03 - The Night Sky Project - Positions & Motions

Human Coordinates

The star maps in The Trained Sky Star Atlas show the celestial sphere from the inside, but in celestial coordinates, not the coordinate system we mortals live in. After all, when was the last time your head pointed north? Unless you're an astronaut or an Eskimo, the answer is never. We live in *human coordinate systems* where our heads point *up* not north. Still we constantly confound both coordinate systems by using phrases like "up north" and "down south" and our eternal habituation to hold maps north side up even when looking south. If you go outside and hold The Trained Sky Star Atlas north side up, it won't guide you through the stars. Only when you hold The Trained Sky Star Atlas in celestial coordinates does it work. Not as onerous a task as you now think if you just approach it with the right slant.

Your *human coordinate system* starts with *up*, something you've learned intuitively by age one in standing up and falling down — otherwise known as discovering gravity. The Earth's gravity defines which direction your head points in the universe. That point straight overhead is your *zenith*, and the point straight underfoot is your *nadir*. From these two fundamental points, you can define the rest of your human coordinate system. That's right, your very own coordinate system, for nobody else on the Earth has the same zenith and nadir as you. From zenith and nadir, you can now define up and down.

Point a finger at your nadir (feet). Swing your arm from your nadir to your zenith (overhead) and it moves *up.* Swing your arm from your zenith to your nadir and it moves *down.* Now point your finger halfway between your zenith and nadir and spin around in a circle. Your finger sweeps out a circle about you called your *horizon*. Notice that your horizon lies halfway between your zenith and nadir, not where the sky meets the ground (fall into a well and the sky meets the ground near your zenith, not at your horizon). Up and down give directions between zenith and nadir but what about directions around the horizon?

The two remaining directions in your human coordinate system, *left* and *right*, are not so intuitive. To define them, we have to rely on something else, so take your watch off and place it on the ground at your nadir. Point a finger outwards at your horizon and watch your watch. As you turn *clockwise*, your finger will swing around your horizon to the *right*. Turn *counterclockwise* and your finger swings around your horizon to the *left*.

The horizon also gives the official name to your human coordinate system; the *horizon coordinate system*. It shall remain human coordinate system in this book. You can finish your human coordinate system by defining coordinates and giving them names and measures. The *altitude* coordinate measures the distance, in degrees (°), arc-minutes ('), arc-seconds(") up or down from your horizon. Altitude starts from zero at your horizon and goes up to +90 ° at your zenith or down to -90 ° at your nadir. It's coordinate pair *azimuth* measures the distance rightward around your horizon in degrees (°), arc-minutes ('), arc-seconds("). Azimuth starts at *zero* degrees from a magic point on your horizon called the *north point* and increases rightward around the horizon *360* ° back to where you started from. What, however, is the north point?

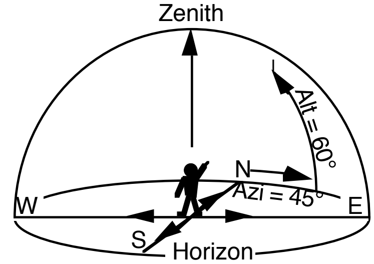

Figure 2-1

Look north from where you stand (that's Earth north like on a compass or a road map). The Earth's surface curves down away from you, so you can't see all the way to the north pole.

Where your gaze dead-ends at the horizon is your *north point*, the furthest point north you can see (Figure 2-1). Look to the right of your north point for your *east point* at an azimuth of 90 °. Another 90 ° further brings you to the *south point* at an azimuth of 180 °. Swing just 90 more degrees on around and there's your *west point* at azimuth 270. Look at a compass and you'll see all these points engraved right on it.

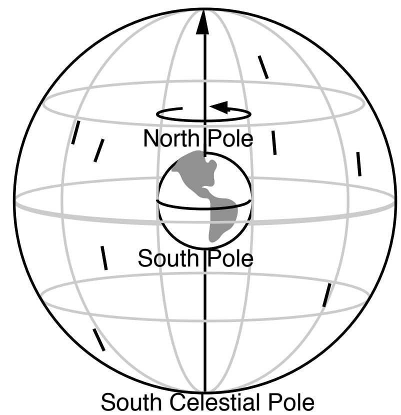

Figure 2-3

Using the coordinate pair altitude and azimuth you can pinpoint the location of any object in the little piece of the universe that extends from the earth at your feet above the horizon to infinity overhead. Your human coordinate system provides the framework within which your mind structures the universe. Without a structure, you cannot interpret what your eyes see. Objects are indistinguishable, for they are all just "out there." Without the structure of positions and directions provided by your human coordinate system, you would be paralyzed. Which direction do you move? Where do you reach?

By Any Other Name

Reach for the stars if you know where. Although the human and celestial coordinate systems seem very different they are structurally identical (Table 2-1). Both coordinate systems are *spherical coordinate systems* (maps of spheres) and both map the same sphere (the sky). Each system has two fundamental points, one great circle halfway between the fundamental points, four directions and two coordinates. The fundamental difference is how the Earth defines the fundamental points; the Earth's rotation defines north and south celestial poles, the Earth's gravity defines zenith and nadir.

Table 2-1: Coordinate Systems Structures

Structure	Celestial	Human
fundamental points	north celestial pole south celestial pole	zenith nadir
defined by earth's	rotation	gravity
great circle	celestial equator	horizon
directions	North South East West	up down left right
coordinates	declination right ascension	altitude azimuth

When a sphere like the Earth spins, everything moves except two special points (Figure 2-3). Call these two points *poles* and name one the *north pole* and the other the *south pole* to avoid confusion. These poles originate the *terrestrial* (Earthly) *coordinates* of *north pole, south pole, equator, latitude, longitude, north, south, east* and *west* as we normally use them on the Earth, not the celestial sphere. The north celestial pole is that point on the celestial sphere directly over the north pole of the Earth, and the south celestial pole is directly under the south pole.

Gravity defines your zenith and hence all your human coordinate system except for the north point. That requires the Earthly direction north (defined by the Earth's rotation). So your human coordinate system depends upon the Earth's rotation, as does the celestial coordinate system — both systems are tied to the Earth. The Earth provides the bridge from one to the other. Referring back to the issue that started this chapter; how do you hold up The Trained Sky Star Atlas? You should really ask: "How do I transform the celestial coordinate system into my human coordinate system?"

Between Heaven and Earth

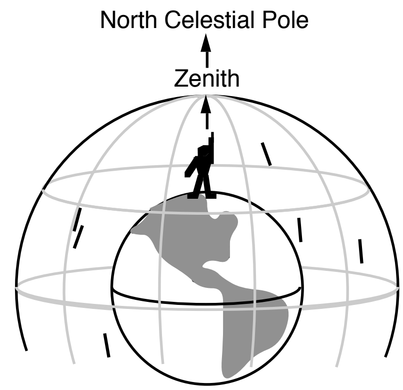

Figure 2-4

The best place to start is where both coordinate systems look the same, so put on your parka and start walking to the north pole. At the north pole, the Earth's gravity aligns you perfectly with the Earth's rotation axis (since you're standing right on top of it). The north celestial pole is directly over the Earth's north pole at your zenith, the celestial equator lies at the horizon. Here and here alone directions in celestial coordinates match common sense: up is north, down is south, right is west, left is east (Figure 2-4). Common sense also cautions you about frostbite, so start hiking south but walking backwards so you can keep an eye on the zenith and north celestial pole.

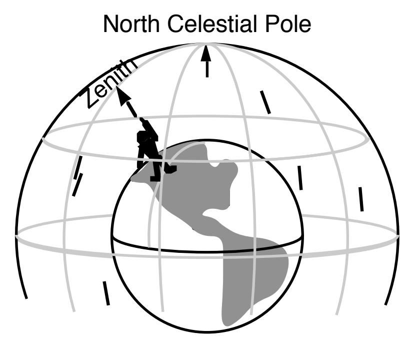

Figure 2-5

One step south and the north celestial pole no longer hovers at your zenith since you no longer align with the Earth's rotation (Figure 2-5). The further you hike back over the curve of the Earth, the further your head tilts away from the north celestial pole. However, being human and thinking the universe revolves around you, you perceive the celestial pole as tilting away from your zenith.

Look over your shoulder in the direction you're walking and you'll see the celestial equator tilting upward just as fast as the north celestial pole drops. Look to the west and you'll see the celestial equator pivoting clockwise around the point where it touches the horizon. When you're two thirds of the way back to the Earth's equator (at latitude 30°), stop to take off your parka and look around to orient yourself (Figure 2-6). Back north, where your footprints fade away into the distance, the north celestial pole has dropped 60 ° down from the zenith to just 30 ° above the horizon (Figure 2-6a). An interesting coincidence by the way, you can determine your latitude by measuring the altitude of the north celestial pole. Off to the west and east, the celestial equator tilts up at a 60 ° angle from the horizon. Although the celestial sphere has tilted, it has not distorted (Figure 2-6b).

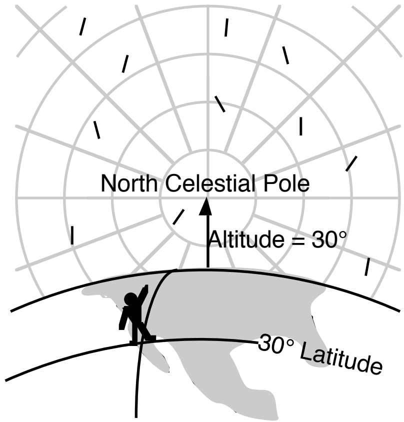

Figure 2-6a

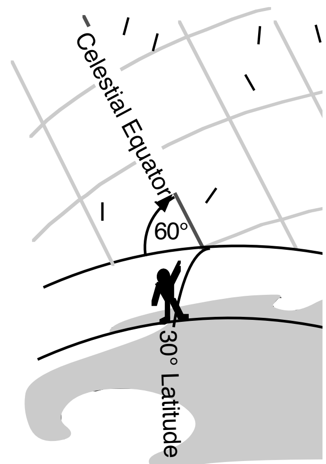

Figure 2-6b