Astronomy of the Northern Sky - Star Colors and Spectral Types

- Larry Krumenaker

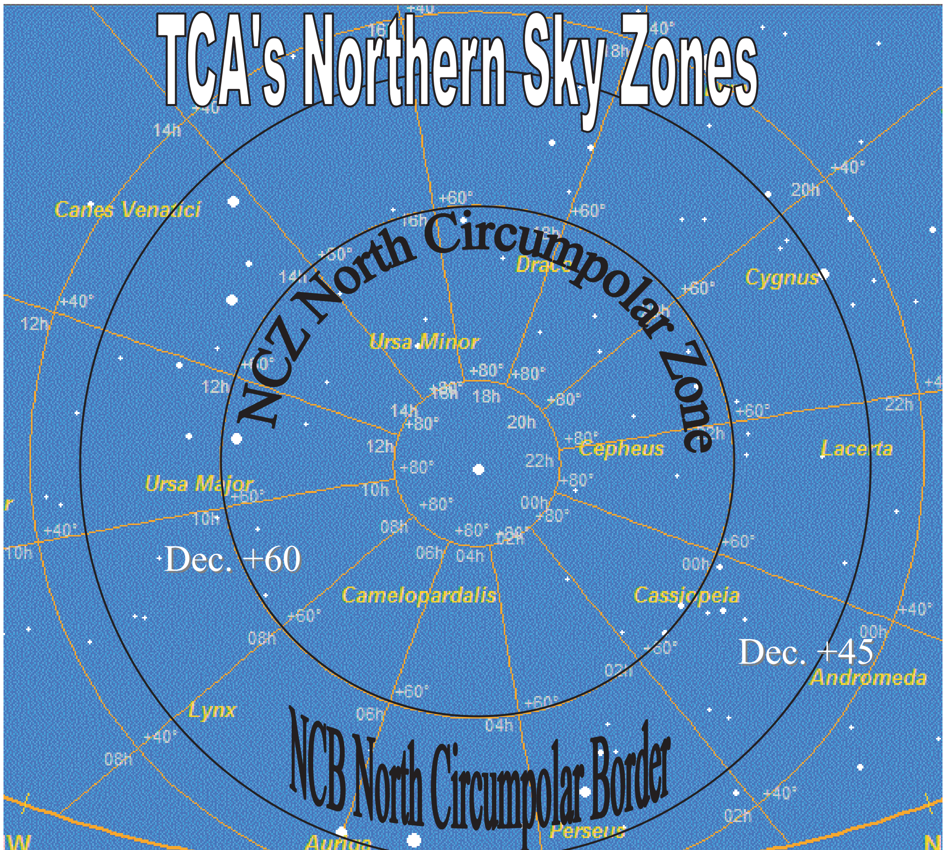


Figure 1. *TCA*'s definition of Northern Sky areas.

This article continues *TCA*'s new series "Astronomy of The Northern Sky," where we will point out a number of objects to teach certain astronomy concepts year round. This issue we look at star colors and stellar spectra. Let us remind ourselves what part of the northern sky we are talking about!

For our series we define the North Circumpolar Zone (NCZ) as all those objects found between declinations +60 to +90 (see Figure 1, to the left). The outlying area of declinations +45 to +60 we will call the North Circumpolar Border (NCB). These limits come from what stars are always circumpolar, whether you are in northern Europe or on the US-Mexico border. The outer limit is set by the northern limit of our readers' locations and these stars are circumpolar for them, the other limit is set at no more than half a sky, but not circumpolar for the more southerly observers.

Subtle and Important

Color is subtle. It is caused by the temperature of a star's surface. But it is hard to see for two reasons. First, our eyes are not good at detecting color in faint light. Things have to be bright in order for the cones in our eyes that detect color to activate a signal to the brain. Stars are usually not bright enough . Second, despite the nice renderings on star charts and astronomy books, star colors are just not so blatant. Even our Sun, usually drawn a brilliant yellow, is actually a pale shade of yellow.

What we'd like to show are star colors as seen mostly through binoculars or small telescopes. Actually, a really good way to show star colors is through photography, especially film photography. Slightly defocus the camera and the colors saturate the film and become quite obvious.

Knowing colors gives the student at least the chance of knowing a star's temperature and we do this through the spectral classes of the stars. The usual sequence, from hot blue/white stars to the coolest stars of red, is with the letters, in order, O, B, A, F, G, K, M. While the rickety and chauvinistic old mnemonic about kissing is often used, I have my students create acronyms of their own.

Star colors are also traditionally quantified with the B-V color index. "B", here, is not the spectral class but the brightness of the star measured in a segment of the blue part of the spectrum, the part that most matched the original blue-light sensitive photographic plates and, later, a blue photoelectric measurement. "V is centered on the part of the spectrum most matching the peak color sensitivity of the eye, hence "V" stands for Visual. Blue stars will have zero or negative values, red stars will have B-V $\geq$ +1.

It will be a policy of this column that the brighter the star for a characteristic, the greater prominence we will give it, as ease of locating the object is paramount for school students. Additionally, in this case, the brighter the star, the more likely the star color will be seen. Among the more than 300 stars brighter than ~magnitude 3.5, those found in the northern sky fall into all the major spectral classes except the hottest and coolest, the O's and M's. (Our source for this is the list of Brightest Stars in the Royal Astronomcial Society of Canada's *Observer's Handbook*.) Thus, we will not have the most blue-white or most reddish stars. That's nature for you.

Pedagogically, people learn different ways. Let's present this material in three ways: those stars that are the brightest representatives of each broad class, those closest to the North Celestial Pole (in the NCZ), and those constellations that have all the different classes close at hand in easy to find configurations (great for side by side comparisons!).

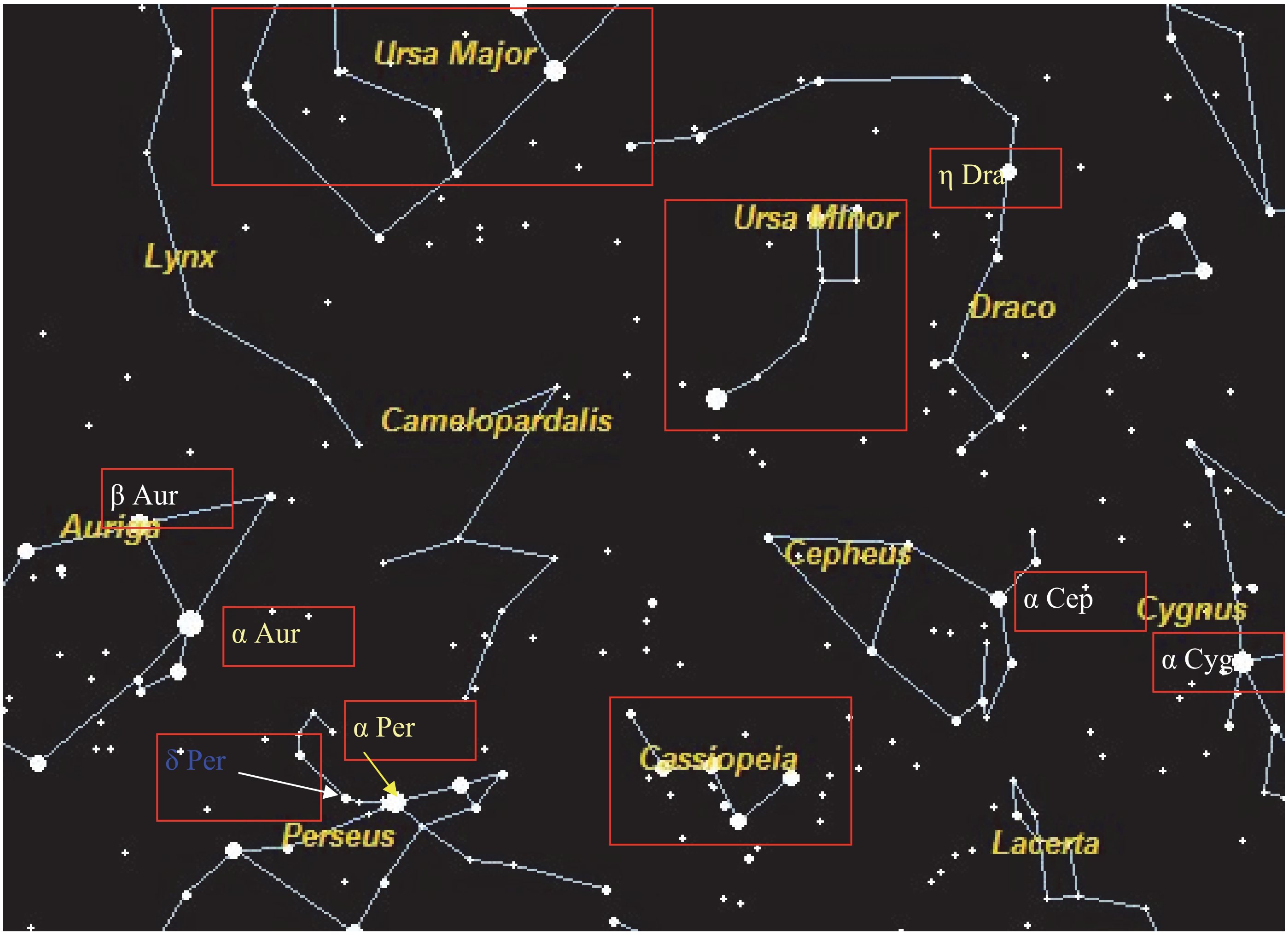


Figure 2. Finding chart for individual stars and constellations with good representatives of the major spectral classifications.

It's Greek To You?

Bayer designation is one of the oldest ways of naming stars. It uses a Greek letter plus the constellation's genitive form, e.g. α Ursa Majoris. Thus the brightest one should be Alpha, the second brightest Beta, and so on. The system isn't perfect, sometimes the names are out of order and sometimes you can have a bunch of stars with the same letter, distinguished by numbers, i.e. ζ^1, ζ^2, etc. and actually listed in positional order.

Below are the Greek letters we'll be using in the article:

Alpha α
Beta β
Gamma γ
Delta δ
Epsilon ε
Zeta ζ
Eta η
Iota ι

These are the abbreviations for the constellations mentioned:

UMa Ursa Major
UMi Ursa Minor
Cyg Cygnus
Aur Auriga
Per Perseus
Dra Draco
Cas Cassiopeia
Cep Cepheus

Best Of Class!

B	η UMa (end of the Big Dipper's handle)
A	α Cyg (Deneb)
	(alternative for winter — β Aur)
F	α Per
G	α Aur (Capella)
K	α UMa (Front top of Big Dipper's bowl)

Brightest Representatives

As stated, if it is brighter, the eye may have an easier time to see the colors. If your eye can't do it alone, use binoculars, and maybe defocus the light beam very slightly so the stars appear as tiny disks, not large ones!

The brightest stars are those generically called first magnitude stars. Our technical definition is those stars brighter than magnitude 1.99.

In The Zone

One advantage (sometimes!) of choosing to use stars close to Polaris is that they all will have about the same altitude above the horizon, give or take. This allows us to ignore the fact that the lower the star's altitude the slightly more redder the air will make it and also the fainter it will be because of extinction, the dimming of light as it goes through more air.

The brightest ones in the NCZ aren't necessarily the brightest overall, just merely the brightest representatives that are generally always up in the sky. It helps that the brightest of the F stars in the NCZ is the pole star, Polaris! Easy to find!

Brightest in the Zone

B	δ Per
A	α Cep
F	α UMi
G	η Dra
K	α UMa

Clearly, the best time of year to use this method is during the late winter/early spring months, when all of them are visible, but as this is also the time to see the best constellations of the sky (in many persons' opinions), Orion and company, this is not a bad thing at all! Perseus and Cepheus will be in the western side, Alpha Ursa Majoris in the northeast and Eta Draconis is very low in the northeast and below and to the right of Polaris.

Side By Side Color

The three most prominent North circumpolar constellations are also three places where you can find nearly complete sets of the five spectral classes' representatives and close enough to each other that

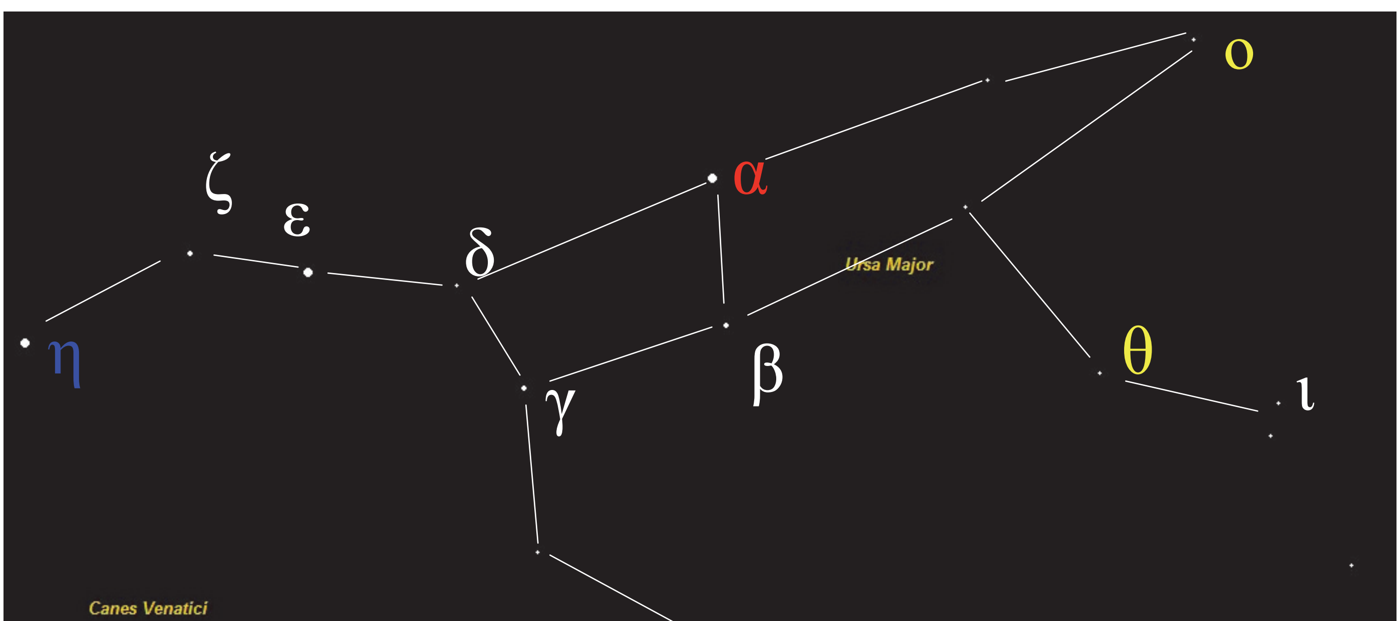
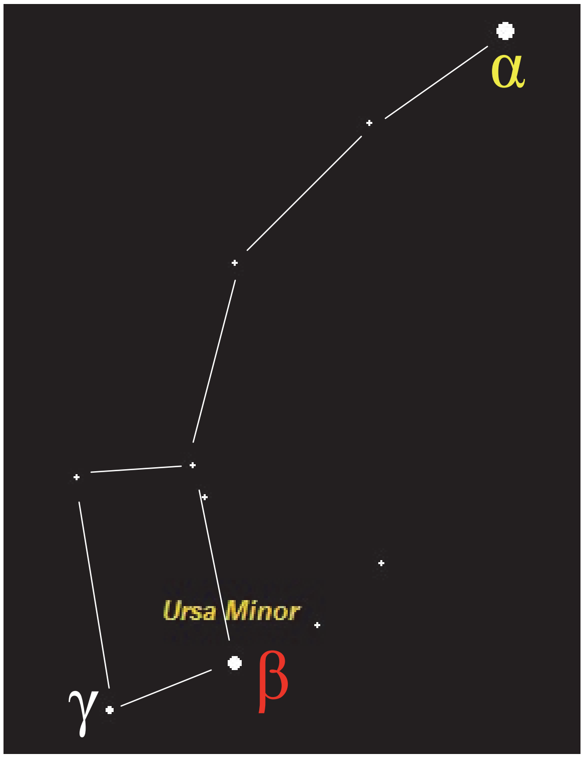


Figure 3. Ursa Major, with its Big Dipper, is the first of three good northern constellations to find stars of various spectral types, side by side.



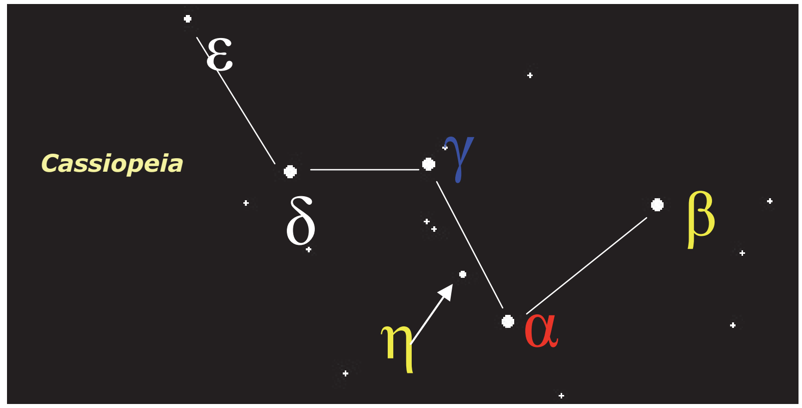


Figure 4 (left) shows Ursa Minor's brightest stars and their star colors; Figure 5 (above) does the same for Cassiopeia's stars.

one can easily zip back and forth between them and see the subtle color differences. These constellations are Ursa Minor in the middle, Cassiopeia on one side, and Ursa Major on the other side.

Ursa Major, when not underneath Polaris, may be the best side-by-side grouping (Figure 3 previous page). In fact, most of the stars of the Dipper actually are traveling together in space, an association rather than a star cluster. There are other members of this group around the rest of the sky. The end stars of the chain that make the Dipper, from front bowl-tip to end of the handle, are very much at opposite ends of the color spectrum and, in fact, do not belong to the group of stars but are traveling separately in different directions from the rest.

Eta is a B star and Alpha a K star; all the other Dipper stars are various types of A stars. Iota, Theta and Omicron, in the Great Bear's nose and front leg, are a A7, F6 and G5 stars (paler white and two shades of yellow).

Ursa Minor, on the other hand, is convenient all year long! It's dim but its three brightest stars are often visible even in light-polluted environments. Alpha (Polaris) is slightly variable in spectrum as well as brightness, ranging from F5 to F8. The second brightest star, in the Little Dipper's bowl, Kochab, is redder, K4. Dimmest of the three, Gamma, also in the bowl, is white, A3 (Figure 4).

The classical Queen of the night, Cassiopeia, usually described as an M, an W, a "3" or an "E" because of its five main stars' layout, serves for when Ursa Major is not convenient (Figure 5). It isn't quite a neat progression of hotter stars to cooler stars as we travel from one end of the five segments to the other. But the blue and white stars are all on the center and left half of the "W" and the cooler yellow and reddish ones are all on the right half. (Eta is the only star not on a traditional line segment, but rather about half way between Alpha and Gamma).

Quantitatively Observing

The B-V color indices of these various stars average out into a nice sequence for those who want numbers. Still it is clearly also notable that one A0 star may not have the same color index as another. This is so for two reasons. First, there is some natural variation. Second, some stars will be redder because there is intervening dust between us and the star. This is most noticeable when the star is in the Milky Way star fields, where most dust will be found. This would certainly be an effect for stars in Perseus, Cassiopeia and Cygnus.

Still, at this level of color-detecting abilities, the averages are sufficient. TCA

Spectral Types Color Indices

Type	Range	Average
B	~0 to -.20	-0.1
A	Early types A0-~A5	0.0
	Late types A7-A9	+0.2
F	.4 to .6	0.5
G	.6 to 1.0	0.8
K	widely variable	1.2