The sky in motion

Koupelis - sections 1.2, 1.3
OpenStax - sections 2.1, 4.1, 4.2

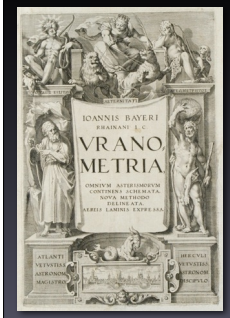
1

The sky in motion

- Constellations
- Introduction to the night sky
- Measuring angles on the sky
- Motion of the celestial sky at different locations on Earth
- Coördinate systems
- Precession
- Motion of the Sun
- Timelapse movies (Stellarium demo)

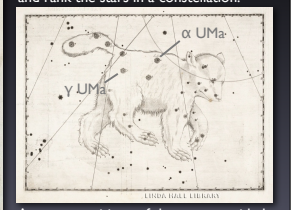
2

Uranometria : the first atlas of the sky



Johann Bayer
(1572 - 1645)

Introduced Greek letters to indicate and rank the stars in a constellation.



Accurate positions of the stars provided by Tycho Brahe.

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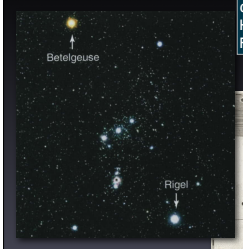
Orion



Betelgeuse (Yad al-Jauzā)

α Ori , 58 Ori , HR 2061 , BD +7d1055 , HD 39801 , SAO 113271 , GC 7451 , FK5 224 , AAVSO 0549+07 , HIP 27989

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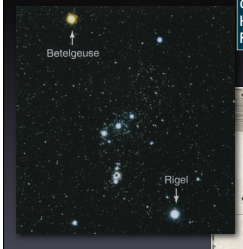
Orion



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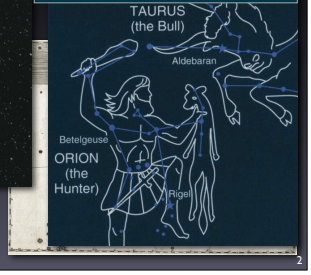

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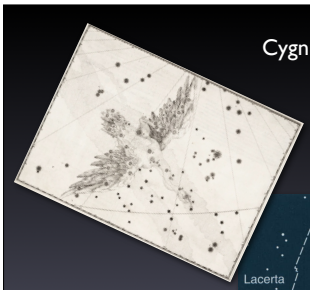
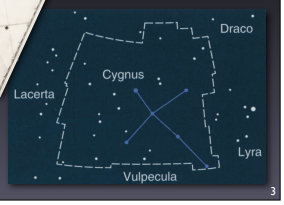
Cygnus - the Swan





Constellations have well-defined boundaries.

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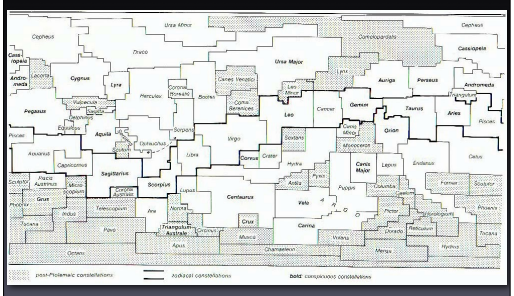
The sky is divided in 88 constellations.



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Definition of constellation boundaries

Established by Committee 3 (Astronomical Notations) of the International Astronomical Union (IAU).

Based on the article:

Délimitation Scientifique des Constellations,
by E. Delporte, 1930
Royal Observatory of Belgium

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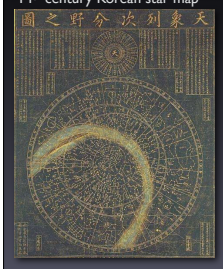
Non-western constellations

14th century Korean star map



Aboriginal constellation 'Emu in the Sky'

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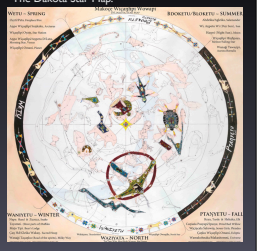
Native American sky maps

Ojibwe Giizhig Anung Masinaaigan
'The Ojibwe Sky Star Map.'

D(L)akota Makoče Wičaŋȟpi Wowapi
'The Dakota Star Map.'



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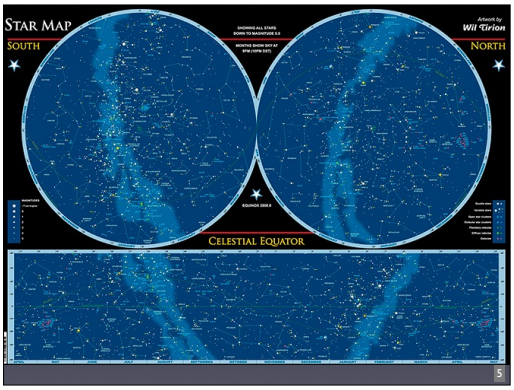

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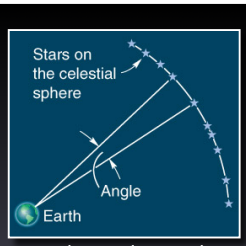
Measuring positions and angles on the sky.



- The angular distance between two objects on the sky is the angle between the two lines in the direction of these objects, as seen by the observer
- 1 *degree* is divided in 60 *arc-minutes* and 1 arc-minute is divided in 60 *arc-seconds*

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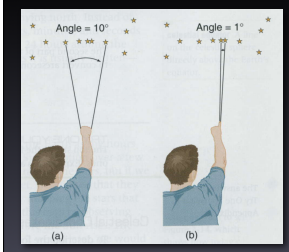
Rules of thumb



The width of a finger is ~1 degree.

Diameter of the Sun and Moon :

½ degree = 30 arc-minutes
=1800 arc-seconds

The unaided eye can separate 2 stars at an angular separation of ~1 arc-minute.

The Hubble Space Telescope can separate 2 stars that are 0.1 arc-second apart.

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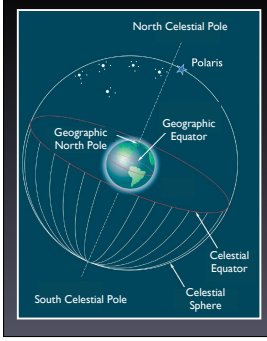
Positions on the sky



- The daily *rotation* of the Earth defines the celestial-equator and the northern and southern celestial poles.
- The polar star *Polaris* (α Ursa Minor) is located, accidentally, in the direction of the Earth rotational axis.
- The celestial equator is the equivalent of the geographic equator.

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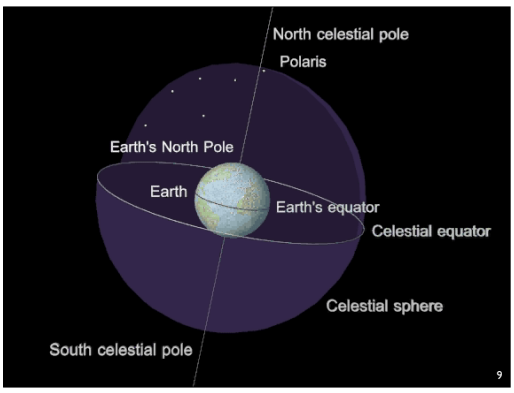

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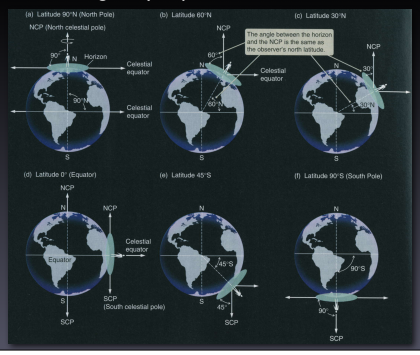
View of night sky depends on location on Earth



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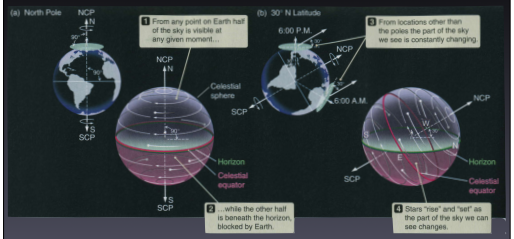
location & rotation

on the north pole at 30° northern latitude



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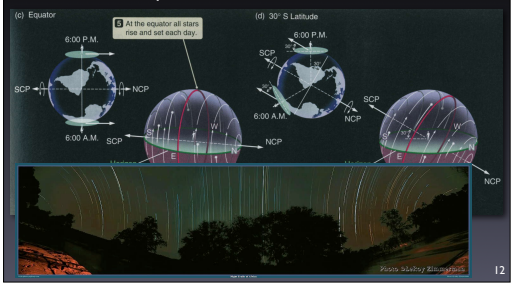
location & rotation

on the equator at 30° southern latitude



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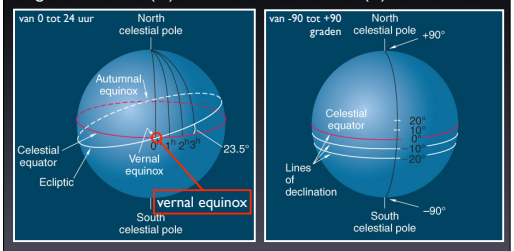
Sky locations are designated by equatorial coördinates.

Right Ascension (α) *Declination* (δ)



Example: α Centauri is located at $\alpha = 14^h\,39^m\,36\overset{s}{.}2$, $\delta = -60°\,50'\,8''$

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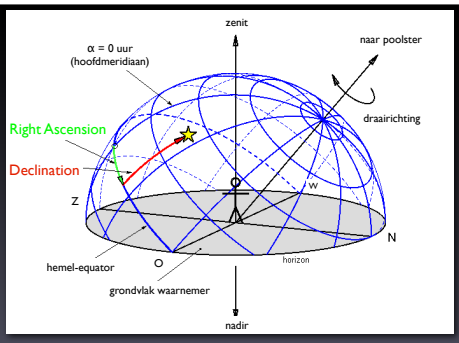

Right Ascension is measured along the celestial equator, increasing to east.
Declination is measured along a meridian, increasing towards north.

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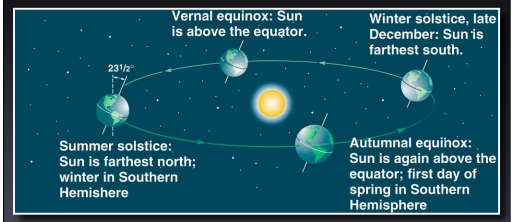
The rotating Earth moves around the Sun in 365,25… days in a nearly-circular orbit.

this orbital plane defines the ecliptic



The axis of rotation is *not* perpendicular to orbital plane!
→ the celestial equator and the ecliptic do *not* coincide…

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Constellations along the ecliptic (zodiac)

summer solstice
α = 6 uur
δ = +23.5°

autumnal equinox : α = 12 uur δ = 0°

vernal equinox : α = 0 uur δ = 0°

winter solstice : α = 18 uur δ = -23.5°

The ecliptic crosses 13 instead of 12 constellations, now including Ophiuchus.

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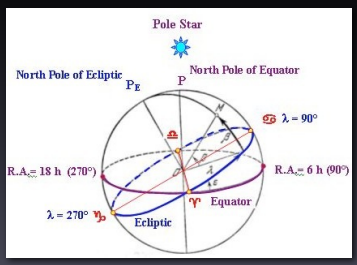
Ecliptic coördinate system



The ecliptic is the plane of reference

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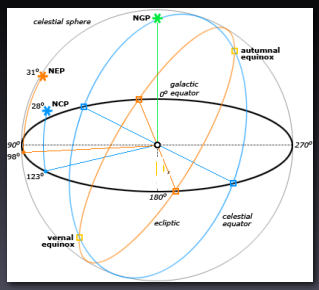
Galactic coördinates



The Milky Way is the plane of reference

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Common sky coordinates:

Name	symbols	reference (zero point)	range
Azimuthal	(Az , Alt)	horizon (north)	Az : 0 → 360 Alt : 0 → 90
Equatorial	(α , δ)	celestial-equator (vernal equinox)	α : 0 → 24 δ : -90 → +90
Ecliptic	(λ , β)	ecliptic (vernal equinox)	λ : 0 → 360 β : 0 → 90
Galactic	(l , b)	Milky Way (galactic center)	l : 0 → 360 b : -90 → +90
Supergalactic	(SGL , SGB)	supergalactic plane (l=137.37° , b=0°)	SGL : 0 → 360 SGB : -90 → +90

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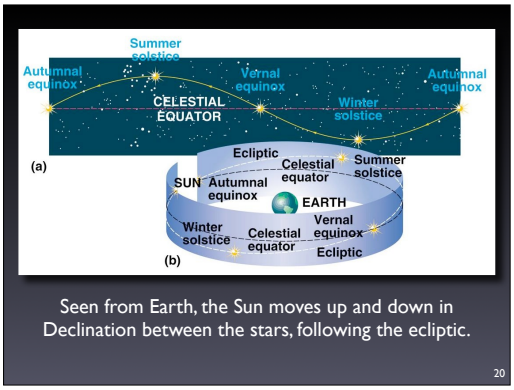

Seen from Earth, the Sun moves up and down in Declination between the stars, following the ecliptic.

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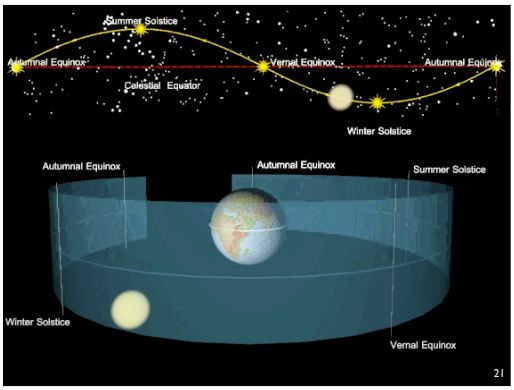

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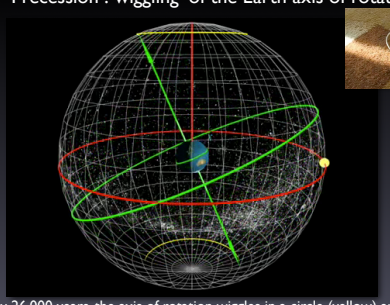
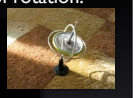
Precession : 'wiggling' of the Earth axis of rotation.





Every 26.000 years, the axis of rotation wiggles in a circle (yellow) around the ecliptic pole. Consequently, the celestial equator (green) 'wiggles' and shifts the vernal equinox along the ecliptic (red) through the various constellations.

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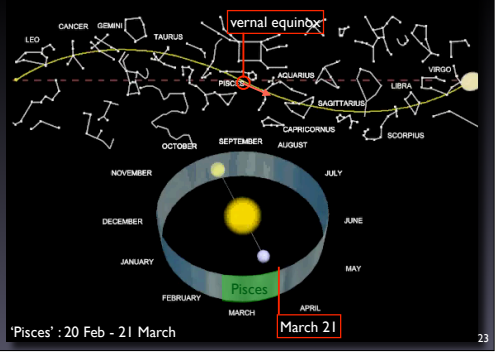
The vernal equinox shifts along the ecliptic with astrological consequences…



'Pisces' : 20 Feb - 21 March

March 21

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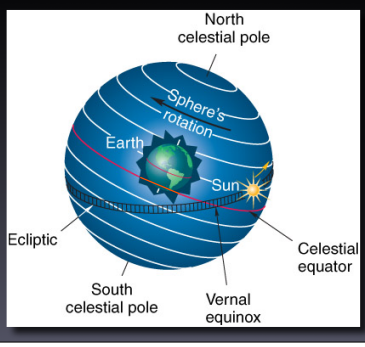
The Sun shifts along the ecliptic, 1 degree per day ...



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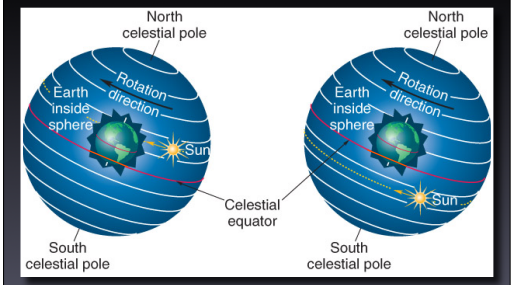
... while the Earth rotates around her axis.



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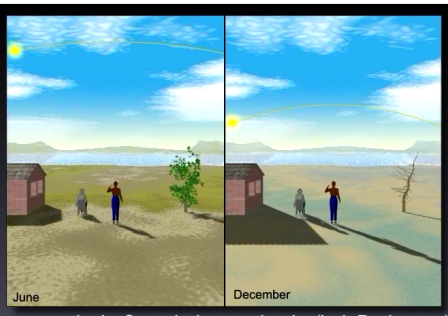

Consequently, the Sun is high up in the sky (high Declination) in summer and low in the sky (low Declination) in winter. This gives rise to the seasons!

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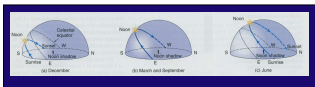
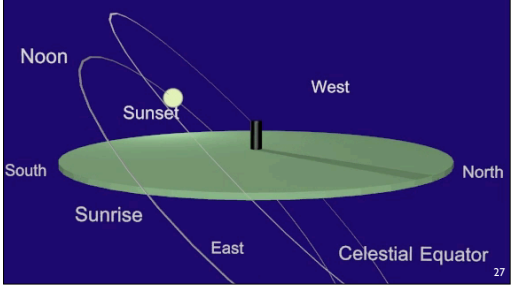


December



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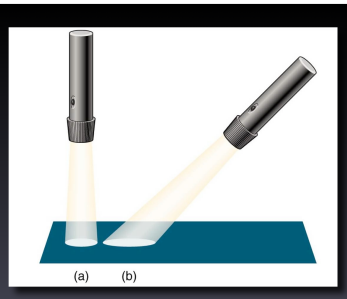

The heating of the surface of the Earth depends on the elevation of the Sun!

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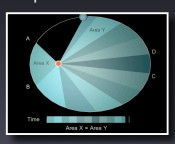
Take a picture at the same time every week in the same direction on the sky:

Analemma

A consequence of :
- obliquity of the Earth axis
- Kepler's second law.



The Sun does not move along the ecliptic with constant speed.

https://analemma.com

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circumpolar stars around the north celestial pole.

southern Alberta (+51°), autumn

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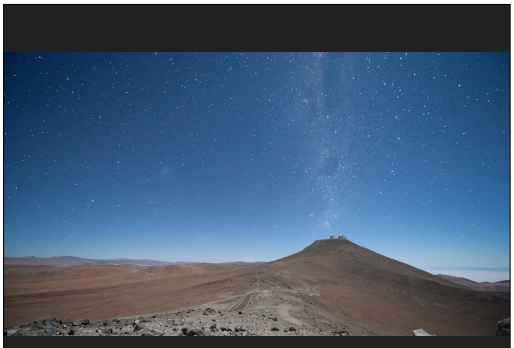

http://www.eso.org/public/videos/?search=timelapse+night+sky

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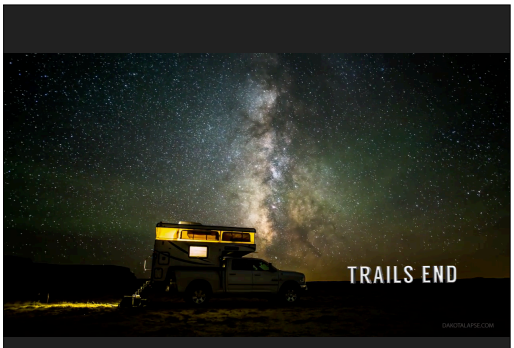

http://www.dakotalapse.com/time-lapse-videos/

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Demo Stellarium

www.stellarium.org