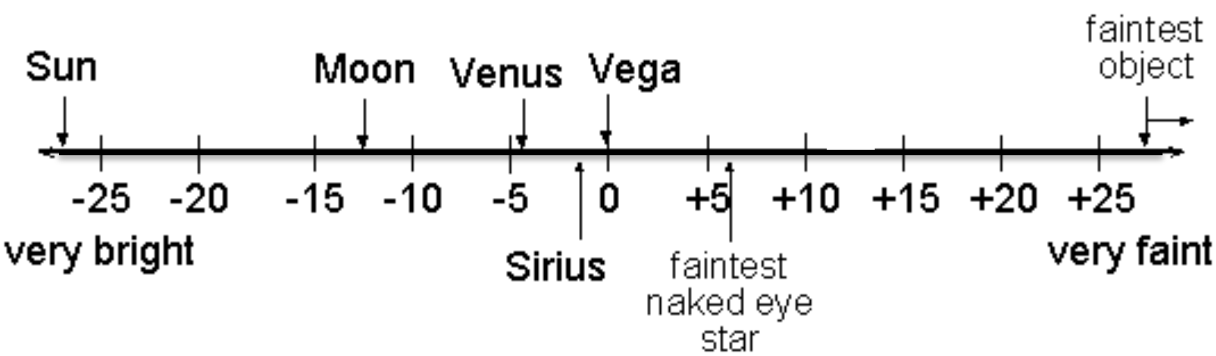
Counting Stars and Limiting Magnitude

Introduction

We've all heard about "light pollution", but how much does it really change what we see in the night sky? In this lab, we'll learn about apparent magnitudes, and how astronomers can use the idea of a "limiting magnitude" to compare how much light pollution affects the number of visible stars in a particular area.

The magnitude system is a scale that astronomers use to compare how bright an object is. Apparent magnitudes measure how bright a star or planet appears in the night sky, as opposed to absolute magnitudes, which measure how bright a star actually *is* (we'll do more with absolute magnitude in a later lab). Apparent and absolute magnitudes are based on a system developed by ancient Greek astronomers.

The original Greek scale has +1 for the brightest stars, and +6 for the dimmest stars. If the smaller number for brighter stars bothers you, think of ranking schemes (as did the Greeks), where the brightest stars were "first place" or "top tier" stars, and the dimmest stars are in "sixth place," earning the Miss Congeniality prize. Modern astronomers later revised this scale, once they started finding out that stars can be brighter than +1 or fainter then +6. Brighter than the "first place" +1 stars are "zero place" stars, and brighter than those stars are "-1 place" stars. These are the *really* bright stars. There are also lots of stars dimmer than +6, but due to the limitation of the human eye these cannot be seen with the naked eye, even under the best of circumstances. Typically these stars can easily be observed with telescopes or even decent binoculars.



Apparent brightnesses of some objects in the magnitude system.

(Image credit: Nick Strobel, www.astronomynotes.com)

In theory, when you look out at the night sky you should be able to see every star with an apparent magnitude brighter than +6. In reality, streetlights and Earth's own atmosphere work against this, and you won't be able to see stars that are too faint. The atmosphere actually reflects some of the streetlight back down towards the surface, making it that much more difficult to see the stars. The moon can even cause light pollution, especially when it's full. What this means for us is that the apparent magnitude of the faintest star we'll be able to see is likely to *not* be +6, but +5 or +4 (or even lower). The cutoff magnitude of the faintest star you can detect is called the limiting magnitude. In the rest of the lab, we're going to learn the technique for figuring out the limiting magnitude, and practice under some different conditions.

Procedure

Step 1: Get a set of three Orion star charts from the instructor. These charts represent what the sky looks like in the constellation Orion in rural, suburban, and urban lighting environments. Using a ruler, place yourself about 5 feet away from the charts and count the number of stars in the "Orion's Torso" asterism. Include any stars that are on or inside the border and definitely count the "corner" stars.

Q1: How many stars did you individually count in Orion's torso under urban conditions?

Q2: How many stars did you individually count in Orion's torso under suburban conditions?

Q3: How many stars did you individually count in Orion's torso under rural conditions?

Q4: Determine the average number of stars counted by your group under each set of conditions (for example, add up all your answers to Q1, and divide by the number of people in your group).

a. Group average number of stars under urban conditions
b. Group average number of stars under suburban conditions
c. Group average number of stars under rural conditions

Step 2: Refer to Table 1, which lists the stars in Orion's torso in order from brightest (lowest apparent magnitude) to faintest (highest apparent magnitude).

Q5: How many stars in Orion's torso are **brighter** than Polaris, which has apparent magnitude +2.0? (Remember: the smaller the magnitude, the brighter the star!)

Q6: What is the limiting magnitude (that is, the magnitude of the faintest star your group could see) under each set of conditions?

a. Urban
b. Suburban
c. Rural

Step 3: Refer to the graph showing number of visible stars versus limiting magnitude.

Q7: Based on your answers to Q6, how many stars could you expect to see in the night sky under each of the following conditions? Remember: you can only ever see half of the sky at once, so make sure to divide *N* by two.

a. Urban
b. Suburban
c. Rural

Follow-up Questions

Q8: What generalization statements, in complete sentences, can you make about how the limiting magnitude changes with respect to light pollution?

Q9: What generalization statements, in complete sentences, can you make about how the number of visible stars in the sky changes with respect to light pollution?

Next, consider the following statement about the number of visible stars:

"In the center of a city, where the naked-eye limiting magnitude due to extreme amounts of light pollution can be +4 or less, as few as 200 to 500 stars are visible." (Wikipedia article on "Naked Eye")

Q10: Based on the procedure you followed and the evidence you gathered in the previous steps, would you agree or disagree with the Wikipedia article? Explain your reasoning and use specific evidence from your data to support your reasoning.

Preparation and Planning for Observing Assignment #2

Q11: If you were going to repeat our star-counting experiment outside to test the limiting magnitude, would it be better to observe your target constellation when it is near the horizon, or when it is high in the sky? Explain your reasoning.

Q12: Using your star wheel, identify roughly what time of night Sagittarius will appear in this portion of the sky (your answer from Q11) over the next month.

Q13: Describe precisely what evidence you would need to collect in order to answer the research question of, **"Is there more or less light pollution at the Petaluma SRJC campus than at the Santa Rosa SRJC campus?"** You do not need to actually complete the steps in the procedure you are writing.

Q14: Create a detailed, step-by-step description of evidence that needs to be collected and a complete explanation of how this could be done--not just "Drive to each location and count stars," but exactly what would someone need to do, step-by-step, to accomplish this. You might include a table and sketches--the goal is to be precise and detailed enough that someone else could follow your procedure.

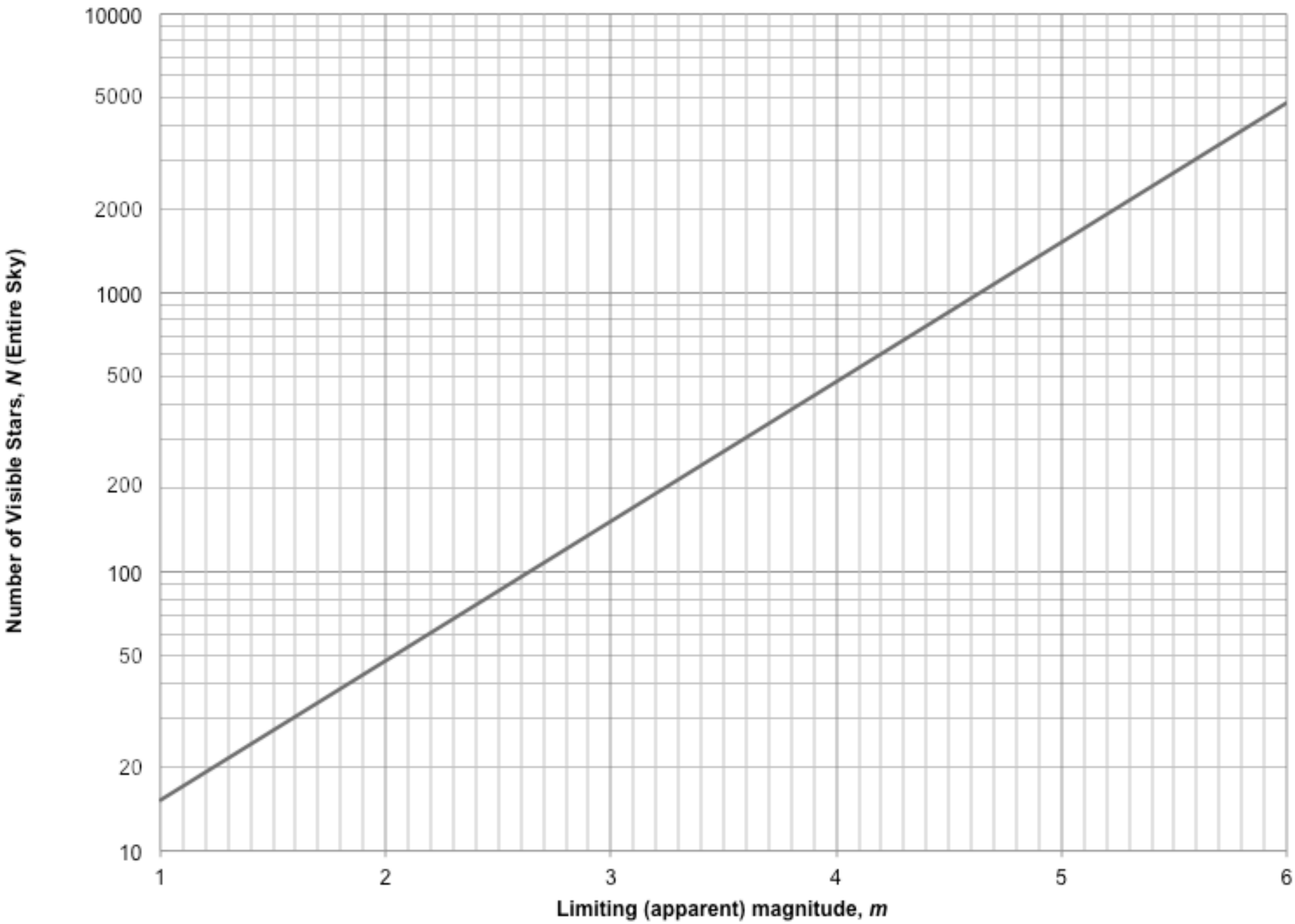
Note: You will be using the procedure that you describe in Q13 and Q14 to complete the next observing assignment, so your future self will thank you for writing clear explanations!

Table 1: Apparent Magnitude of Stars in Orion

	Star Name	m
1	Rigel	0.18
2	Betelgeuse	0.58
3	Bellatrix	1.64
4	Alnilam	1.69
5	Alnitak	1.74
6	Saiph	2.07
7	Mintaka	2.25
8	Na'ir al Saif	2.75
9	Meissa	3.39
10	τ Ori	3.59
11	Sigma Ori	3.75
12	Phi 2 Ori	4.06
13	29 Ori	4.12
14	32 Ori	4.18
15	Phi 1 Ori	4.37
16	w Ori	4.50
17	42 Ori	4.56
18	v Ori	4.59
19	HIP26199	4.75
20	49 Ori	4.75
21	51 Ori	4.87
22	HIP26736	4.93
23	Trapezium 1A	4.96
24	θ2 Ori	4.96
25	45 Ori	5.21
26	52 Ori	5.25
27	38 Ori	5.31
28	HIP25980	5.31
29	W Ori	5.35
30	33 Ori	5.43
31	HIP26345	5.68
32	HIP25751	5.75
33	HIP25708	5.78
34	HIP26487	5.84
35	HIP26762	5.90
36	HIP26108	5.90
37	HIP26535	5.93
38	HIP26624	5.96
39	HIP26926	5.96
40	HIP25187	5.96
41	HIP27560	5.98
42	TYC4774-934-1	6.00
43	HIP26427	6.00

Table 2: Apparent Magnitude of Stars in the Teapot (Sagittarius)

	Star Name	m
1	Kaus Australis	1.79
2	Nunki	2.05
3	Ascella	2.60
4	Kaus Media	2.72
5	Kaus Borealis	2.82
6	Nash	2.98
7	Phi Sag	3.17
8	τ Sag	3.32
9	77 G. Sgr	5.28
10	75 G. Sgr	5.37
11	HD171238	5.44
12	37 G. Sgr	5.53
13	18 Sgr	5.58
14	66 G. Sgr	5.90


10000
5000
2000
1000
500
200
100
50
20
10
1
2
3
4
5
6
Number of Visible Stars, N (Entire Sky)
Limiting (apparent) magnitude, m