

Stars - their place in a Skyscape



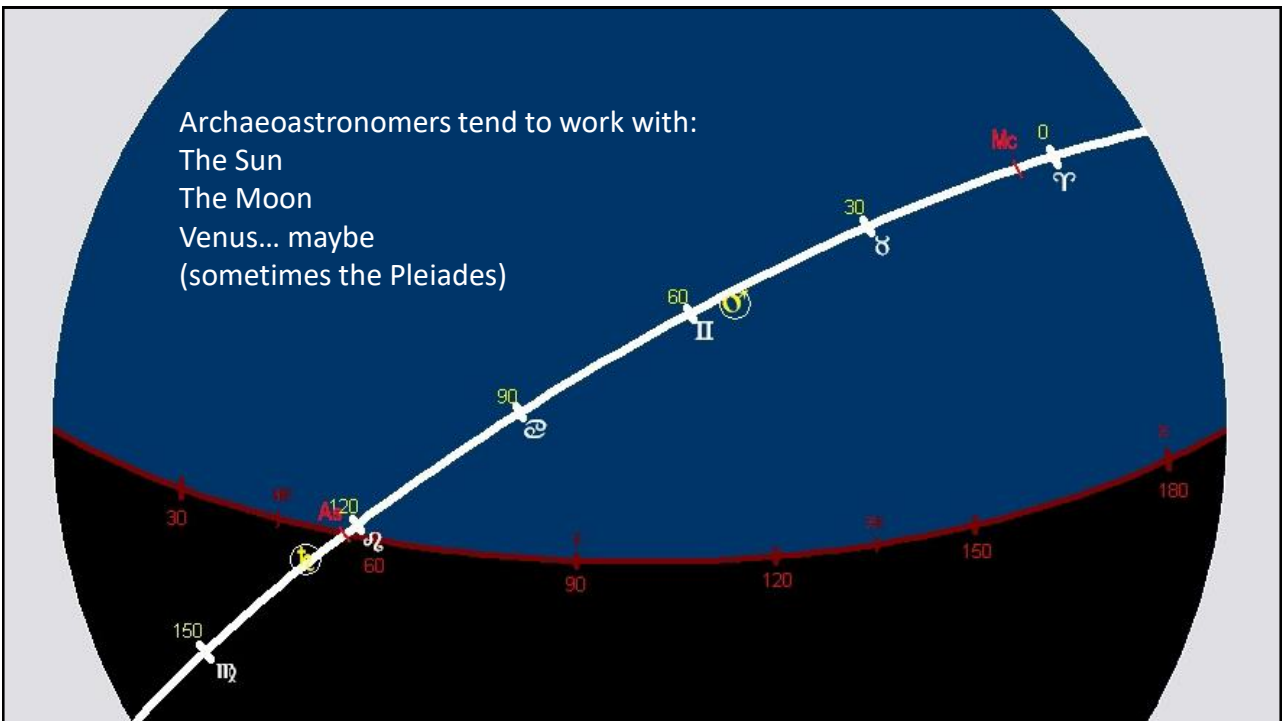
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- Skyscapes Module
- MA in Cultural Astronomy and Astrology



1

Archaeoastronomers tend to work with:
The Sun
The Moon
Venus... maybe
(sometimes the Pleiades)



2

Why are the other 99.99% of heavenly objects ignored?

Some common arguments:

- They are not as bright.
- There are so many stars that one can make a case for any star at any location.
- They are subject to precession so it is hard to really know how they are located in the skyscape.
- A general confusion of terms used to talk about how the stars move.



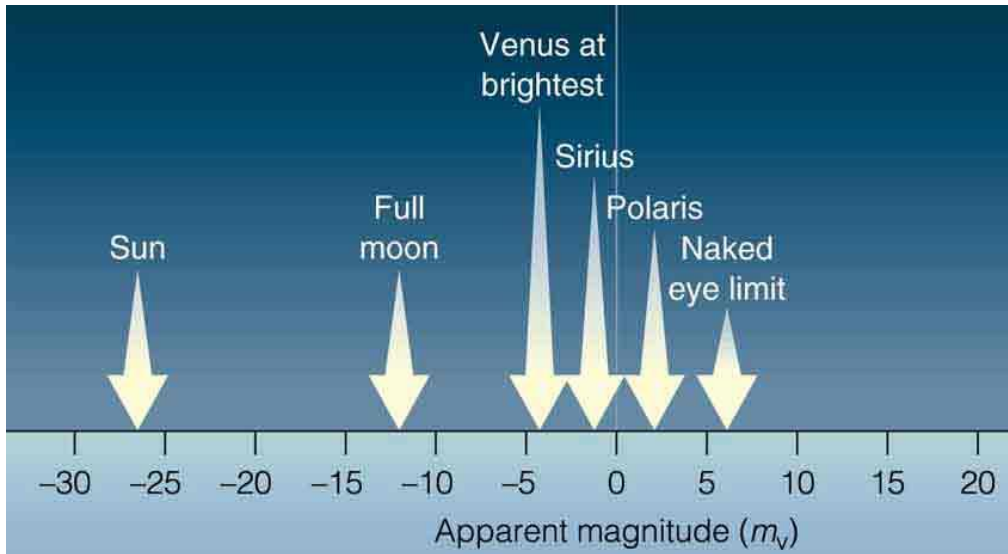
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Part 1 : Brightness, Precession, Extinction and Refraction

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Stars are not as bright as sun or moon.

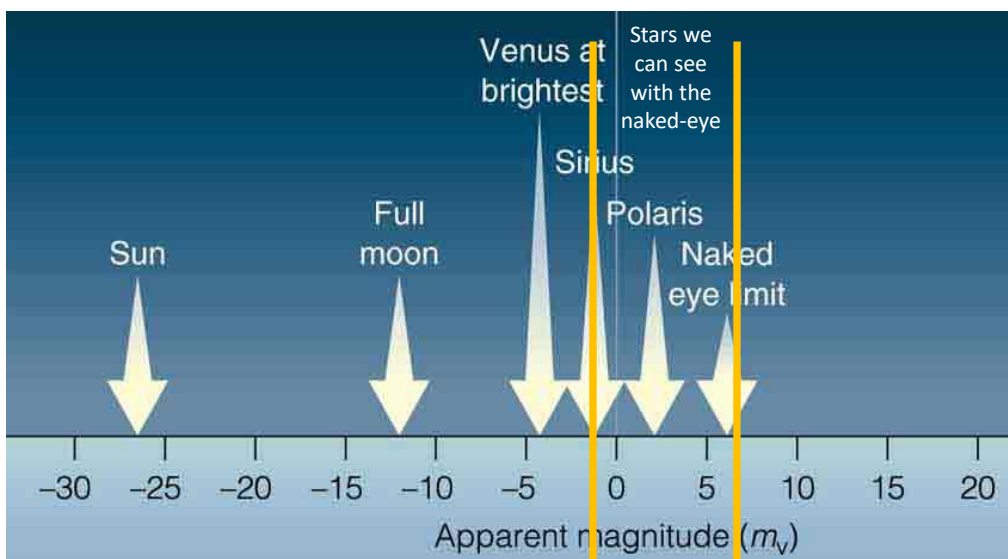
The level of brightness of an object in the sky is measured by **magnitude**. The smaller the magnitude the brighter the object.



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The brightness of stars: - Magnitude

The level of brightness of an object in the sky is measured by magnitude. The smaller the magnitude the brighter the object.



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The brightness of stars:

List of Bright Stars

Star	m_v
Sirius	-1.4
Canopus	-0.7
Rigel Kentaurus	-0.3
Arcturus	-0.1
Vega	0.0
Capella	0.1
Rigel	0.1
Procyon	0.4
Betelgeuse	0.4
Achernar	0.5
Hadar	0.6
Altair	0.8
Acrux	0.8
Aldebaran	0.9
Antares	0.9
Spica	0.9
Pollux	1.2
Fomalhaut	1.2
Deneb	1.3
Beta Crucis	1.3
Regulus	1.4
Adhara	1.5
Castor	1.6
Shaula	1.6
Bellatrix	1.6
El Nath	1.7
Miaplacidus	1.7
Alnilam	1.7



There are 26 – 28 bright stars in the sky, that is up to a magnitude of around 1.5, while up to mag 2, there are 49 stars.

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HR	Proper Name	Bayer	Flam	Cons	Magn	B-V Colour	Other Names	RA	Dec	Description
2491	Sirius	Alp	9	CMa	-1.46	White	Canicula; Dog Star; Aschere	101°17'	-16°43'	The brightest and red star in the face called Sirius
2326	Canopus	Alp	0	Car	-0.72	White	Suhel; Suhail	095°59'	-52°42'	The bright star in the oar called Canopus
5340	Arcturus	Alp	16	Boo	-0.04	Orange	Haris-el-sema	213°55'	+19°11'	The bright star in the fringe of the Tunic
5459	Toliman	Alp1	0	Cen	-0.01	Yellow	Rigel Kentaurus; Rigel Kent	219°54'	-60°50'	The star at the tip of the right foot
7001	Vega	Alp	3	Lyr	0.03	White	Wega; Fidis; Harp Star	279°14'	+38°47'	The bright star in the shell called the Lyre
1708	Capella	Alp	13	Aur	0.08	Yellow	Alhajothe; Hircus; Amilthea	079°10'	+46°00'	The star in the left shoulder and called Capella
1713	Rigel	Bet	19	Ori	0.12	White	Algebar; Elgebar	078°38'	-08°12'	The bright star in the left foot common with the Water
2943	Procyon	Alp	10	CMi	0.38	Green	Elgomaisa; Algomeysa; Antecanis; the	114°50'	+05°14'	The bright star in the hind parts of the little dog called Procyon
0472	Achernar	Alp	0	Eri	0.46	Blue-Green		024°26'	-57°14'	
2061	Betelgeuse	Alp	58	Ori	0.50	Red	Betelguex; Betelgeuze; Beteiguex; Al	088°48'	+07°24'	The bright red star in the right shoulder
5267	Agena	Bet	0	Cen	0.61	Blue-Green	Hadr; Wazn; Mah Fuh; Two Men that	210°57'	-60°22'	The star below the knee in the left foot
7557	Altair	Alp	53	Aql	0.77	White	Altair	297°42'	+08°52'	The bright star in the broad of the back of the Eagle
1457	Aldebaran	Alp	87	Tau	0.85	Red	Cor Tauri; Parilicium; The Follower	068°59'	+16°31'	The bright red star in the Hyades in the southern eye
6134	Antares	Alp	21	Sco	0.96	Red	Cor Scorpii; Kalb al Akrah; Vespertilio	247°21'	-26°26'	The red star in the middle of the body called Antares
5056	Spica	Alp	67	Vir	0.98	Blue-Green	Azimech; Spica Virginis; Alaraph	201°18'	-11°10'	The star in the left hand called Spica
2990	Pollux	Bet	78	Gem	1.14	Orange	Hercules	116°20'	+28°02'	The star in the head of Pollux, the eastern twin
8728	Fomalhaut	Alp	24	PsA	1.16	White	Fomalhaut; Os Piscis Meridiani; Os Pis	344°25'	-29°37'	The star fish's month, the same as that at the beginning of the V.
7924	Deneb Adige	Alp	50	Cyg	1.25	White	Deneb Cygni; Deneb el Adige; Deneb;	310°21'	+45°17'	The bright star in the tail
4853	Mimosa	Bet	0	Cru	1.25	Blue-Green	Becrux	191°56'	-59°41'	The star in the heel of the foot
4730	Acrux	Alp1	0	Cru	1.33	Blue-Green		186°39'	-63°06'	The star in the Centaur's foot and at the base of the Cross
3982	Regulus	Alp	32	Leo	1.35	Blue-Green	Cor Leonis; Rex; Al Kalb al Asad; Kabe	152°06'	+11°58'	The star at the heart called Regulus
2618	Adara	Eps	21	CMa	1.50	Blue-Green	Adhara	104°39'	-28°58'	The star under the curve of the belly
4763	Gacrux	Gam	0	Cru	1.63	Red		187°47'	-57°07'	The star near the right foot of the Centaur and at the top of the C
6527	Shaula	Lam	35	Sco	1.63	Blue-Green	Al Shaulah; The Sting	263°24'	-37°06'	In the tail of the Scorpion
1790	Bellatrix	Gam	24	Ori	1.64	Blue-Green	the Amazon Star	081°17'	+06°21'	The star in the left shoulder
1791	El Nath	Bet	112	Tau	1.65	Blue-Green	Alnath; Nath; The Butting One	081°34'	+28°36'	The tip of the northern horn and the right foot of the Charioteer
3685	Miaplacidus	Bet	0	Car	1.68	White		138°18'	-69°43'	
1903	Alnilam	Eps	46	Ori	1.70	Blue-Green	Alnihan; Alnitam	084°03'	-01°12'	The middle star in the Belt

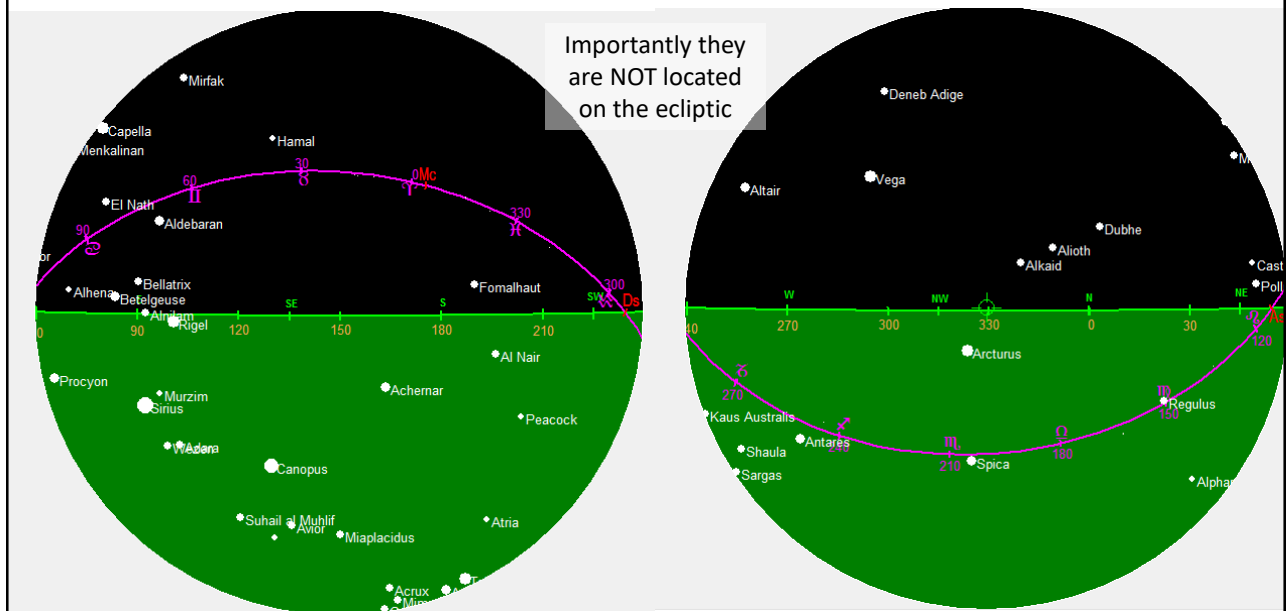
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Bright stars – 1.74 to 2 for 2000 CE

8425	Al Nair	Alp	0	Gru	1.74	Blue-Green	Alnair; The Bright One	332°04'	-46°58'	
4905	Alioth	Eps	77	UMa	1.77	White	Aliath	193°30'	+55°58'	The first star of the three in the tail after the beginning of the tail
3207	Suhail al Muhlif	Gam2	0	Vel	1.78	Blue-Green	Al Suhail al Muhlif, Regor	122°23'	-47°20'	The bright star below the door on the deck of the Argo
1017	Mirfak	Alp	33	Per	1.79	Green	Mirphak; Marfak; Algenib	051°05'	+49°52'	The bright star in the right side of Perseus
4301	Dubhe	Alp	50	UMa	1.79	Orange	Dubb; Ak	165°56'	+61°45'	Of the stars in the quadrilateral, the bright star in the back
2693	Wezen	Del	25	CMa	1.84	Yellow	Alwazn; Wesen; Al Wazor; Al Wazn	107°06'	-26°24'	The star at the beginning of the left thigh
6879	Kaus Australis	Eps	20	Sgr	1.85	White	Nibat Anu	276°03'	-34°23'	The star in the southern part of the bow
5191	Alkaid	Eta	85	UMa	1.86	Blue-Green	Benetnash; Benetnasch; Elkeid	206°53'	+49°19'	The third star at the tip of the tail
3307	Avior	Eps	0	Car	1.86	Orange		125°38'	-59°31'	
6553	Sargas	The	0	Sco	1.87	Green		264°20'	-43°00'	The star in the fifth joint Lying in the Milk Way
2088	Menkalinan	Bet	34	Aur	1.90	White	Menkalina	089°53'	+44°57'	The star in the right shoulder of the charioteer
6217	Atria	Alp	0	TaA	1.92	Red		252°10'	-69°02'	
2421	Alhena	Gam	24	Gem	1.93	White	Almeisan; Proudly Marching One.	099°26'	+16°24'	The star in the end of the left foot of the western twin, Pollux
7790	Peacock	Alp	0	Pav	1.94	Blue-Green		306°25'	-56°44'	
3748	Alphard	Alp	30	Hya	1.98	Red	Alfard; Alphart; Kalbelaphard; Cor Hyd	141°54'	-08°40'	The bright star of the two in the south
2891	Castor	Alp	66	Gem	1.98	White	Apollo; The Mortal One; The Horseman	113°39'	+31°53'	The star in the head
2294	Murzim	Bet	2	CMa	1.98	Blue-Green	Mirzam; Mirza; The Announcer	095°40'	-17°57'	The star at the end of the forefoot
0617	Hamal	Alp	13	Ari	2.00	Orange	Hemal; Hamul; Ras Hammel; El Nath	031°48'	+23°28'	The bright star at the base of the right horn

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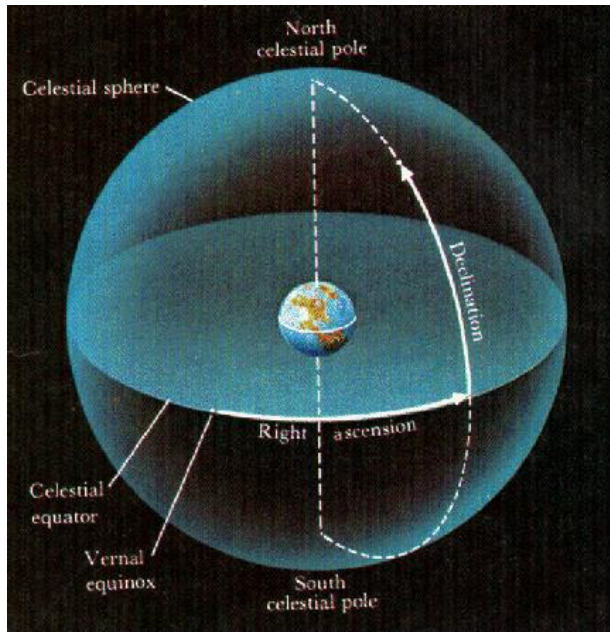
Are there too many stars? The 49 stars from -1.5 to 2 magnitude, on the celestial sphere.



Their visibility however is SEASONAL – called the Star Phases

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REMINDER : Basic numbers you need to understand



The Fixed Address System

Cities have a longitude and latitude
sky objects have a Right Ascension and Declination

**Declination is *like* latitude and
RA is *like* longitude (time based)**

E.G. The Fixed Address of
the star Sirius the star:

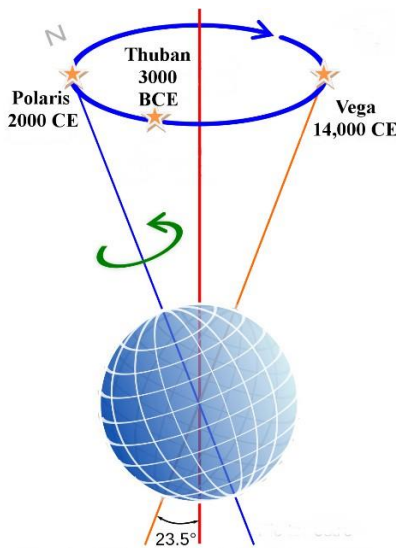
RA: 06:45:38

Dec: $-16^{\circ}44'$

Thus if the **pole moves**, so too **the equator**
and so too the star's RA and declination

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Precession - how it effects the relationship of a star to a place



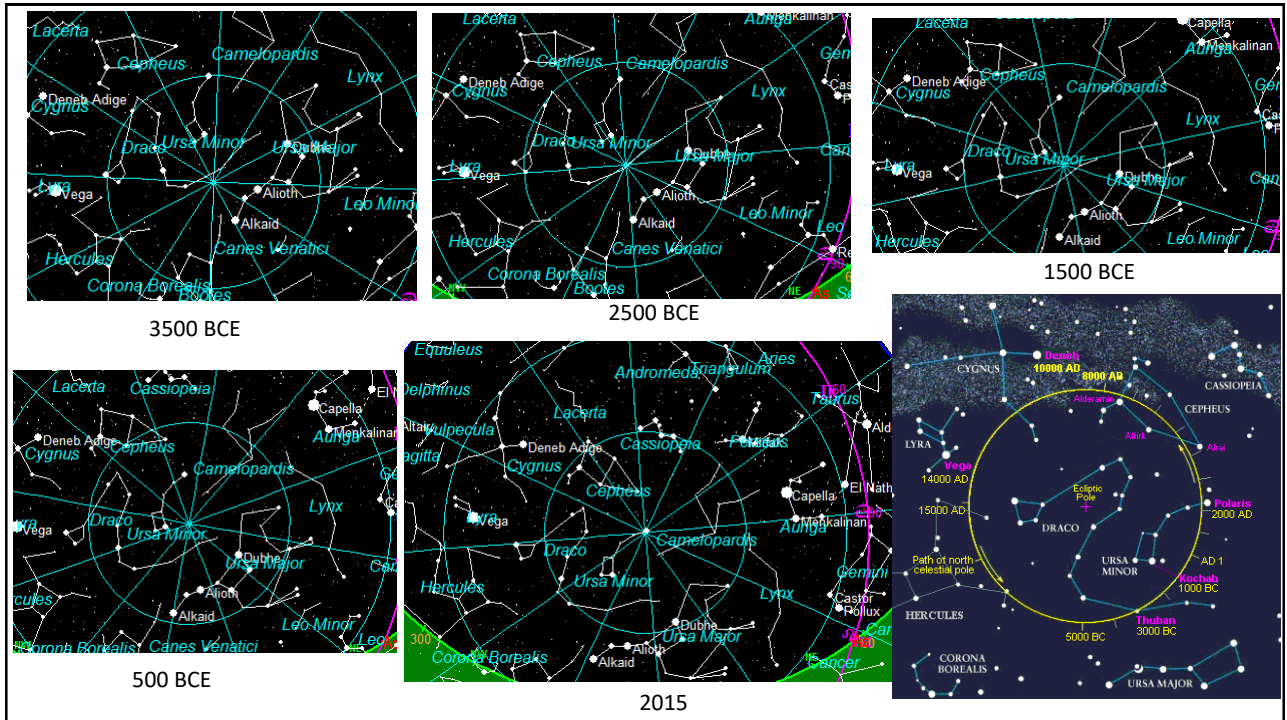
The North Star is now Polaris but 5000
years ago it was Thuban and 12,000
years from now will be Vega.

The rotation of the pole takes about 26,000 years
to move through its full circle. As it moves the
equator, which is always 90° degrees to the pole,
also moves.

Thus since a star's 'address' is based on its distance
north or south of the equator its 'address' changes

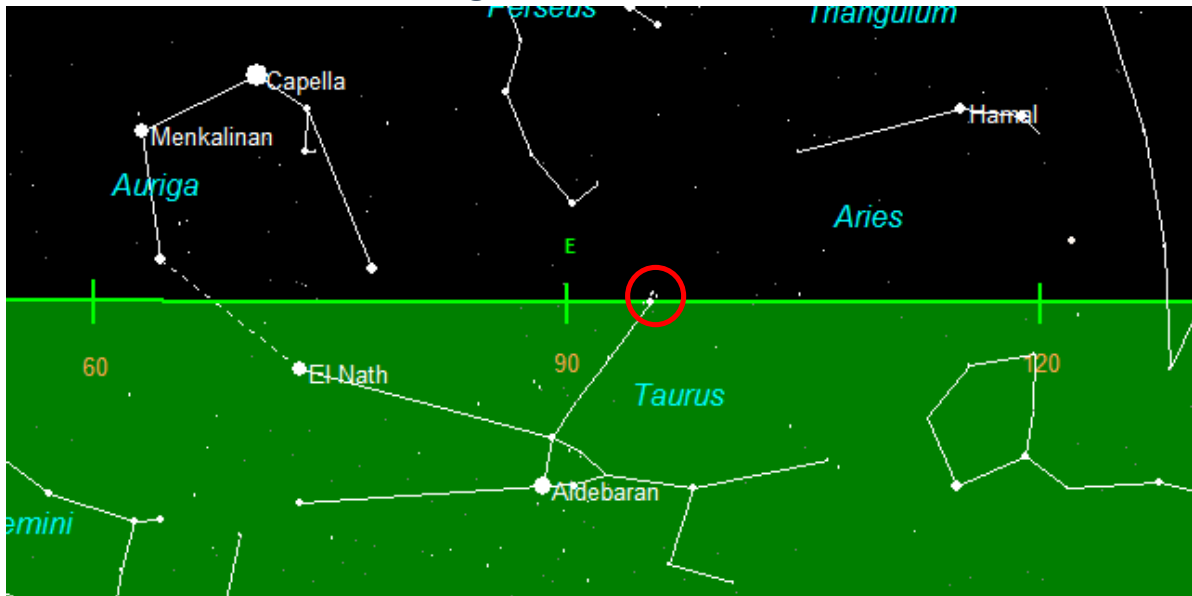
The stars do not move (ignoring proper motion) but
rather the earth moves and thus for a given
location the stars will shift against the horizon.

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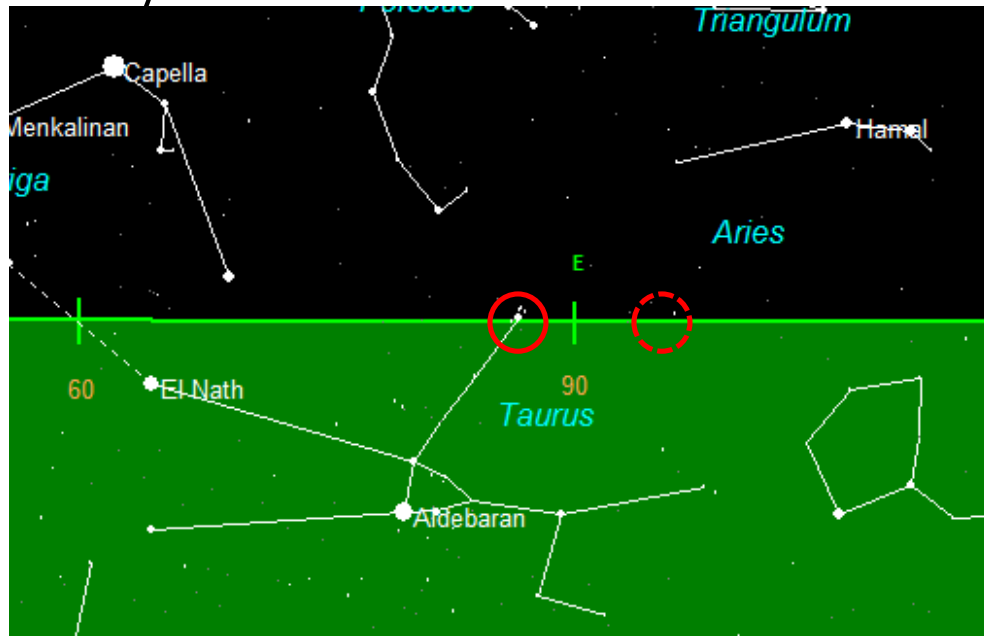
Precession - Moves the stars against the horizon



3500 BC – The Pleiades rises a little south of east - azimuth 95°

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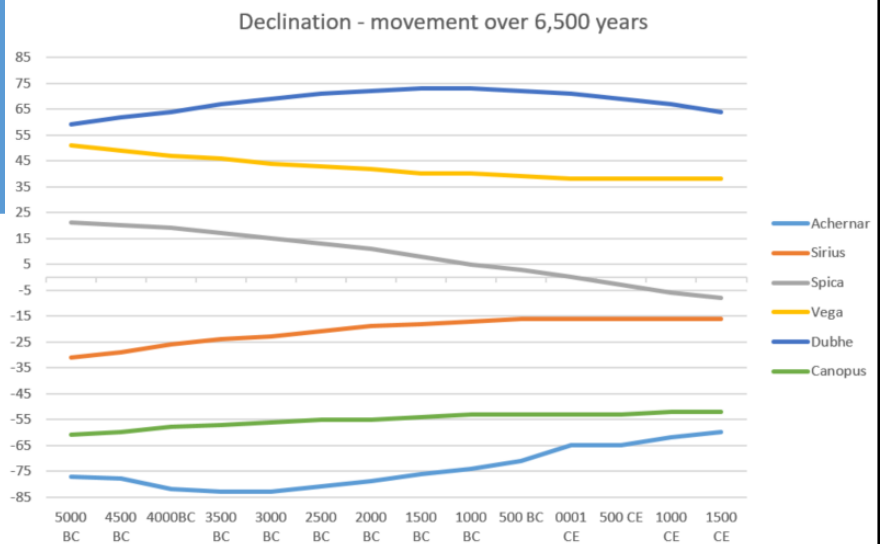
1000 years later



2500 BC –
The Pleiades
rises a little
south of east
- azimuth
 86°

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The effect of
precession is not
uniform in its
influence on the
position of the
stars



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EXTINCTION: How we see the stars on the horizon

The atmosphere causes rising stars to be extinguished as they cross over the horizon.

Hence simply working with a star's declination to see where it cuts the line of the horizon will not necessarily be sufficient to understand a star's relationship to a location.

As a good rule of thumb (see Bradley Schaefer) the brighter the star the smaller the angle of extinction.

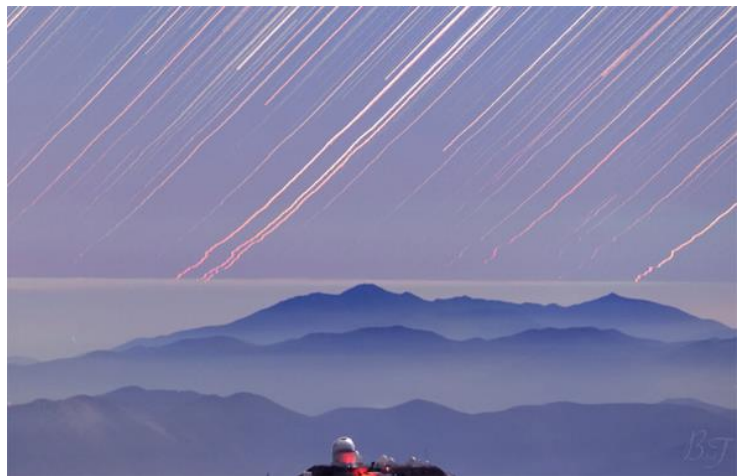
For every degree of magnitude add a degree to the height the star must rise before it is visible.

Thus a star like Sirius for -1.5 mag, will be visible right on the horizon but a star like Hamal, in the constellation Aries with it magnitude of 2 , will need to be 2° above the horizon before it is visible.

Schaefer, Bradley. "Atmospheric Extinction Effects on Stellar Alignments." *Archaeoastronomy* 10 (1986): 32-42.

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Refraction –
stars shift in
azimuth as
they rise and
set



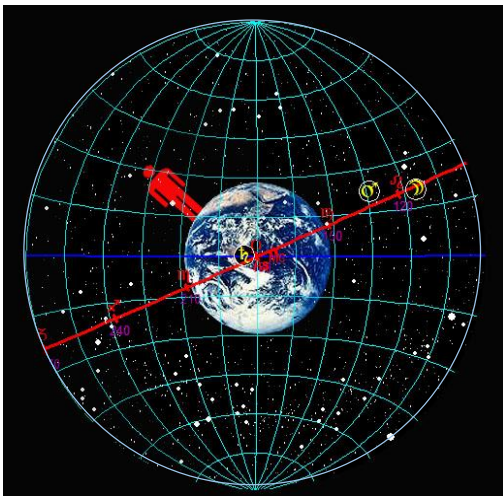
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Part 2 : Star Phases and the visibility of stars for a given location



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What stars are visible for a given location



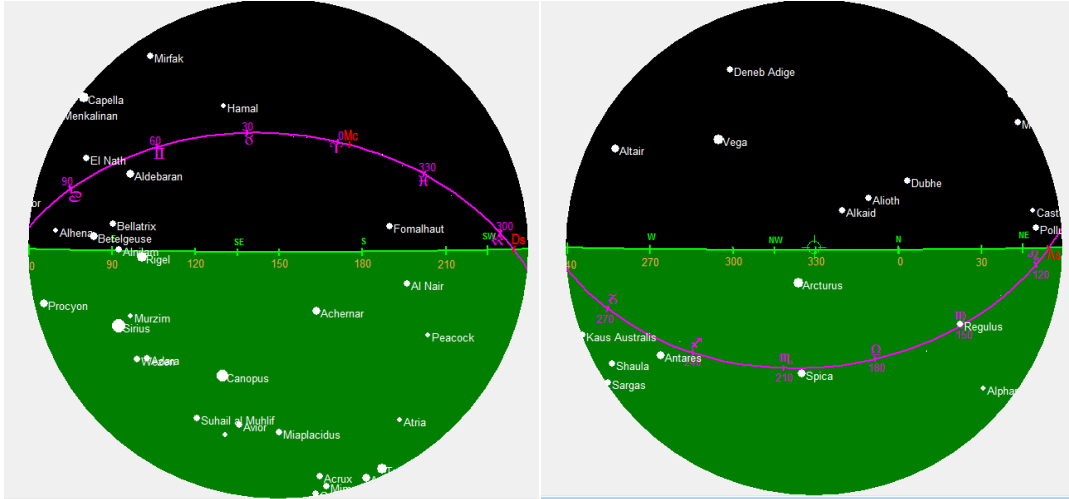
To gain a rough guide to a star's visibility subtract the observer's latitude from 90° .

The resulting answer will be the declination of a star that will either never rise or never set.

E.G. At a latitude of 51 North. $90 - 51 = 39$.
Thus stars with a declination of **greater than 39 North** will never set while stars with a declination of **greater than 39 South** will never rise.

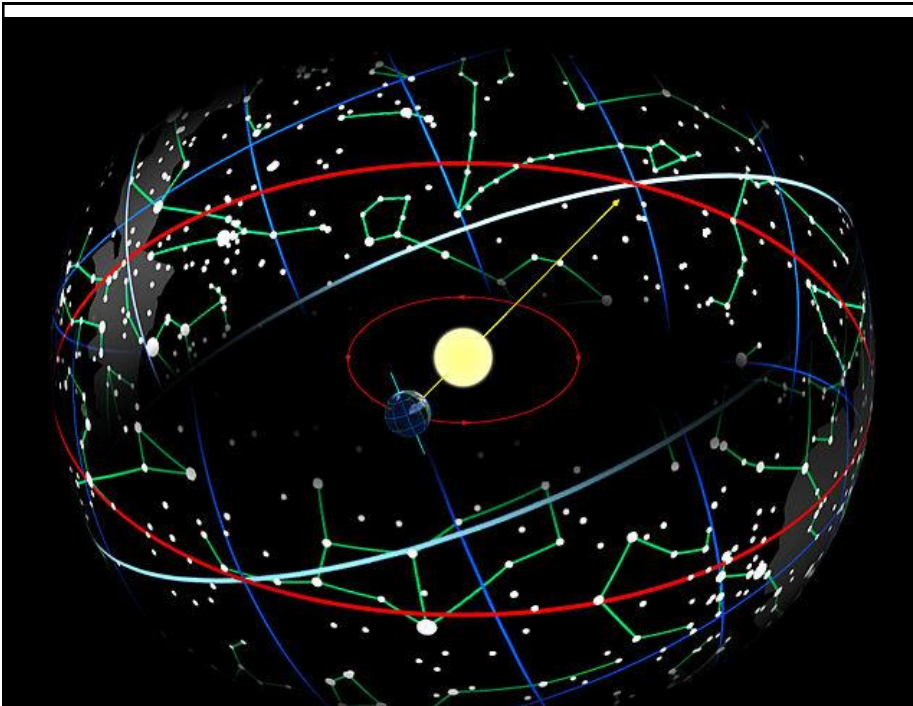
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Are there too many stars? Given that not all stars are visible for a given location then the number of bright stars that may be a part of the location skyscape is reduced.



Additionally WHEN these visible stars are visible is SEASONAL

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A star is only visible if it is above the horizon when the sun is below the horizon.

Thus since the stars do not move it is the **movement of the sun along the ecliptic** that will cause the stars to appear or disappear from the night sky.

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Four types of star visibility for a given location

	Group 1	Group 2	Group 3	Group 4
Ptolemy's Star Phase Type	Circumpolar	Curtailed Passage	Arising and Laying Hidden	Never rises
Star's relationship to the observer. (The orientation of the star and the observer is based on the ecliptic not the equator.)	Star is located on the <u>same</u> side of the ecliptic as the observer and its declination is <u>greater</u> than the co-latitude of observer.	Star is located on the <u>same</u> side of the ecliptic as the observer and its declination is <u>less</u> than the co-latitude of the observer.	Star is located on the <u>opposite</u> side of the ecliptic to the observer and its declination is <u>less</u> than the co-latitude of the observer.	Star is located on the <u>opposite</u> side of the ecliptic to the observer and its declination is <u>greater</u> than the co-latitude of the observer.
Observation	Always visible for whole night Never seen to touch the line of the horizon — never rising or setting.	Visible every night Sometimes seen to set and rise during the <u>same</u> night while at other times it is visible at sunset and still visible the following dawn.	Sometimes visible Sometimes rising or setting during the night while at other times not seen at all during the whole night.	Never Visible

Brady, Bernadette, 'A Consideration of Egyptian Ascension Mythology as a Reflection of the Mythopoeic Nature of Star Phases and Its Implication for Belief in the Descent of Divine Beings', in *Current Research in Egyptology Volume Xii*, ed. by Heba Abd El-Gawad, et al. (Oxford: Oxbow, 2012), pp. 40-47.

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Sun		Observation of Phase Type: Arising and Laying Hidden	Visible or Not Visible
The Sun in the same part of the sky as the star	Acronychal setting	Star sets at sunset and begins its period of invisibility. The star is seen at sunset, low in the west and setting. After this event the star is no longer seen in the night sky over a period of days, weeks or months.	NOT VISIBLE
Sun moves past the star, now the star can be seen at sunrise	Heliacal Rising	Star rises at sunrise and ends its period of invisibility. The star is seen to rise just before the sun. Having returned to visibility the star then proceeds, over the following weeks, to rise earlier and earlier before dawn. Eventually it begins to sink in the west by the time the sun rises.	RETURN TO VISIBILITY Seen to RISE before the sun.
The term of 'heliacal rising' for an ALH star is, thus, unambiguous as the term 'morning rising' is used exclusively for a star of the Curtailed Passage phase (fig 3) which when rising before the sun it not actually returning to visibility. T			
Sun in the opposite (before) part of the sky to the star	Morning Setting	Now at sunrise the star is seen to be setting. However, earlier in the night the star was seen to rise.	VISIBLE The star is seen to RISE in the evening and SET before the following dawn.
Sun in the opposite part (after) of the sky to the star	Evening Rising	Night after night the star rises earlier and earlier in the evening until finally it rises as the sun sets.	VISIBLE The star appears higher in the sky each evening but finally begins to SETS before the dawn.
		From this period the star appears higher in the sky at each sunset. Over the next few weeks or months the star is visible at sunset but sets later in the night. Eventually the star is in the western sky at sunset and sets just after sunset — its acronychal setting.	

The Descending Stars produce the phenomena of a Heliacal Rising Star

This is a star returning to visibility by rising just before sunrise.

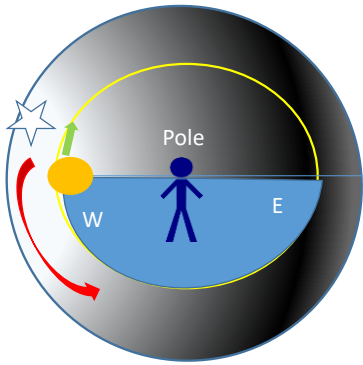
Table from Bernadette Brady, 'Star phases: naked-eye astronomy of the Old Kingdom pyramid text. In: Silva, F. & Campion, N. (eds.) *Skyscapes: The Role and Importance of the Sky in Archaeology*. Oxford: Oxbow 2013.

Star Phases:

See Ptolemy, Claudius, *The Phases of the Fixed Stars*. trans. Robert Schmidt (Berkeley Springs, WV: The Golden Hind Press, 1993).

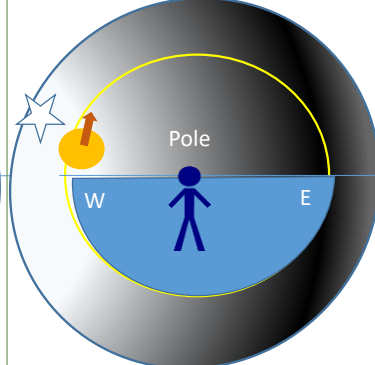
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The Descending Stars – Arising and Laying Hidden

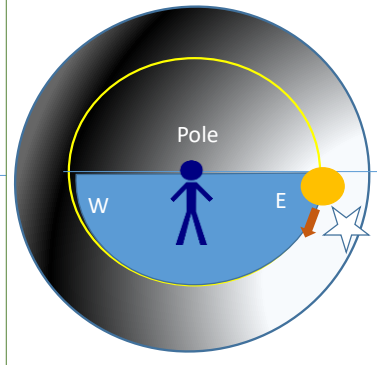


Stage1: Star is seen to be low in the west at sunset.

Sun moves along the ecliptic
1° per day
Earth rotates



Stage 2: In a few days the sun has moved forward along the ecliptic but the star does not move against the ecliptic so now, at sunset, you *cannot* see the star.

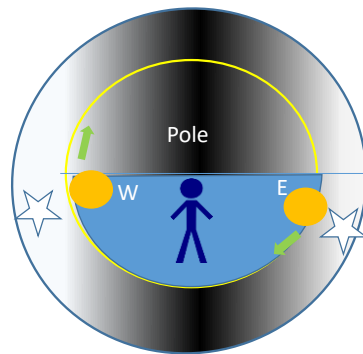


Stage 3 – At sunrise the next morning the star has not risen.

This star is SOUTH of the ecliptic thus it has a larger orbital circle than the sun.

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The Descending Stars - ALH – return to visibility

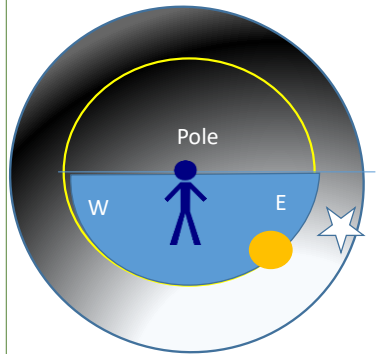


Stage 4: The star is not visible all night. It moves on a larger circle than the sun and thus sets before sunset and rises after sunrise.

Period of invisibility

Depending on the star will last for a few days to a few months.

Sirius disappears from view for the latitude of Egypt at the time of the Old Kingdom for around 70 days.



Stage 5 – The sun moves past the star. Finally at sunrise the star is seen to rise just before sunrise – rebirth. Heliacal Rising Star.

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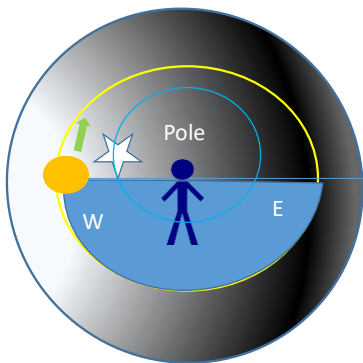
Sun		Observation of Phase Type: Curtailed Passage	'Circumpolar' or not 'circumpolar'
Sun opposite the star	Acronychal Rising	Star rises at sunset and begins its period of circumpolar-like behaviour. The star is seen to rise at sunset. For some days, weeks or months after this event the star is seen in the night sky at sunset and is still there by the following dawn.	'Circumpolar' activity Star does not touch the horizon
Sun opposite the star	Heliacal Setting	Star sets at sunrise and ends its period of circumpolar-like behaviour. Over time the star appears closer to the western horizon at sunset. Eventually it is seen to be setting as the sun rises but will be back in the sky the following sunset.	End of 'Circumpolar' activity
Sun in same part of the sky as the star	Morning Rising	Now at sunset the star is observed as being high in the night sky. The star will set at some time during the night. However, every night, at sunset, it appears lower in the western sky until eventually it is seen to both set in the early evening and then rise in the morning just before the dawn.	Visible but setting early in the evening and rising before the dawn.
Sun in same part of the sky as star	Evening Setting	The star continues to set early in the evening until finally it sets as the sun sets, but it will rise again before sunrise.	Set with the sun but will rise later in the evening.
The term 'evening setting' is used here for stars which belong to the CP phase for, after setting at sunset, they will be seen to rise later in the same evening. Whereas the term of 'acronychal setting' is used for a star which belongs to the ALH phases which after being seen to set at sunset will <u>not</u> be visible again in the night sky for some days, weeks or months.			
		Now slowly over some days, weeks or months the rising time of the star will move closer to sunset until eventually it is seen to rise as the sun sets — its acronychal rising. The star now begins its period of circumpolar-like activity.	

The Ascending Stars

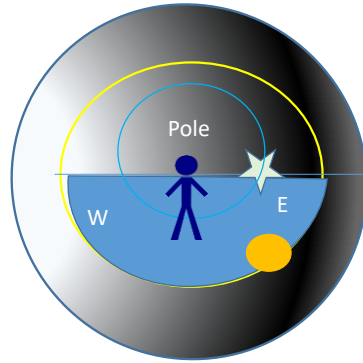
Star rises or sets but then spends a period of time acting as a circumpolar star after which it returns to earth.

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The Ascending Stars – Curtailed Passage



Stage1: Star is seen to be low in the west at sunset.



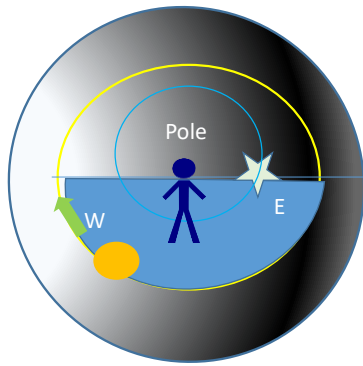
Stage 2: Later that night, the star is seen to rise BEFORE the sun. The Star escapes the earth!

Star looks like it is going to disappear. It sets below the earth **but rises again that very night.**

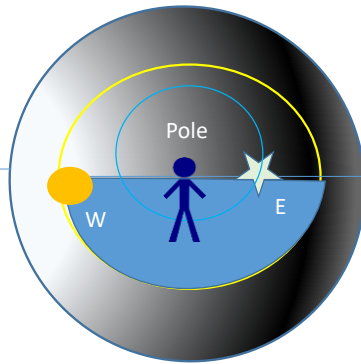
This star is NORTH of the ecliptic thus has a smaller orbital circle than the sun.

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The Ascending Stars - CP



Stage 3: The sun keeps moving along the ecliptic. Star seen to rise earlier each evening.



Stage 4: Eventually the star is seen to rise at sunset.

Acronychal Rising

From this point on this star is higher in the eastern sky at sunset and stays visible all night – it has become a circumpolar star.

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Star Phases for a particular Landscape

There will be a set place on the horizon for Descending Stars:

- A place on the horizon that a certain star will **re appear just before sunrise** after being missing from the night sky for a set period of time (Heliacal Rising Star). For the northern hemisphere this will be in the **South East**.
- A place on the horizon where a certain star will **set at sunset and begin its period of being absent from the night sky**. This will be in the **South West**.

There will be a set place on the horizon for Ascending Stars:

- The place on the horizon where a certain star will **rise but if it rises at sunset it will be beginning its period of acting as a circumpolar star**. This will be in the **North East**.
- The place on the horizon where a certain star will **set but if it sets at sunrise it will be returning to earth after being a circumpolar star**. This will be in the **North West**.

30



The Eastern Horizon: The significant star places.

The north east will have locations where a star will rise just after sunset and begin its period of curtailed passage – becoming a circumpolar star.

The south east will have location where a star will rise just before sunrise and it will be the heliacal rising star, returning to visibility after some weeks or months being absent from the night sky.

31



The Western Horizon: The significant star places.

The north west will have locations where a star will set, and if it does this at sunset then it marks its return to earth, the end of its period of curtailed passage and being a circumpolar star.

The south west will have location where a star will set just after sunset and will be beginning its period of invisibility where it is some weeks or months being absent from the night sky.

32

Stars for a given location and era

- Stars rise (or set) at the same place on the horizon.
 - Stars can thus produce calendar and navigational markers.
- Stars will have:
 - Brightness and colour.
 - A star phase will relate to a date (season) and a place on the horizon.
- If possible consider local place names and folklore.

33

Part 3 : Different Cultures see the stars in different ways



34

Seeing Stars with Different Eyes



Other cultures see the sky with the constellations defined by the dark areas of the sky. There is no reason why this would not have been the case for the megalithic builders.



35

Thus stars can
be a vital part
of the skyscape



36

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