

Lab 10: Sunspot Tracking

This assignment is worth a maximum of 5.0 points, and is due at the end of lab today. Work cooperatively and collaboratively as a team. Each person in your group will be awarded the same points as determined from grading a randomly selected worksheet from your group.

Assemble Your Group

- [0.4 points.] Find your assigned group members, and have everyone sign each other's worksheets. Credit is awarded for each person (present) that has brought a calculator to lab today.

Yourself: _____  Team member: _____ 

Team member: _____  Team member: _____ 

Sunspotting and Solar Rotation

- [1.0 point.] As the Sun rotates about its own axis, sunspots (temporarily cooler, darker magnetic regions) appear to move across the surface of the Sun. From their motion, Galileo Galilei and other astronomers deduced that the Sun was a rotating object, rather than a flat disk on the celestial sphere, as was previously thought. You are going to track sunspots in order to determine the rotation period of the Sun.

Refer to the grid guide on the next page when making measurements from the March 2002 active region map (ARM) data packet provided by the Mees Solar Observatory atop Haleakala, HI*, which schematically records the daily location of sunspots and groups of sunspots on the surface of the Sun.

- Figure 17.33 on page 414 of Fix, *Astronomy: Journey to the Cosmic Frontier*, 4/e shows the number of sunspots that appear each year, which occur in approximately 11-year cycles. Answer the following questions.

Next sunspot minimum year after 2007: _____.

Next sunspot maximum year after 2007: _____.

As of 2007, the Sun is currently

at minimum
at maximum
going from minimum to maximum
going from maximum to minimum

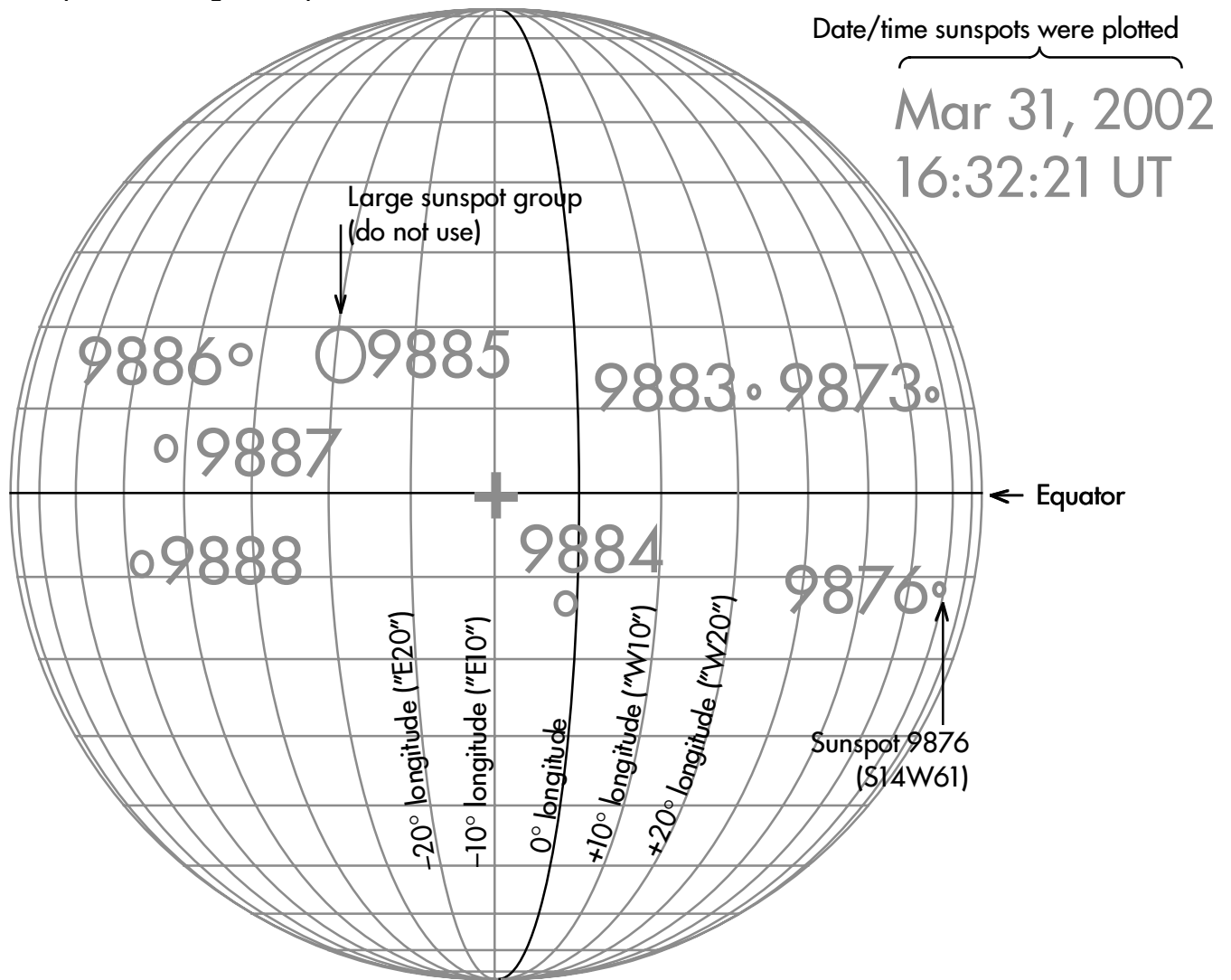
 sunspot activity.

- Each person should keep track of at least one different March 2002 sunspot, for a total of four sunspots in your group. Avoid sunspot groups (the large circles). On the next page, record their sunspot numbers, start date and position code, and end date and position code. The start and end dates for a sunspot should span *at least* five days (longer is better). You will analyze this data later.

* <http://www.solar.ifa.hawaii.edu/ARMaps/archive.html>

Group member; sunspot number:	Start date: (March xx)	Start position: (XxxXxx)	End date: (March xx)	End position: (XxxXxx)

Sample Active Region Map (ARM) data



Joint USAF/NOAA Solar Region Summary (MAR 30, 2002 24:00:00 UT)

NMBR	LOCATI	LO	AREA.	Mcl	LL	NN	MAG	TYPE
9876	S14W61	...	...	...	...	...	...	...
9878	N09W55	...	...	...	...	...	...	...
...

} Record NMBR and LOCATI codes for your sunspot

SolarScope™ Sunspotting

3. [1.6 points.] You will observe sunspots today (weather permitting). *Under no circumstances should you look at the Sun directly or through a telescope!* First characterize the expected sunspot-resolving power of the SolarScope™ projector, and then verify your predicted observations with actual sunspot projections (if it is sunny outside).

- (a) Recall that the *angular resolution* of a telescope is the measure of the smallest details that can be sharply focused (lower θ values are better), as measured in arcseconds.

$$\text{Angular resolution } \theta \text{ [arcseconds]} = 250,000 \times \frac{\text{wavelength } \lambda \text{ [cm]}}{\text{diameter } D \text{ [cm]}}$$

Calculate the angular resolution of the SolarScope™ projector, with a visible light wavelength $\lambda = 5.50 \times 10^{-5}$ cm. (This is the same calculation that was done in Lab 5.)

Sunspotter angular resolution $\theta =$ _____ arcseconds.

- (b) Your instructor will provide your group with a current "white-light" photo of the Sun (as of yesterday/today, or at least a photo of the most recent sighting of sunspots). Given that the angular size of the Sun is 1,800 arcseconds, determine the angular sizes (in arcseconds) of the largest visible sunspot and the smallest visible sunspot on the photo, by using the conversion factor below. Then indicate which of these two sunspots (if any) are expected to be resolvable using the SolarScope™ projector. *Clearly label on your photo the two sunspots used in this analysis.*

$$\text{_____ mm} = 1,800 \text{ arcseconds}$$

$$1 \text{ mm} = \text{_____ arcseconds}$$

(Use this conversion factor to find the angular size of each sunspot)

Largest sunspot size: _____ mm = _____ arcseconds
Resolvable? _____

Smallest sunspot size: _____ mm = _____ arcseconds
Resolvable? _____

- (c) Given that the diameter of the Sun is 1.39×10^9 m, determine the actual sizes (in meters) of the largest visible sunspot and the smallest visible sunspot, by using the conversion factor below. Then indicate which of these two sunspots (if any) are expected to be larger in size than the Earth, which is 1.28×10^7 m in diameter.

$$\underline{\hspace{2cm}} \text{ mm} = 1.39 \times 10^9 \text{ m}$$

$$1 \text{ mm} = \underline{\hspace{2cm}} \text{ m}$$

(Use this conversion factor to find the diameter (in m) of each sunspot)

Largest sunspot size: $\underline{\hspace{2cm}}$ mm = $\underline{\hspace{2cm}}$ m
Larger than Earth? $\underline{\hspace{2cm}}$

Smallest sunspot size: $\underline{\hspace{2cm}}$ mm = $\underline{\hspace{2cm}}$ m
Larger than Earth? $\underline{\hspace{2cm}}$

- (d) Take the Solarscope™ projector outside (if it is sunny). *Demonstrate to your instructor that you are able to obtain a sharp, projected image of the Sun.*

Stamp:

- (e) Carefully sketch and/or trace the positions and shadings of any sunspots you are able to resolve on your projected Sun image, on an attached page. Label on this diagram the two sunspots you analyzed on your photo (if they are resolvable.)
- (f) Discuss whether your observations in (e) are consistent with the expected angular resolution of the Solarscope™ projector from (b).

Analyzing Solar Rotation Rates

4. [2.0 points.] You will need the group data from 2(b). Make sure to show your work and explain your reasoning; you are graded on the thoroughness of your analysis.

- (a) For each of your group's sunspot results, determine the elapsed longitude angle between the start and ending positions ("E" longitudes are measured to the left of the 0° longitude line, "W" longitudes are measured to the right of the 0° longitude line). Then determine the elapsed number of days between the start and end dates. Calculate the rotation rate, and the period (round-trip time) of each sunspot.

$$\text{Rotation rate } [^\circ/\text{day}] = \frac{\text{Elapsed longitude } [^\circ]}{\text{Elapsed time } [\text{days}]}$$

$$\text{Period } [\text{days}] = \frac{360^\circ}{\text{Rotation rate } [^\circ/\text{days}]}$$

Sunspot number:	Elapsed longitude angle [°]	Elapsed time [days]	Rotation rate [°/day]	Period (round-trip time) [days]

- (b) Explain how your results in (a) support the fact that the Sun is not a solid, rigid rotating object, but is a diffuse object with a surface that experiences *differential rotation* (cf. Fix, *Astronomy: Journey to the Cosmic Frontier*, 4/e, page 407, and Fig. 17.37, p. 416).
- (c) From your results in (a), determine the average rotation period of the Sun. Explain why your result for the average rotation period of the Sun, as seen from the Earth, is *more* than 24.7 days (or *should* be more than 24.7 days!), which is the true rotation rate of the Sun, as seen from a stationary point in space. Use a diagram of the Earth and Sun, and indicate how their motions produce this discrepancy.