

Lab 3: Observing the Night Sky

Part I: The Celestial Sphere

The Sun and its system of planets are embedded in an enormous, pancake-shaped assemblage of billions of stars known as the Milky Way galaxy. We view these stars from a moving platform, Earth. From our vantage point, stars can be seen in every direction.

Introducing the Celestial Sphere

A powerful tool to help us orient ourselves to the night sky is known as the “Celestial Sphere.” The Celestial Sphere is a giant, imaginary sphere centered on the Earth. The stars in the Milky Way are so far away that they appear “fixed,” i.e., their positions relative to one another don’t change noticeably. (In practice, they do move, but it takes tens of thousands of years for the small changes to become visible to the unaided eye.) Because of this, we can imagine (as ancient astronomers did) that the stars are all located on a giant sphere with the Earth at the center.

Let’s sketch the Celestial Sphere. The small circle below represents Earth, with the North Pole (NP) straight up, the South Pole (SP) straight down, and the equator running through the middle. Draw a large circle representing the Celestial Sphere, centered on the Earth. Make it take up the whole space! Now use a ruler to connect the North and South Poles, and extend the line (the Earth’s spin axis!) until it touches the top and bottom of the Celestial Sphere. Label the two points where the axis touches the Celestial Sphere “NCP” and “SCP” (North Celestial Pole and South Celestial Pole). Like the Earth, the Celestial Sphere also has an equator. Draw it in, and label it.



88 Official Constellations

Humans naturally find patterns, and cultures all over the world have associated different patterns of stars with real or imaginary creatures, with gods and demi-gods, and more. For astronomers, who use scientific methods to study the stars, it helps to divide the Celestial Sphere into different regions to help locate stars and other objects of interest. In 1930, astronomers around the world met to define a unified system in which the Celestial Sphere is divided into 88 regions, or constellations.

Constellations are like countries... they have borders. Bright stars are like big cities, and can help you find the patch of sky associated with the constellation. Even if a star is too faint to be shown on the celestial sphere, it's in the constellation if it's within its borders, just as a city or town is in a country whether or not it appears on a particular map. Moreover, an object is said to be "in" a constellation if it lies within its boundaries, regardless of how far away it is. Thus the Sun is sometimes "in" Scorpius, though it's much closer than any stars in the constellation. And the galaxy known as M31 is also called the "Andromeda galaxy" because even though it is much farther away than any of the stars in the constellation, it lies in their direction.

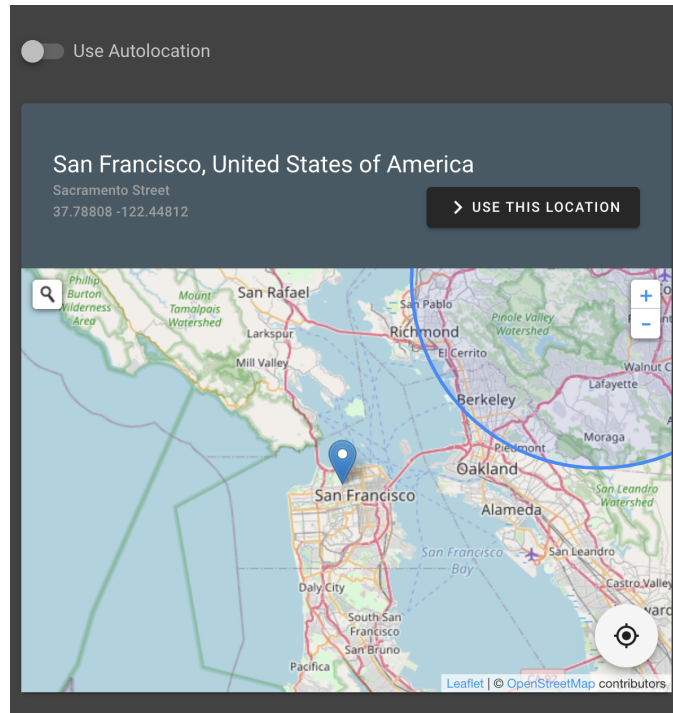
Well-known patterns of stars that are not official constellations are called **asterisms**. We will go more into what separates a constellation from an asterism later in the lab.

Virtual Celestial Sphere

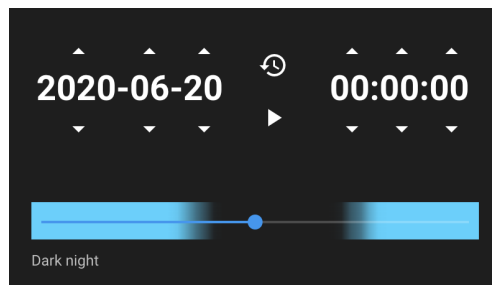
We are going to explore constellations and asterisms using an astronomy program called Stellarium. This will be our virtual celestial sphere! Once you make your way to the website, ***follow the steps below*** to correctly setup the page for the correct location and to help you get familiar with it.

<https://stellarium-web.org/>

1. **Set the correct location.** We are all going to use San Francisco as our location so that we can all see the same constellations. At the bottom of the webpage you should see a button that tells you where you're observing from. It'll say "near (location)," click that button. Once the map pops up, drag the location pin to San Francisco and click "> use this location" above the map. Also make sure that the toggle for "Use Autolocation" is turned off.



2. **Set the correct time.** At the bottom right of the screen you should see another button with the time and date. Click that button. Once the window pops up you should see something that looks like the image below. Set up the date and time to match the image below. Set it for June 20th 2020 at midnight. Also be sure to "pause" time. You'll see the pause button in the middle of the popup. Finally, be sure that the bar on the bottom is set to "Dark night".



3. Turn on Constellations.

At the bottom, you'll also see a bunch of symbols which will turn on and off certain features of the night sky. If you hover your cursor over the symbols, they should tell you what each one is. Turn on the "Constellations" and "Constellations Art" symbols. They are the two left symbols along the row. Once you do that, you should see lines connecting stars and fun pictures that represent what each constellation was named after. You should not have to turn anything else on or off. The standard setting should be fine.

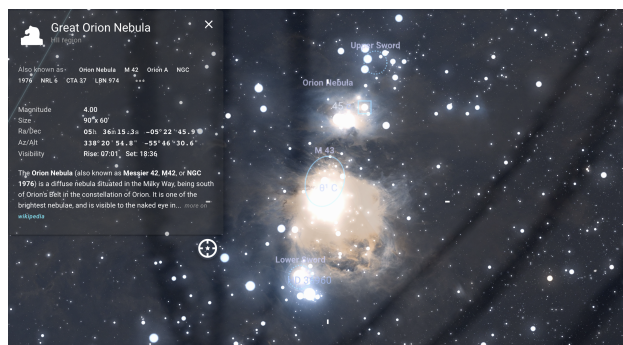


4. Quick Overview

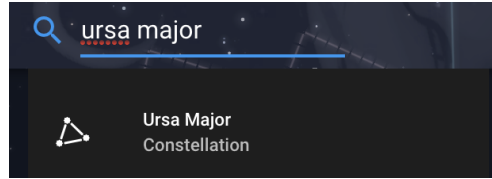
Now let's look at what's on the view screen. At the bottom you should notice a dark area with maybe some trees or houses, this is your horizon. You should also notice as you click and drag around the horizon there are four letters, "N", "E", "S" and "W" which stand for the four cardinal directions, North, East, South and West.



Everything else on viewer should be in the sky! If you play around with it you may also notice that you can zoom in and out. Try zooming in on a star or something interesting in the sky. You may find that you can zoom in a great deal and learn about that particular object.

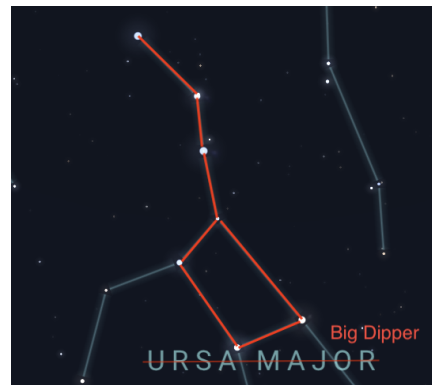


At the top of the webpage, you should see a search bar. Type in “Ursa Major” and click on the top search that is suggested as shown in the image below.



This should take you to the **constellation** of Ursa Major or “Great Bear”. Notice now that there is a blocky dashed line border around the image of Ursa Major. This is the boundary for this constellation, it defines that area of the sky as the Ursa Major constellation. The constellation got its name from the stars that appear to create the “image” of a great bear.

You should also notice that there are lines that connect the brightest stars in Ursa Major. These lines are what trace out asterisms. They are the pictures that can be made from bright stars in the sky. Do you maybe notice the Big Dipper inside of the constellation of Ursa Major? The picture below shows a zoomed in portion of the constellation Ursa Major that is the **asterism**, the Big Dipper (drawn with the red lines).



Next, type “Polaris” into the search bar and click on the top result in the search. It should take you to a star that is somewhat near the constellation Ursa Major.

1) What constellation is Polaris in?

This star is known as the “North Star” and it is not only apart of the the constellation of Ursa Minor, but also a part of the asterism the “Little Dipper.” If you click on the constellation name, the dashed line borders will appear.

One great way to find Polaris is to use the Big Dipper. Once you get familiar with its shape, it can be easy to recognize when you're looking at the sky (try this whenever you're out at night with a somewhat dark sky). The image below shows how you can use the two bottom stars in the Big Dipper to point to Polaris or the "North Star." You should also notice on the horizon that the "N" direction is directly under Polaris. This is how you can find North if you're ever lost and is also why Polaris is given the nickname the "North Star."



Now that you're all setup and had a small tour of the Northern sky, answer the following questions using Stellarium:

- 2) Find at least 6 constellations using our virtual Celestial Sphere (Stellarium), starting with any that you or your lab partners recognize the names of. List their names here.

- 3) Are all constellations the same size? The same shape? If not, find a big one and a small one. Write their names here.

- 4) Locate the bright star Vega. What constellation is it in?

- 5) Locate the bright star Antares. What constellation is it in?

Part II: Getting started with Star Wheels

The **Star Wheel** is a very handy device for learning your way around the night sky! It consists of two parts that can rotate relative to each other. When you match up today's date with a time, the white areas show what parts of the night sky will be visible at night (assuming buildings, trees, or clouds don't get in the way!).

The white circular part that rotates is a projection of the celestial sphere onto a flat surface. The stars that appear on the top (northern) half of the Celestial Sphere appear on one side, while the stars that appear on the bottom (southern) half of the Celestial Sphere appear on the other side. The opaque blue parts of the Star Wheel mask out the parts of the Celestial Sphere that cannot be seen because they are blocked by the Earth. The edges of these blue regions represent the horizon (the horizontal line dividing the Earth and sky in all directions if you are in a big, flat open field).

First you'll need to set your Star Wheel to the date and time you will be observing. To do this right, you need to know that the Star Wheel uses "Standard Time." If the time currently in use is "Daylight Time," the star wheel will be showing what the sky will look like when your clock reads 9 pm (since Daylight Time is 1 hour ahead of Standard time). California uses Daylight Time from the second Sunday in March to the first Sunday in November.

Now take a look at the "front" side of your Star Wheel (the side with the white oval opening). Notice the cardinal directions NORTH, EAST and WEST marked along the horizon.

To identify constellations in the northern part of the sky, you'll hold the Star Wheel up high, with the northern horizon at the bottom, parallel to the floor. Then you can try matching it up with what you see. Constellations on the Star Wheel will be oriented the same way they are on the night sky.

To learn constellations in the eastern part of the sky, rotate the Star Wheel so that the eastern horizon is at the bottom and parallel to the floor. A similar procedure works for the west. Always hold the Star Wheel up high, right next to the part of the sky you are looking at. To identify constellations in the south, turn over your star wheel!

The video below is a complete introduction to the different parts of your star wheel and how to use it properly.

<https://youtu.be/wU1-PPnufpE>

Symbols and other information on your Star Wheel

Your Star Wheel shows several hundred of the stars that can be seen with the unaided eye in the night sky. The brightest stars are shown as big dots, the fainter stars as smaller dots. Take a close look at the Star Wheel to see how the following things are represented or labeled:

- star names are given in _____ letters
- constellation names are given in _____ letters
- asterism names are given in _____ letters with
_____ around them
- the brightest stars in constellations are connected by _____ lines
- asterisms are connected by _____ lines

A few non-stellar objects from the Messier catalog are shown (see key on back of Star Wheel)

- globular star clusters are shown as _____
- open star clusters are shown as _____
- nebulae (fuzzy objects) are shown as _____
- galaxies are shown as _____

Note that this Star Wheel is designed for a latitude of 32 degrees, but works well for latitudes between about 30-40 degrees. San Francisco's latitude is 38 degrees.

Now see if you can answer these questions using your **Star Wheel**.

6) How many stars make up the Big Dipper asterism? What constellation are they in?

7) What named star is part of the Little Dipper asterism? What constellation is it part of?

8) What three stars make up the “summer triangle” asterism? What constellations are they in? (***Hint:*** *Some asterisms are big and span multiple constellations. The stars that make up these larger asterisms are connected with dashed lines on your Star Wheel.*)

9) What six stars make up the “winter hexagon” asterism? What constellations are they in?

10) Find more named stars, and the constellations they’re in. Remember to turn over the Star Wheel!

11) Find, name and state the object type of 3 non-stellar objects. Look for “M” for “Messier”!

Now that you are oriented to where N/S/E/W are along the horizon, work on identifying the remaining bright stars. An important group to focus on in the fall is the “Summer Triangle” asterism, which is high in the sky in the late summer and early fall. This makes it one of the easier patterns to recognize from San Francisco since buildings don’t get in the way as much when stars are high up. Judging from your star wheel, which of the three named stars in this asterism is...

- highest in the sky? _____
- closest to the eastern horizon? _____
- closest to the southern horizon? _____

Now try to identify the summer triangle using Stellarium (<https://stellarium-web.org/>). You cannot use the search function for asterisms, so just look around the virtual sky. Once you have located what you think are these three bright stars in Stellarium, double-check your identifications by looking for additional stars that make up the three constellations that these bright stars are part of. Here are some things to look for:

- Lyra: four faint stars making a small parallelogram (diamond) shape
- Cygnus: five stars making up the “Northern Cross” asterism
- Aquila: two stars on either side of the bright star

More constellations containing bright stars

- | | |
|--------------|---------------|
| • Ursa Minor | • Scorpius |
| • Pegasus | • Bootes |
| • Cassiopea | • Sagittarius |

Hint: turn over your star wheel when you are looking for constellations above the southern horizon!

We will be using Stellarium and your Star Wheel for a big portion of the semester (it may also help you with your SkyWatch assignment). So make sure you’re comfortable using these tools!