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# Chasing the Pole — Howard L. Cohen

*Polaris like supernal beacon burns, a pivot-gem amid our star-lit Dome*

*~ Charles Never Holmes (1916)*

**New star gazers often believe the North Star (*Polaris*) is brightest of all, even mistaking Venus for this best known star.** More advanced star gazers soon learn dozens of nighttime gems appear brighter, forty-seven in fact. Polaris only shines at magnitude +2.0 and can even be difficult to see in light polluted skies. On the other hand, *Sirius*, brightest of all nighttime stars (at magnitude -1.4), shines twenty-five times brighter!

Beginning star gazers also often believe this guidepost star faithfully defines the direction north. Although other stars staunchly circle the heavens during night's darkness, many think this pole star remains steadfast in its position always marking a fixed point on the sky. Indeed, a popular and often used Shakespeare quote (from *Julius Caesar*) is in tune with this perception:

*"I am constant as the northern star,*
*Of whose true-fix'd and resting quality*
*There is no fellow in the firmament."*

More advanced star gazers know better, that the "true-fix'd and resting quality"of the northern star is only an approximation. Not only does this north star slowly circle the northen heavenly pole (Fig. 1) but this famous star is also not quite constant in light, slightly varying about 0.03 magnitudes. Polaris, in fact, is the brightest appearing Cepheid variable, a type of pulsating star.

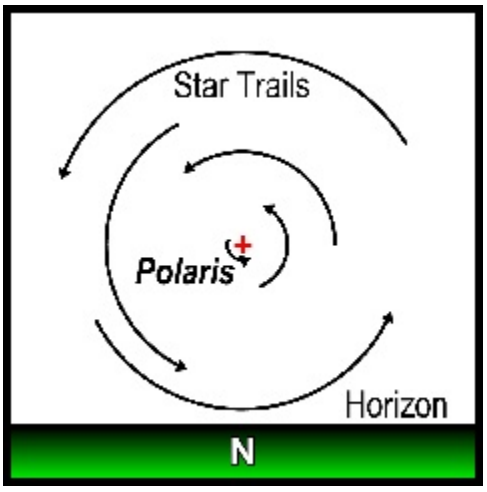


**Fig. 1. Circumpolar Star Trails.** All stars circle the pole (plus mark) including Polaris. The small circle traced by the pole star may make it seem like Polaris does not move.

Still, Polaris is a good marker of the north cardinal point. Pointing the polar axis of an equatorial driven telescope mount at Polaris will allow celestial objects to remain visible for many minutes using moderate power eyepieces. However, following stars and planets more precisely requires adjusting the polar axis for the deviation of Polaris from the true north celestial pole. Of course, one can adjust or "polar align" modern portable astronomical mounts with their "GoTo" capabilities and several alignment stars. Yet equatorial mounts with an auxiliary polar sighting telescope can also do an excellent and quick job of accurately aligning the mount's polar axis. This method allows one to correct for the difference between the position of Polaris and the north celestial pole. Nevertheless, just how far is the North Star from the north celestial pole?

## Polaris the Star—Some Basics

Since Polaris is so widely known, the literature is filled with an abundance of information about this north pointing star, especially about its interesting physical characteristics. In fact, this star goes by at least three dozen monikers including Alpha Ursae Minoris Aa (abbreviation Alf or α UMi Aa), One UMi Aa (1 UMi Aa), the "Lodestar" (rarely used) and dozens of catalog designations as HD 8890, SAO 308 and ADS 1477 A. This last name indicates this star is double by its inclusion in ***A**itken's New General Catalog of **D**ouble **S**tars (1932)*.

In fact, did you know Polaris has an eighth magnitude companion, Alf UMi B, 18 arc seconds away? This star may have an orbit about Polaris that requires tens of thousands of years to complete once. (This dim star was first seen by William Herschel in 1780.) Try observing this faint double even if you only have a two or three-inch aperture telescope. This star has even been seen with apertures less than two inches (Hirshfeld and Sinnott 1985).

Note: An *arc second* (arc sec or ") is 1/3600 of a degree and an *arc minute* (arc min or ') is 1/60 of a degree. A quarter (25 cents) viewed from 3.1 miles would look one arc sec wide!

Polaris is also designated **SBC9** denoting inclusion in the ***9th S**pectroscopic **B**inary **C**atalog*. Another companion, Alf UMi Ab (about 0.2" away), orbits much closer, approximately 20 astronomical units from Polaris in a highly eccentric orbit requiring about 30 years for one revolution. Since an *astronomical unit* is effectively the Earth's mean distance from the Sun, this makes this star's orbit similar in size to the orbit of Uranus (but much more noncircular). The Hubble Space Telescope finally imaged this third star a few years ago (Hupp et al. 2006).

Interestingly, all three stars in this triple system have similar principle spectral classes (Type F) showing they are all slightly hotter than the Sun. Polaris, however, is a supergiant or bright giant star, about 2,400 times more luminous than the Sun and 45 times larger in diameter, but much more evolved. It is passing through a stage of instability probably having exhausted most of its core hydrogen fuel.

This type of instability marks Polaris as a Cepheid variable, the closest known, approximately 130 parsecs or 430 light years away. Some astronomers think Polaris could be closer, only about 300 light years away. (If so, this star is less luminous than previously believed.) Polaris rhythmically shrinks and swells changing its luminosity about 2 percent over 4.0 days. Recent studies suggest, however, that this star's luminosity varied more strongly a century ago (15 percent) while its overall brightness has increased 15 percent. Meanwhile, its period may be decreasing eight seconds per year. In addition, historic records suggest Polaris may have been 2-1/2 times fainter looking (one magnitude) 2000 years ago (Irion 2004). Our North Star may not be brightest in our sky but it may be even more fascinating and odd than previously thought—and more inconstant!

## How Far the Pole?

However, we are drifting from our main point, how far the pole? According to Meeus (1997), Polaris is currently (epoch 2010.0) at a mean declination of +89°18'25". (*Declination* is like latitude on the Earth, but a measure of how far from the *celestial equator*.) This puts Polaris 2,495 arc seconds (41'35" or about 0.693 degrees) from the celestial pole.

Since the angular diameter of the Moon is about one half degree, about 1.4 “moons” can fit between Polaris and the north celestial pole. Thus, during a celestial day (23h56m), Polaris circles the pole staying about 0.7 degrees away from “true north” (Fig. 2). Only when the North Star is directly above or below the celestial pole as it crosses the *celestial meridian* (called *upper* and *lower transit* respectively), is Polaris accurately north. Figure 2 also shows the celestial meridian is an imaginary vertical circle to the horizon passing through the celestial pole and the *zenith*, or over head point. Its intersection with the horizon defines the north cardinal point.

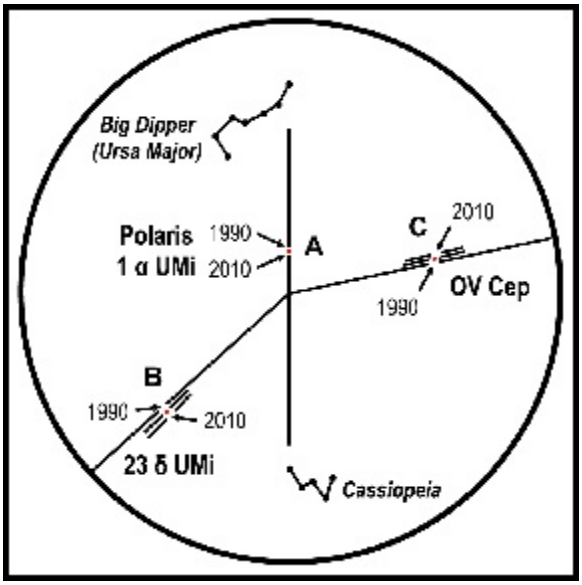


**Fig. 3. Polar Aligning Reticle.** Engraved reticles like this can be used to quickly and accurately align the polar axis of an equatorial telescope mount that has a polar alignment finder. See text for instructions.

## Polar Alignment Reticles

Equatorial mounts with a polar alignment telescope can easily and quickly adjust for Polaris not being true north by using an appropriately engraved *reticle* (pattern) in the alignment telescope’s eyepieces. (See Figure 3.) The procedure is simple and straightforward:

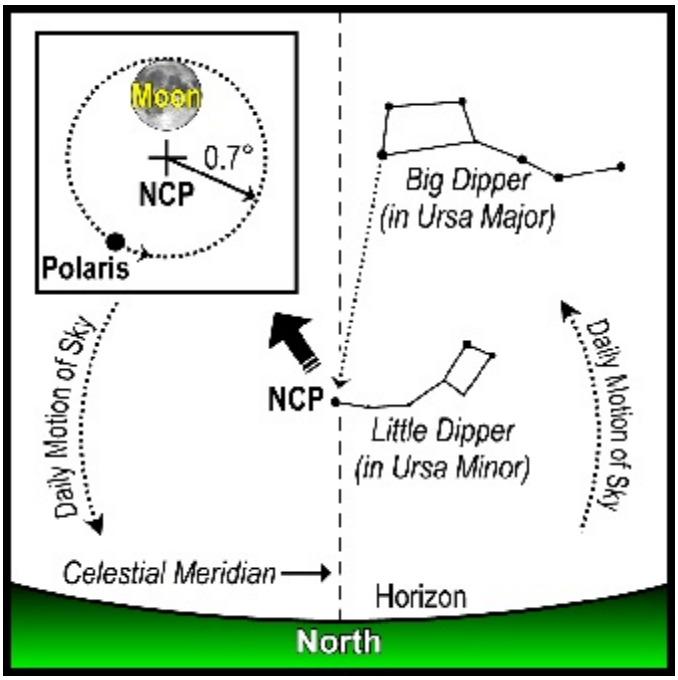


**Fig. 2. Polaris and the North Celestial Pole (NCP).** The pole star is currently about 0.7° from the NCP, which it circles in a celestial day. Nearly 1-1/2 full moons can presently fit between Polaris and the NCP. (See inset.)

1. Approximately center Polaris in the alignment scope by moving the mount.
2. Rotate the alignment scope’s reticle eyepiece so the Big Dipper (an asterism in *Ursa Major*) or *Cassiopeia* is oriented as seen on the sky.

   (Neither constellation will probably appear in the alignment scope’s narrow viewing field.)
3. Place Polaris in gap A using the mount’s fine azimuth and altitude adjustments.
4. Fine-tune the rotation of the reticle and again adjust the mount in azimuth and altitude to place 23 Delta UMi (mag. +4.3) simultaneously in gap B.

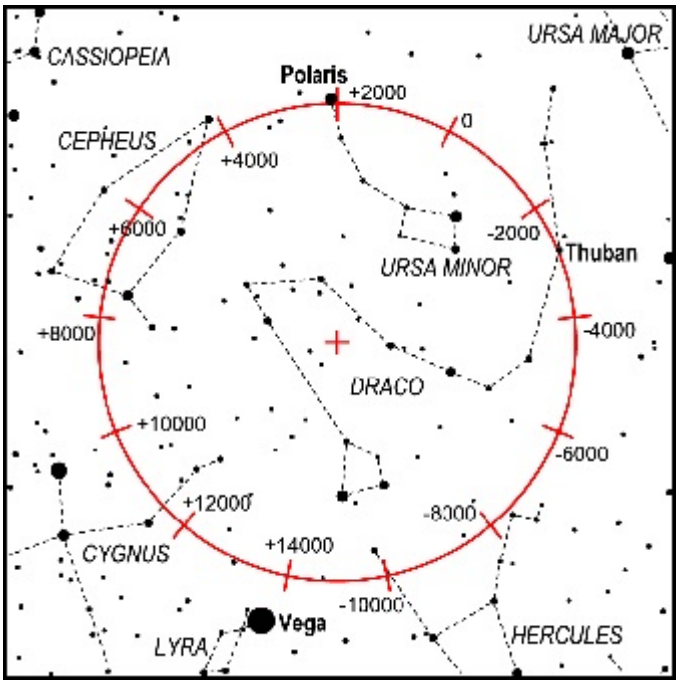


**Fig. 5. The Precessional Circle About the North Ecliptic Pole.** The North Celestial Pole (NCP) circles the North Ecliptic Pole (plus mark in center). Positions of the NCP (graduated circle) are shown against northern constellations at 2000 year intervals. Alpha UMi (Polaris) is presently the closest bright star to the North Celestial Pole.

5. Similarly, for greater accuracy, simultaneously place OV Cephei in gap C if this star is visible.

   (This star may not be visible since its magnitude is +5.1.)

Notes on the Alignment Reticle:

A. The positions of the three stars in the gaps depend on the year. (More on this below.) For example, the three lines at each gap in Figure 3 show positions for the years 1990, 2000 and 2010.

B. Questions and confusion have arisen about the identification of the star designated OV Cephei (Cep) in Figure 3. Some instructions describing this procedure name this star 51 Cep. This is a *Flamsteed designation* for this star. (The eighteenth century astronomer John Flamsteed catalogued stars by numbers.) Although Flamsteed numbers are still commonly used, this is an uncommon, historical designation for this star. Better to use OV Cep. This type of nomenclature using preceding letters before the constellation name shows the star is variable. However, OV Cep varies only a few hundredths of a magnitude.

C. Alignment reticles usually have adjustment lines for use in the Southern Hemisphere but are omitted in Figure 3 for clarity.

## Precession or Where is Polaris Now?

Figure 3 shows different places for positioning the stars in the reticle because the phenomenon known as *precession* (or *precession of the equinoxes*) causes the locations of stars to change with respect to the celestial poles. Briefly, precession is a slow gyration of Earth's axis around the pole of the *ecliptic* (Sun's apparent path on the sky). See Figure 4. The cause of precession is primarily the gravitational pull of the Sun, Moon and other planets on Earth's equatorial bulge. Precession causes the position of the north celestial pole to circle the *north ecliptic pole* about every 26,000 years (Fig. 5).

Fortunately, we are in a period when a reasonably bright star (Polaris) is very close to the north celestial pole (Fig. 5). In fact, the gap between Polaris and the pole is closing with a minimum distance reached in 92 years, on February 2102 (Fig. 6). Then, Polaris will be less than one half degree (1,657 arc sec or 27'37") from the celestial pole (Meeus 1997). This is a separation just a bit less than the Moon's angular diameter.

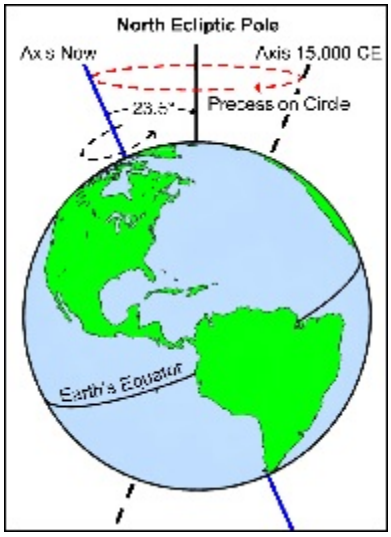


**Fig. 4. Precession of Earth's Axis.** The Earth's rotation axis slowly changes its direction with a period of about 26,000 years. This causes the position of the North Celestial Pole to change relative to the stars. The Earth's axis will have shifted about 180° by the year 15,000 as shown.

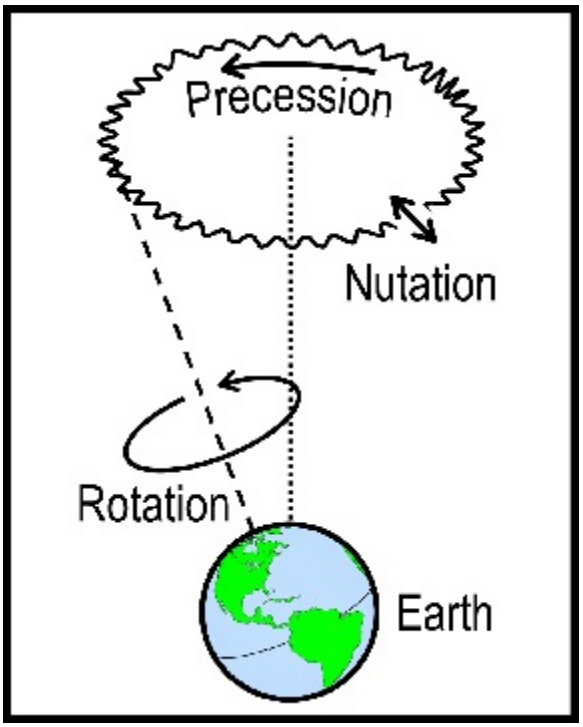


**Fig. 7. Nutation.** The Earth's poles precess with a slight "nodding motion" called nutation with a principal period of almost 19 years.

Not only will the declination of Polaris and therefore its polar distance slowly change over the coming years but this star's right ascension will also change. (*Right ascension* is like longitude on Earth showing the star's position east of the *vernal equinox*.) However, the small polar distance of Polaris is causing precession to produce a **very rapid increase** in right ascension. Polaris is now (2010.0) 2h43m42s east of the vernal equinox but by 2100.00 will be 5h53m29s east (Meeus 1997).

After the year 2102, Polaris will increase its distance from the celestial pole. Use Figure 5 to decide when Polaris should lose its designation as the pole star. And, which star should next be designated "Polaris"?

What about a "south polar star"? I will leave that to readers to investigate and submit articles on the southern stars.

Finally, to complicate matters, precession is not pretty. As the pole precesses it does so with a slight irregular motion or "nodding" called *nutation* with an amplitude of 9 arc sec and a period of 18.6 years. See Figure 7. This effect and the *aberration of light* due to the orbital motion of the Earth around the Sun, changes the mean position of celestial objects by a small amount. So, at any given moment, the actual (*apparent*) positions of stars deviate slightly from their mean positions for that year.

For the perfectionist, the least apparent polar distance of Polaris will occur nearly two years before its least mean polar distance—on 2100 March 24 with a value of 27'09" (Meeus 1997).

As usual, mark your calendars. ¤

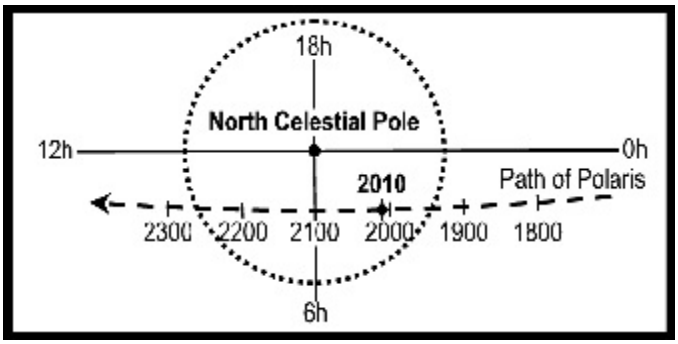


**Fig. 6. The Wandering Celestial Pole.** The path of Polaris with respect to the North Celestial Pole is shown at 100 year intervals. Actually it is the Pole that moves with respect to the "pole star." The circle has a radius of one degree. Lines of Right Ascension (similar to longitude on Earth) are drawn at 0, 6, 12 and 18 hours. The current position (2010) is also marked. Polaris will be closest to the pole in about 90 years. (Diagram adapted from Meeus 1997.)

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