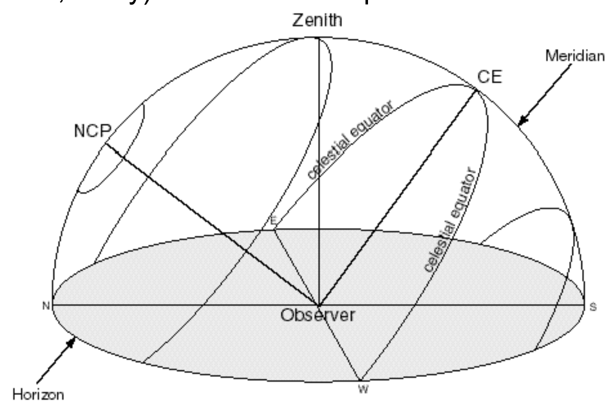
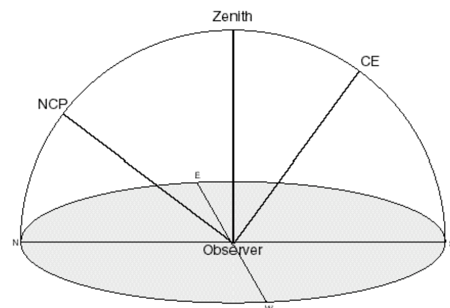
AST101: Introduction to Latitude

The planetarium sky you have seen so far throughout this course represents the visible sky from East Lansing. It's similar enough to the way the sky looks throughout the continental U.S. that we generally don't bother with the differences. But for places substantially different in latitude, such as Australia, Central America, northern Canada, for examples, the sky does change. We'll observe these differences in the planetarium, but we'll first explore them with diagrams.

The drawing at right represents the celestial sphere (hemisphere, really). Think of it as a picture of the planetarium dome that's transparent. You are standing at the center, where it's labeled "Observer" (and where the planetarium projector normally sits). Notice the horizon ring and the four labeled directions, N, S, E, W. The North Celestial Pole (NCP), Zenith, and Celestial Equator (CE) are also labeled. The arc across the top of the drawing represents the meridian. Confirm that it passes through due North, NCP, Zenith, and due South. Finally, several loops have been drawn in to indicate how various stars would move across the sky as time passes, that is, how the celestial sphere rotates. One of the loops is labeled "celestial equator," and it passes through due East and due West, as you would expect.

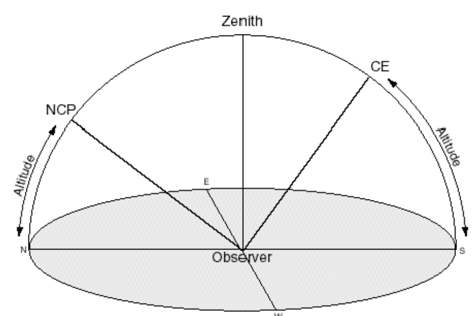


When we use this type of diagram to illustrate latitude differences, we typically simplify the drawing by showing only the horizon and meridian, as depicted in the second drawing to the right. We do this because the obvious changes (and those easily measured) take place along the meridian. Before we consider those changes, let's review the concept of altitude, as represented on this new diagram, and introduce another concept: zenith distance.

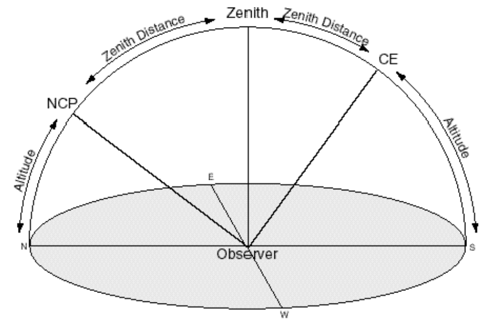


You will recall that the altitude of the NCP is merely the angular distance of the NCP above the north point on the horizon, starting with 0° and counting upward. Estimate from the diagram what the altitude of the NCP is, as drawn above. It appears somewhat less than halfway up, so 40° is a reasonable guess. If we wanted to know precisely, we could use a protractor, centered on the observer, to measure the altitude angle.

Now estimate the altitude of the CE above the south point on the horizon. Similarly, it is a little *more* than halfway up. How about 50° as a rough estimate? We will indicate the altitude angles with arcs, as shown to the right.



Zenith distance (ZD) is what it sounds like: the angular distance between the zenith and the object. The zenith distance of the NCP, in the above example, is a little more than halfway between the zenith and horizon, or about 50°. Similarly, the zenith distance of the CE, along the meridian, is somewhat less than half of 90°, or about 40°.



Notice also that the altitude of an object and the zenith distance of that object are complementary, that is, they add to 90°. So the altitude of NCP + zenith distance of NCP = 90°. You can also see that the altitude of the CE + zenith distance of CE = 90°.

By studying the diagram at right, you should be able to convince yourself of two other similar relationships: The zenith distance of the NCP + zenith distance of CE = 90°, and the altitude of NCP + altitude of CE = 90°.

There are other equivalencies to take note of. The NCP's altitude is equal to what other angle in the diagram? Answer: the zenith distance of the CE. What angle is equal to the zenith distance of the NCP? Answer: the altitude of the CE.

The bottom line: given any one of the four angles — alt of NCP, ZD of NCP, ZD of CE, or alt of CE — you should be able to determine the other three.

By now you may wonder what all of this has to do with latitude. It turns out that the altitude of the NCP as seen from a given location on Earth is equal to the latitude of that place. For example, the latitude of East Lansing is about 43°. Therefore, if you go out some night and measure the altitude of Polaris above the north point on the horizon, you should expect it to be 43° (assuming you have equipment to measure that accurately). We'll demonstrate this equivalency of the NCP's altitude and latitude in the planetarium but if you want to think it through a bit, imagine where the NCP would appear if you were standing on the North Pole (latitude 90°). Then imagine where the NCP would be when standing on the Earth's equator.

Furthermore, because of the interrelationships of the angles described above, if you know any of the four angles, you can determine your latitude. If you want or need to know your latitude on Earth, this is a powerful bit of information. To early sailors, for example, determining latitude could literally mean the difference between life and death.

Consequently, early navigators got clever at finding ways to measure these different angles. Initially, they created simple tools to reliably measure the altitude of Polaris. That was fine at night, but what if they wanted to make daytime measurements? They measured the altitude of the sun as it transited. How does the sun's altitude figure into the four angles diagrammed above? Here's a quick example. You will remember from earlier work in this class that on March 21 the sun's declination is 0°. That means it sits on the CE. So on that date, the altitude of the sun is also the altitude of the CE, and, therefore, you can use the relationships of the angles discussed above to determine the latitude.

We'll discuss an extension of this approach during the next class, but for now, get comfortable with finding latitude, given one of the four angles: altitude of NCP, altitude of CE, zenith distance of NCP, zenith distance of CE. An example, the altitude of a star on the celestial equator is measured to be 35° as it transits. What is the observer's latitude? (Try this problem first. If you get stuck, the answer is at the bottom of the page.)

There will be a five-question quiz on this material at the beginning of the next class, October 31.

(Ans: Latitude is 55°. Lat = Alt NCP, Alt NCP + Alt CE =90°, therefore Lat = 90° - Alt CE.)