Astronomy 211 PROJECT 6 Spring 2018

Polar Project Practice

The Polar Motions Home Lab requires you to observe how the star patterns near Polaris change over a few hours and after at least two months; and to calculate the rotation period of the Celestial Sphere and the length of a year. In this project we'll skip over the problems of making the sky sketches (I'll provide you with computer generated sky sketches) and practice instead the calculational part of the lab.

In the Home Lab you'll observe and sketch the sky near Polaris three times on the first night (over about four hours) and then again on a second night, more than two months later, at a time that matches one of the first night sketches. At the end of this document you'll find four computer drawn sketches. The first three (labeled 1a, 1b, 1c) were made for the early morning of 16-Aug-2015 at midnight, 2 A.M., and 4 A.M.; the fourth sketch (labeled 2) was made (9 weeks later) at the start (midnight) of 18-Oct-2015.

1. Locate and sketch in the stick figure for the Big Dipper. Use the 'Pointers' of the Big Dipper to locate Polaris. Use Polaris to find and sketch in the stick figure for the Little Dipper (not as obvious as the Big Dipper). Approximately opposite the tail of the Big Dipper (through Polaris) locate and sketch in the stick figure for the W of Cassiopeia. Draw these three stick figures on all four sky sketches.

2. Locate and circle (on all four sky sketches) the following stars: Dubhe (α Ursa Major; the lip of the big spoon), Kochab (β Ursa Minor; the lip of the little spoon), and γ of Cassiopeia (middle of the W). These stars are identified on your SC002.

3. Using a straightedge, draw a line from Polaris through each of these stars; extend the line to the diagram edge. Also using a straightedge, draw a line going straight down from Polaris. This line should meet the horizon (bottom of the sky sketch) at the North point on the horizon, so label that point N. Do this for all four sky sketches.

4. Using a protractor centered on Polaris, measure the counter-clockwise angle (0°–360°) from your downward vertical line to the star.

5. Record these 12 angles in the below Summary Table.

Sketch	Time (CST) Date	Location	Dubhe °	Kochab °	γ Cas °
1a	23:00 CST 2015/08/15	SJU Observatory			
1b	01:00 CST 2015/08/16				
1c	03:00 CST 2015/08/16				
2	23:00 CST 2015/10/17				

Note that the times filled into this table seem out-of-step with what was written above... midnight on my watch has been recorded as 23:00 2015/08/15. That is because this sketch was made when daylight saving time was in effect. To convert CDT to CST, subtract one hour. (DST begins mid March and ends early November.)

6. If, during these sequence of sketches, a star has moved through the downward vertical line, add 360° to that star's angles that are to the right of the downward vertical line.

7. Using the first-day data, plot each star's angle directly on the chart that is Figure 1. Note that $1\frac{1}{4}$ cycles are displayed. Plot your starting star positions in the bottom part of the chart, and, if the star moves past the downward vertical, continue on into the top chart. (This is how the chart handles angles that are 'more than 360°.') The x-axis records the number of hours since the initial observation. Locate each star's (time,angle) point accurately perhaps using a straightedge. Each star's sequence of positions should show an approximate linear progression.

8. For each star draw (using a straightedge) the line that best approximates your three data points for the star; extend the line to the rhs of the chart. Note: for these computer generated sketches the three points should be quite co-linear. Typically your own sky sketches for the Home Lab will not be as accurate so the points will deviate more from the 'best approximate' line.

9. Calculate the slope (rise/run) for each of the three lines.

   The slope is best calculated by finding the 'rise' of the line from the lhs to the rhs of the plot (i.e., the difference in angle between the edges: rhs − lhs) and then dividing by the 'run' along the x axis between the lhs and rhs sides (in this case 6 hours).

   Fill this information into the following table:

star	rise °	run h	slope=rise/run °/h
Dubhe		6	
Kochab		6	
γ Cas		6	
	average slope=		$= S_{avg}$

10. Since the stars rotate as if attached to the Celestial Sphere the three slopes should be the same. Any difference is probably the result of less-than-perfect measurement[1]. Calculate the average of your three slopes and fill your result into the above table. We denote this value with the symbol S_{avg}.

    Note that the deviation among these three slopes would give us an estimate of the accuracy of our measurements since we believe they should be identical.

11. If the rotation you measured in a few hours continues, how many hours does it take (call that H) to complete a rotation? You need to solve a proportion of the form:

$$S_{avg} = \frac{360^\circ}{H} \tag{1}$$

[1]No measurement is perfect of course. Perhaps confusingly we talk about this deviation from perfection as an 'error' even though no mistake is involved. (If there is a real mistake, we call that a 'blunder.') 'Uncertainty' would be a better word choice, but 'error' is what is commonly used.

Report your value for H along with the calculations that produced it. Your answer for H should be approximately 24 hours.

12. Next we compare same-time, different-date observations (like 1a and 2 in this example). Since H is nearly 24 hours, in the 63 days between 1a and 2 the Celestial Sphere has made about 63 full rotations. If H were exactly 24 hours, the star pattern in the second-day observations should exactly match the same-time sketch from the first-day observations (i.e., at that time it would be the same every day of the year). If you compare sketch 1a with 2 you'll see that there is a clear rotation between the situations. Evidently the Celestial Sphere has made 63 full rotations plus a bit more. We'll call that extra bit the 'over-rotation'. How much over-rotation occurred? Fill in the below table:

Sketch	Time (CST)	Dubhe	Kochab	γ Cas
	Date	$^\circ$	$^\circ$	$^\circ$
2	23:00 CST 2015/10/17			
1a	23:00 CST 2015/08/15			
difference (over-rotation)=				

$\Downarrow$

average over-rotation= $\boxed{}$ $= OR_{avg}$

13. Since the stars rotate as if attached to the Celestial Sphere the amount of over-rotation should be the same for all three stars. (Again, less-than-perfect measurement means exact equality is unlikely.) Calculate the average over-rotation and record the result in the above table. We denote this value by OR_{avg}.

14. For these observations, this average over-rotation occurred over a period of 9 weeks = 63 days. If the Celestial Sphere is rotating uniformly we can use this result to determine how long it takes for the Sphere to complete a full over-rotation so the star pattern is exactly as it was in the 1a sketch. The time it takes to get the stars back to their original locations is a year. If we let D represent the number of days required for this over-rotation to accumulate to one full rotation then

$$\frac{OR_{avg}}{63 \text{ days}} = \frac{360^\circ}{D} \tag{2}$$

Report your value for D along with the calculations that produced it.

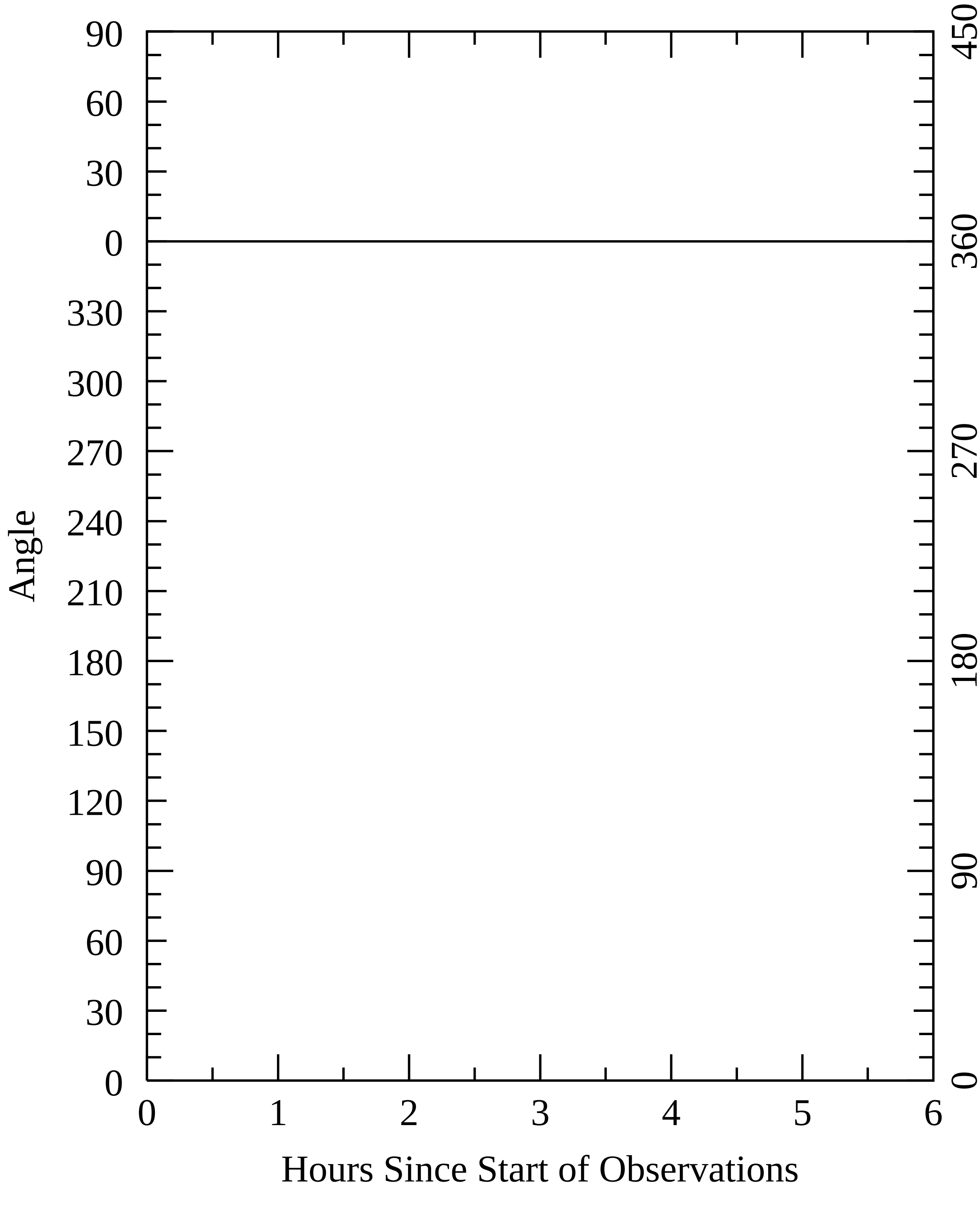
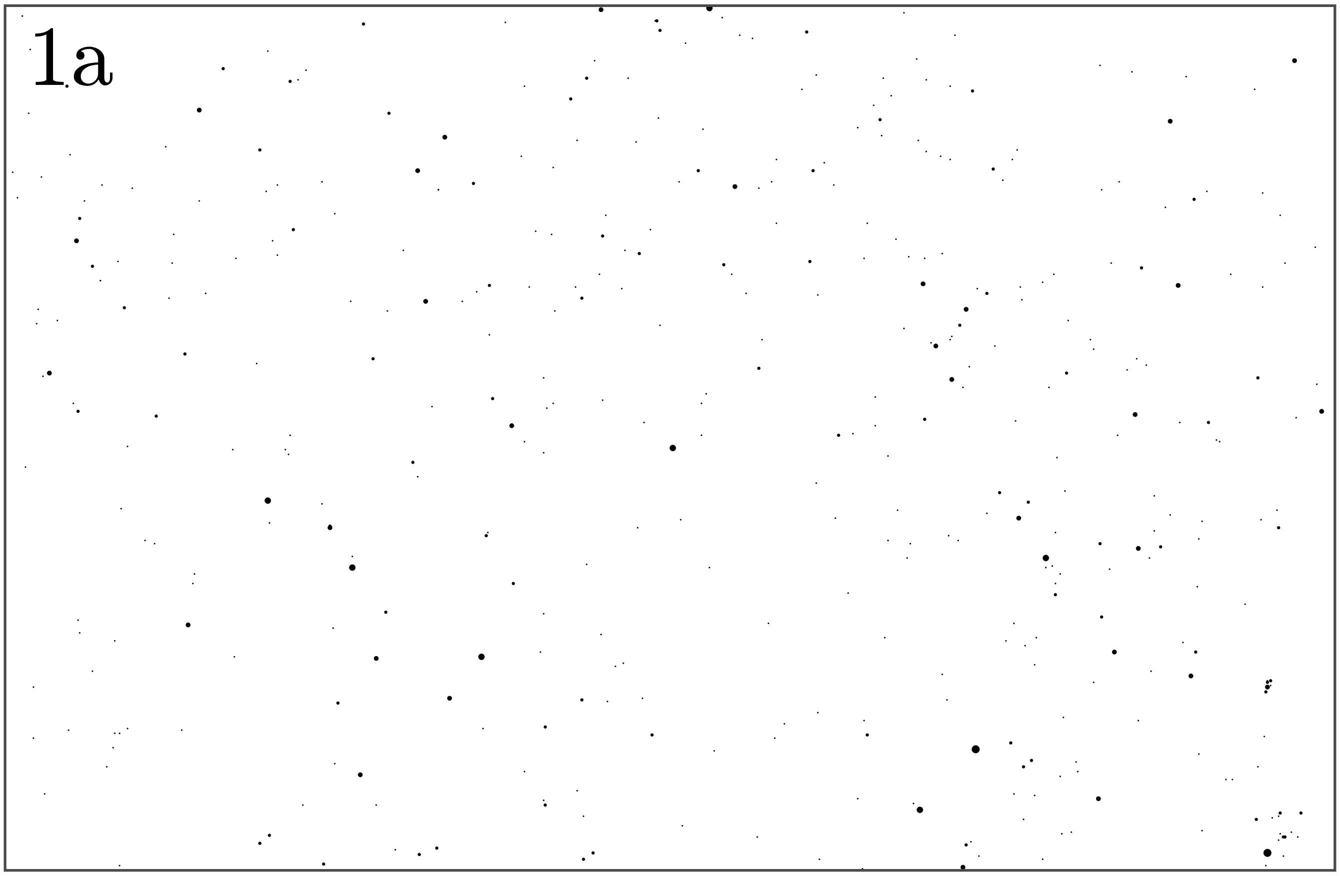
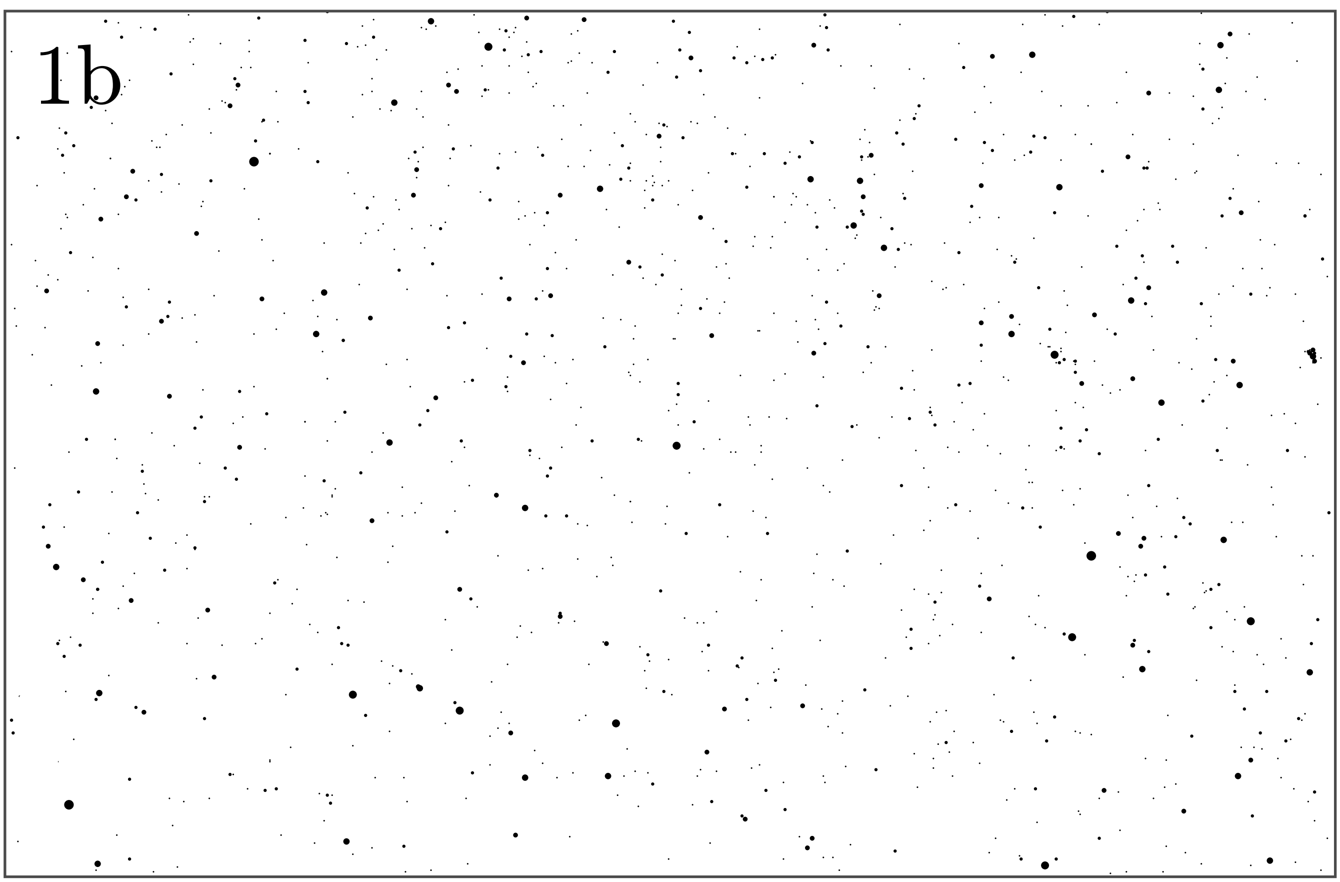
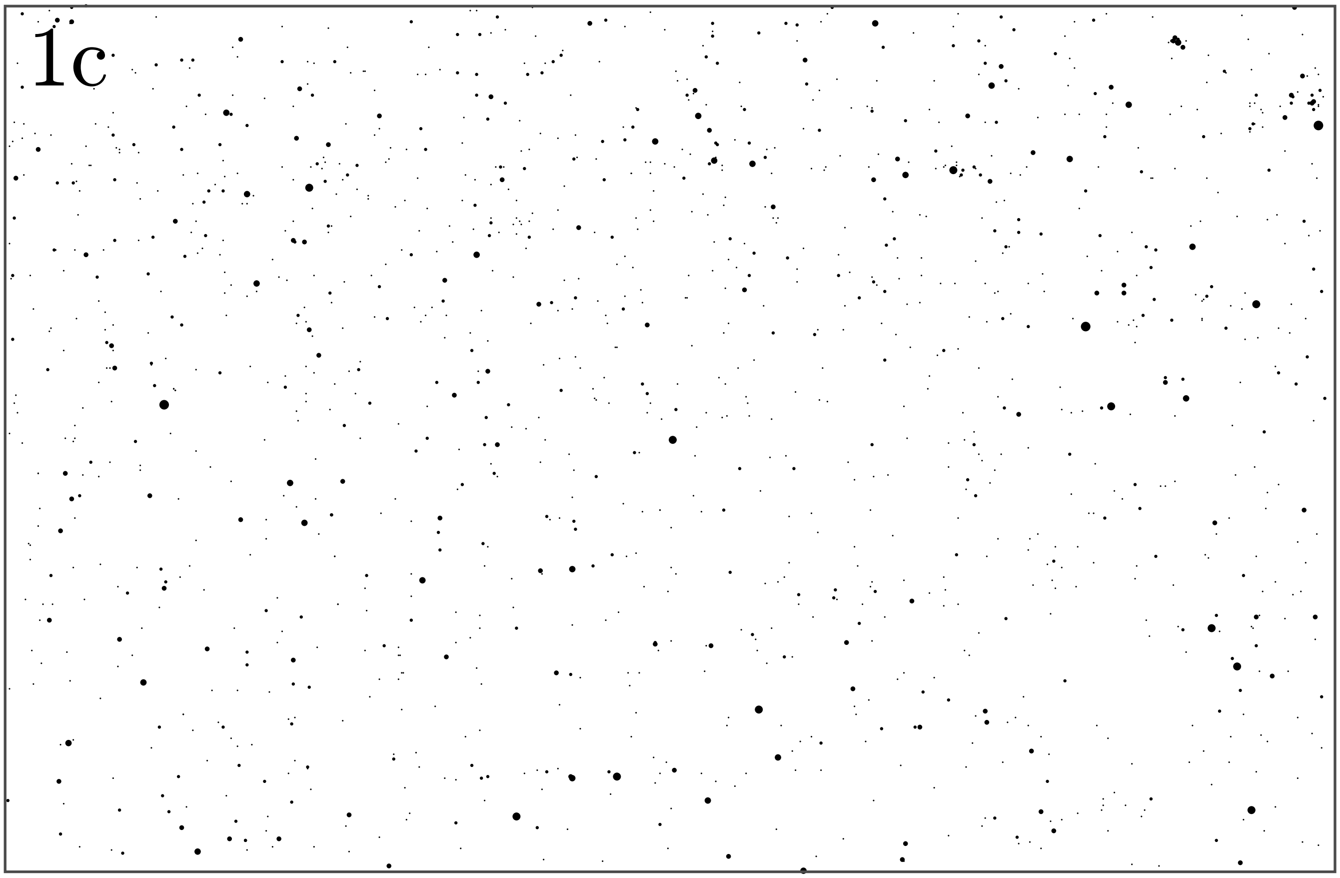


Figure 1: Plot your sketch 1a–1c observations of star angle vs. hours directly on this sheet. Use a straightedge to accurately locate and mark your 3 stars × 3 observations (hour,°) points. $1\frac{1}{4}$ cycles are displayed on the y-axis. Start your plotting in the lower chart and, if the star passes through the downward vertical, continue on to the top chart. Draw in the three lines that best approximate each star's linear progression.

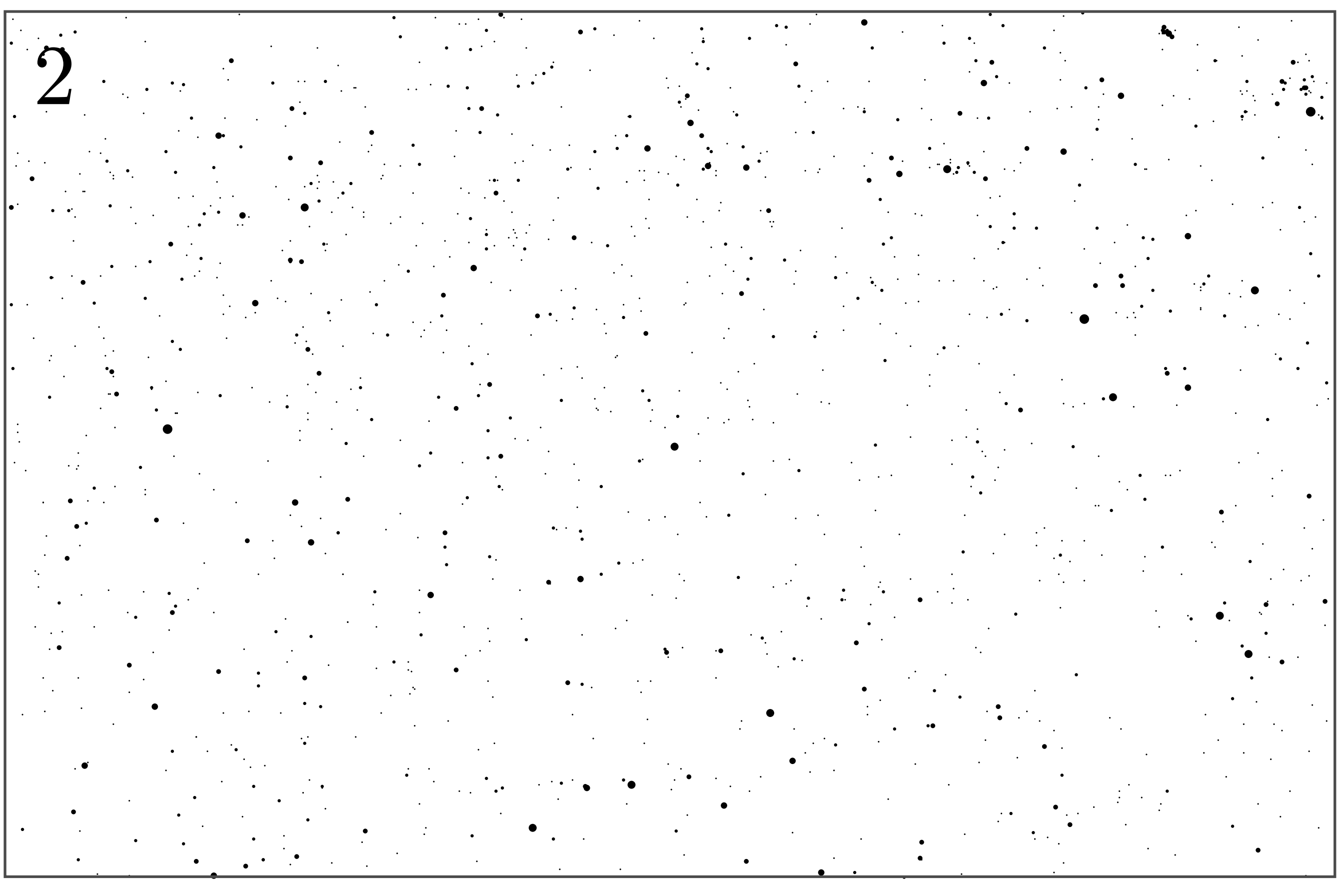




2 hours after 1a



4 hours after 1a



9 weeks after 1a