer: 26.45 days

Note: Include the correct unit in both answers.


50°
40°
30°
20°
10°
Longitude (degree)
0°
-10°
-20°
-30°
-40°
-50°
0
1
2
3
4
5
6
7
8
9
ΔT (Day)

2. Telescope operations

Go to the telescopes that are already set up and look for the specification of the telescope and two eyepieces.

(1) Complete the following Table. (1.2 pt)

Telescope		Eyepieces		
Aperture	20 cm	Type	Focal length	Magnification
Focal length	1800 mm	PL	25 mm	72
Focal ratio (f/)	9	PL	9 mm	200

**** A judge will grade how you operate the telescope.**

(2) Step-by-step operation (3.8 pts)

Step 1: Make the equatorial mount point to the north.

Step 2: Adjust the tripods using the bubble level on the mount.

Step 3: Adjust the elevation angle of the equatorial mount to the latitude at Taipei, 25.0° N.

Step 4: Balance the telescope and counterweight.

Step 5: Balance the telescope parts (main telescope, finder scope, and eyepiece) themselves.

(3) Observing the Sun (3 pts)

Step 6: Put the aperture solar filter in front of the telescope, and adjust the telescope pointing to the Sun, and adjust the focus to see the Sun clearly.

Warning: You must not look at the Sun through a telescope or a finder scope without the solar filter! Otherwise it will cause severe damage to your eyes or permanent blindness.

If it is rainy or cloudy, find any distant building, then adjust the telescope to point to the distant building, and adjust the focus to see it clearly.

(4) Taking a photo of the Sun (2 pts)

Step 7: Mount a digital single-lens camera to the telescope and balance the telescope again, repeating step 4 and step 5.

Step 8: Adjust the focus and take the photo of the Sun.

When you have finished the above procedure, raise your hand, and the judge will let you return to your seat.

3. Calculating the Earth's precession

The Earth rotates as a top and Earth's axis of rotation traces out a cone with an angle shown in Figure 1. That means the Earth's axis is moving along a circle. This is called precession. The celestial pole rotates about the fixed pole of the ecliptic with a circle of radius about 23.5° and a period of about 25,800 years.

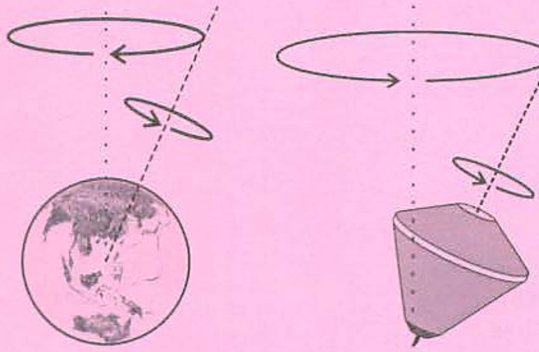


Figure 1

Figure 2 (and a transparent sheet) is the region near Polaris. Figure 3 and Figure 4 are the star tracks around Polaris on the nights of March 10, 1980 and May 20, 2009, respectively.

Figure 2

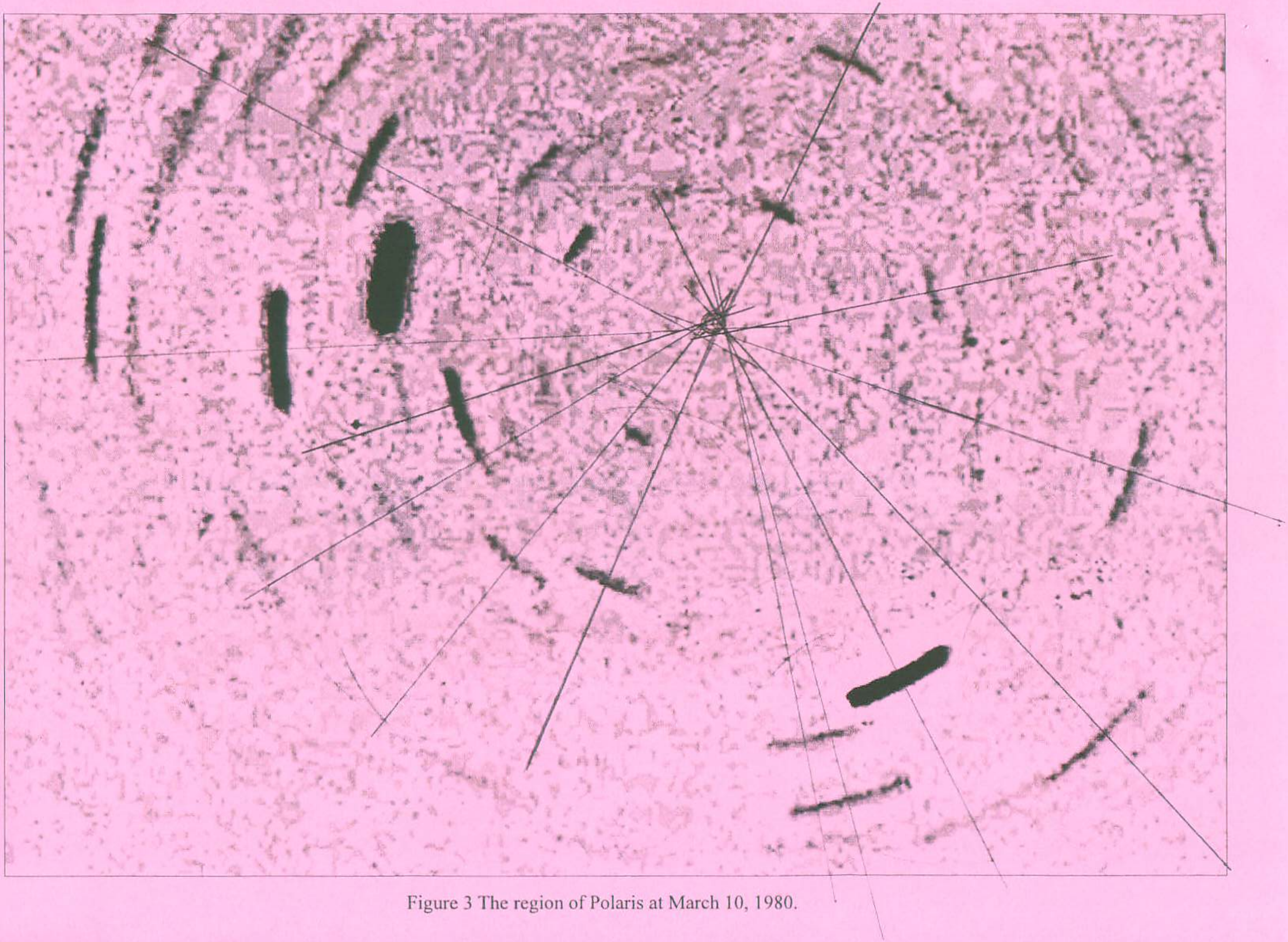


Figure 3 The region of Polaris at March 10, 1980.

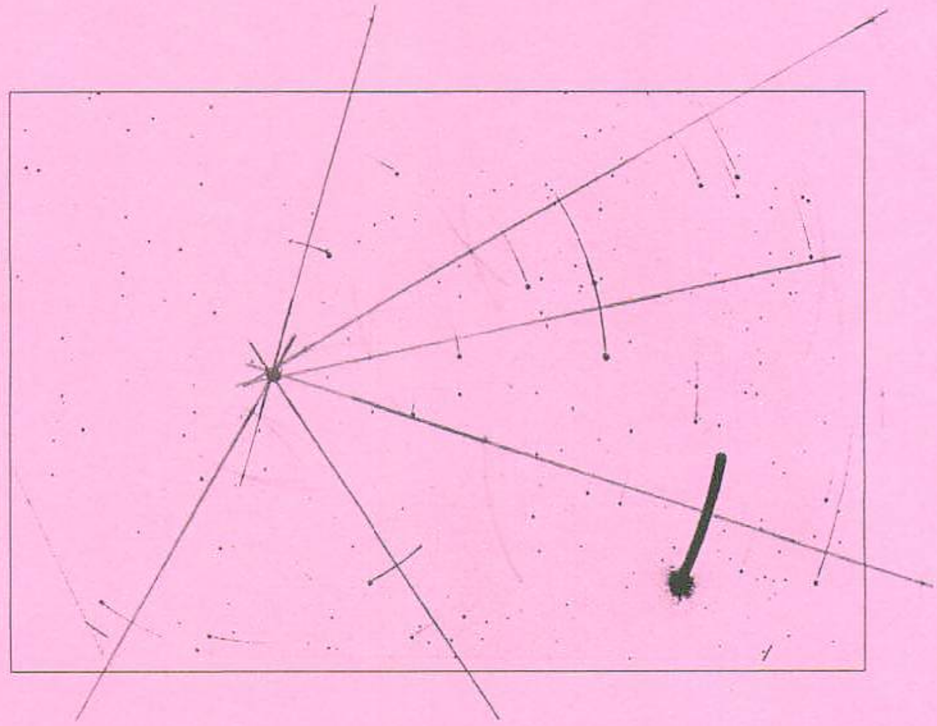


Figure 4 The region of Polaris at May 20, 2009.

(1) Determine the position of the North Celestial Pole and mark it on

(i) March 10, 1980 (Figure 3) (2 pts)

(ii) May 20, 2009 (Figure 4) (2pts)

(2) Overlap the transparent sheet (Figure 2) with Figure 3, and mark the position of the North Celestial Pole determined in Figure 3 on the transparent sheet using a marker pen. (1 pt)

(3) Overlap the transparent sheet (Figure 2) with Figure 4, and mark the position of the North Celestial Pole determined in Figure 4 on the transparent sheet using a marker pen. (1 pt)

(4) Measure the interval, Δx, between the positions of the North Celestial Pole in 1980 and 2009 on the transparent sheet.

(i) Δx = (13.5 + / - 5) mm (1 pt)

(ii) Use the Δx to calculate the Earth's precession (0.46) mm/year. (1 pt)
[show your calculation]

From 1980 March 10 to 2009 May 20, ΔT = 29.2 years

Earth's precession 13.5 mm / 29.2 year = 0.46 mm/yr

(5) The angular separation of star A and star B in Figure 2 (or transparent sheet) is 6195″.

Use this information to calculate the scale of Figure 2, (40.4) arcsec/mm. (1 pt)

[show your calculation]

The distance between star A and star B is 153.5 mm

Scale = 6195" / 153.5 mm = 40.4 "/mm

(6) Use your results from the previous questions to calculate the Earth's precession, (18.7) arcsec/year. (1 pt)

[show your calculation]

(13.5 mm / 29.2 years) * 40.4 "/mm = 18.7 "/year