Astronomical Techniques

Lecture 1

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PDFs of talks

The PDF file for each lecture will be made available to you. So, don't bother copying stuff that is already on the slide.
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Introductions

What I will cover

Astronomical Techniques (Incoherent Detection)

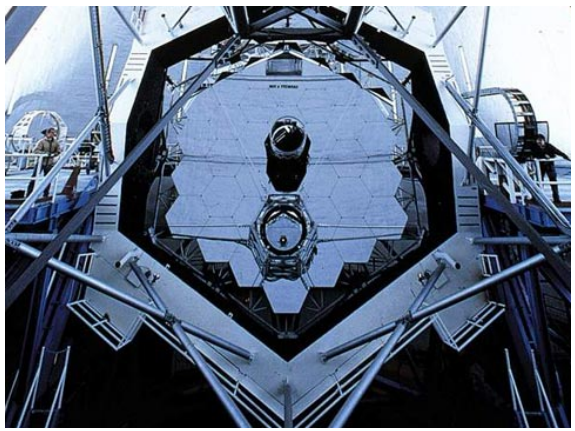
Time and coordinate measurements - Atmospheric effects (absorption, seeing, ...) - Basics of telescopes - Noise and statistics - 0D detectors - Basics of photometry
What I will not cover: Spectroscopic techniques, Instrumentation - CCDs, CMOS devices and IR-Arrays.

Textbooks

Unfortunately, I cannot find one (or a few) textbooks that are both comprehensive and current. This is not the fault of the text book but the fault of the diverse content of these lectures. Periodically, I will refer you to some textbooks for more details.

Questions?

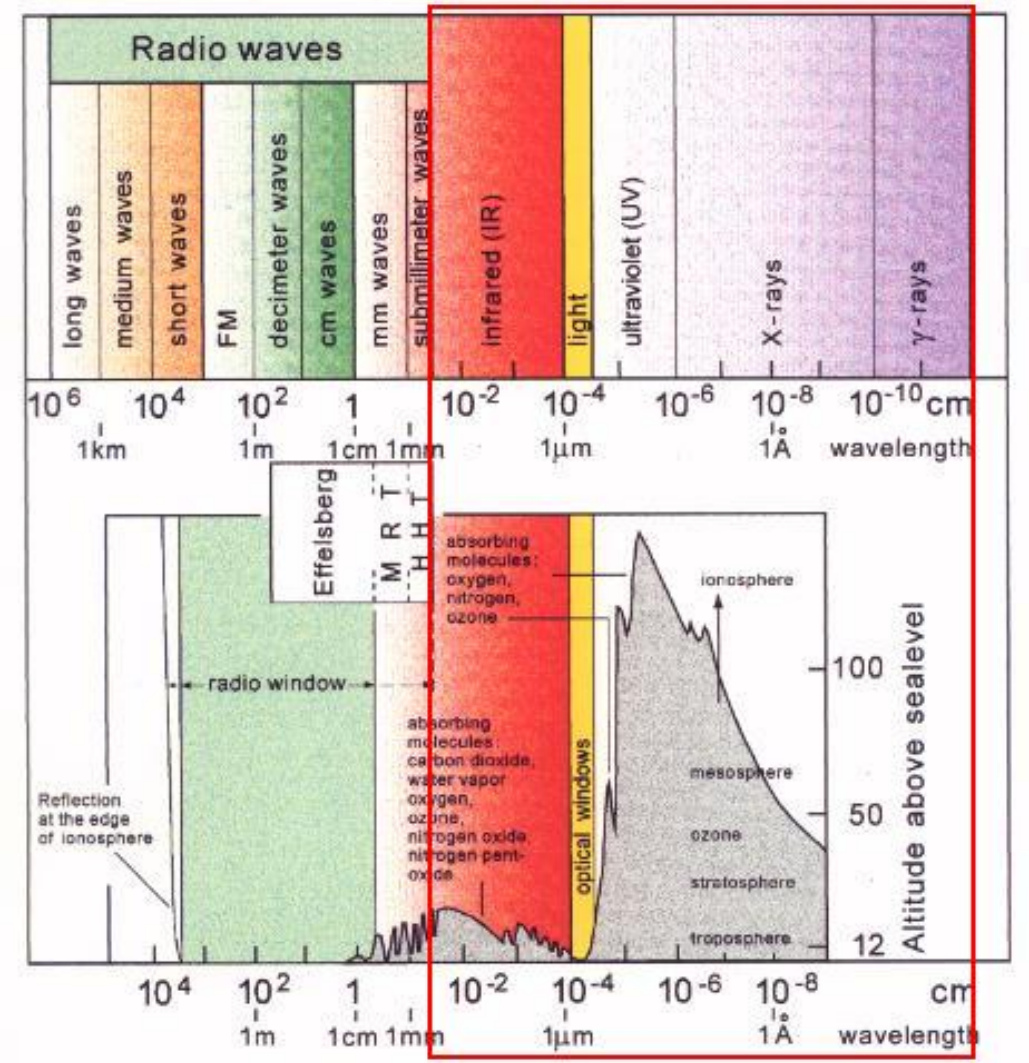
Incoherent-Coherent detection



(a) Incoherent

(b) Coherent

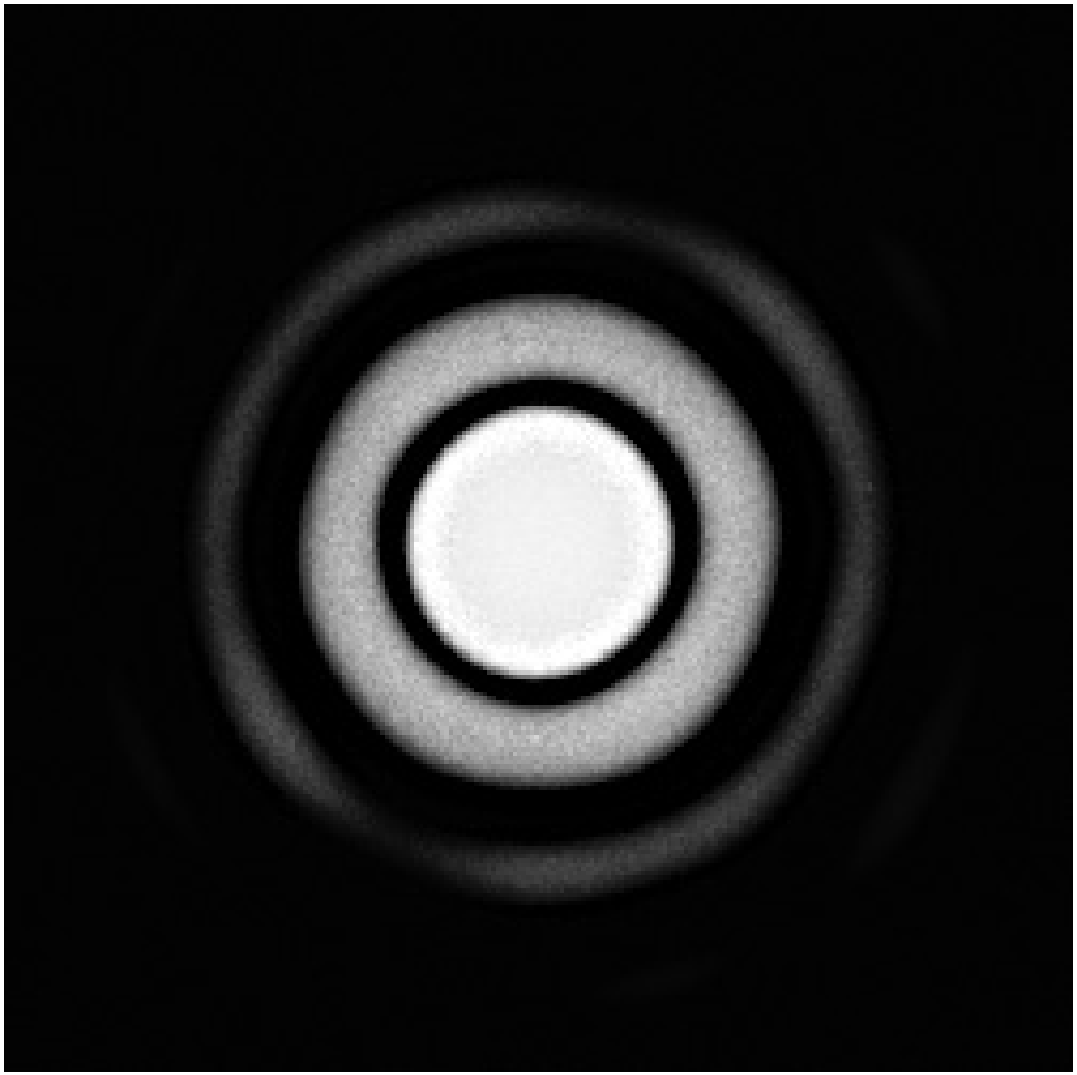
Wavelength regime covered in these lectures



Separate lecture on Radio Astronomy

Coherent-Incoherent division constrained by optics and electronics!

Wavelength between optical and radio



Solar Time

- Local time

Solar Time

- Local time
- Standard time

Solar Time

- Local time
- Standard time
- Greenwich time

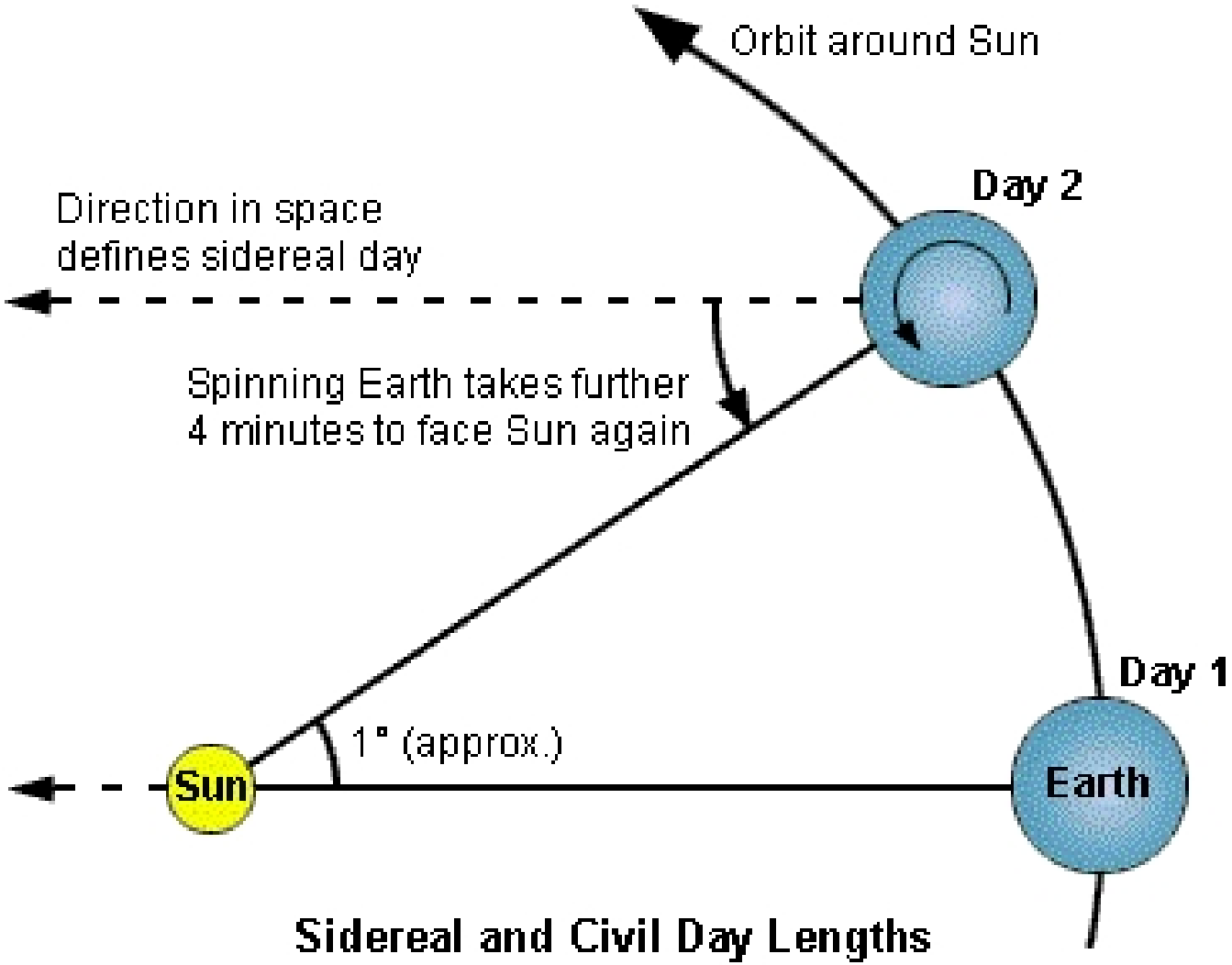
Solar Time

- Local time
- Standard time
- Greenwich time
- Universal time

Universal time

a generic reference to one of several time scales that approximate the mean diurnal motion of the Sun; loosely, mean solar time on the Greenwich meridian (previously referred to as Greenwich Mean Time). In current usage, UT refers either to a time scale called UT1 or to Coordinated Universal Time (UTC). UT1 is formally defined by a mathematical expression that relates it to sidereal time. Thus, UT1 is observationally determined by the apparent diurnal motions of celestial bodies, and is affected by irregularities in the Earths rate of rotation and needs correction. UTC is an atomic time scale but is maintained within 0s.9 of UT1 by the introduction of 1-second steps when necessary.

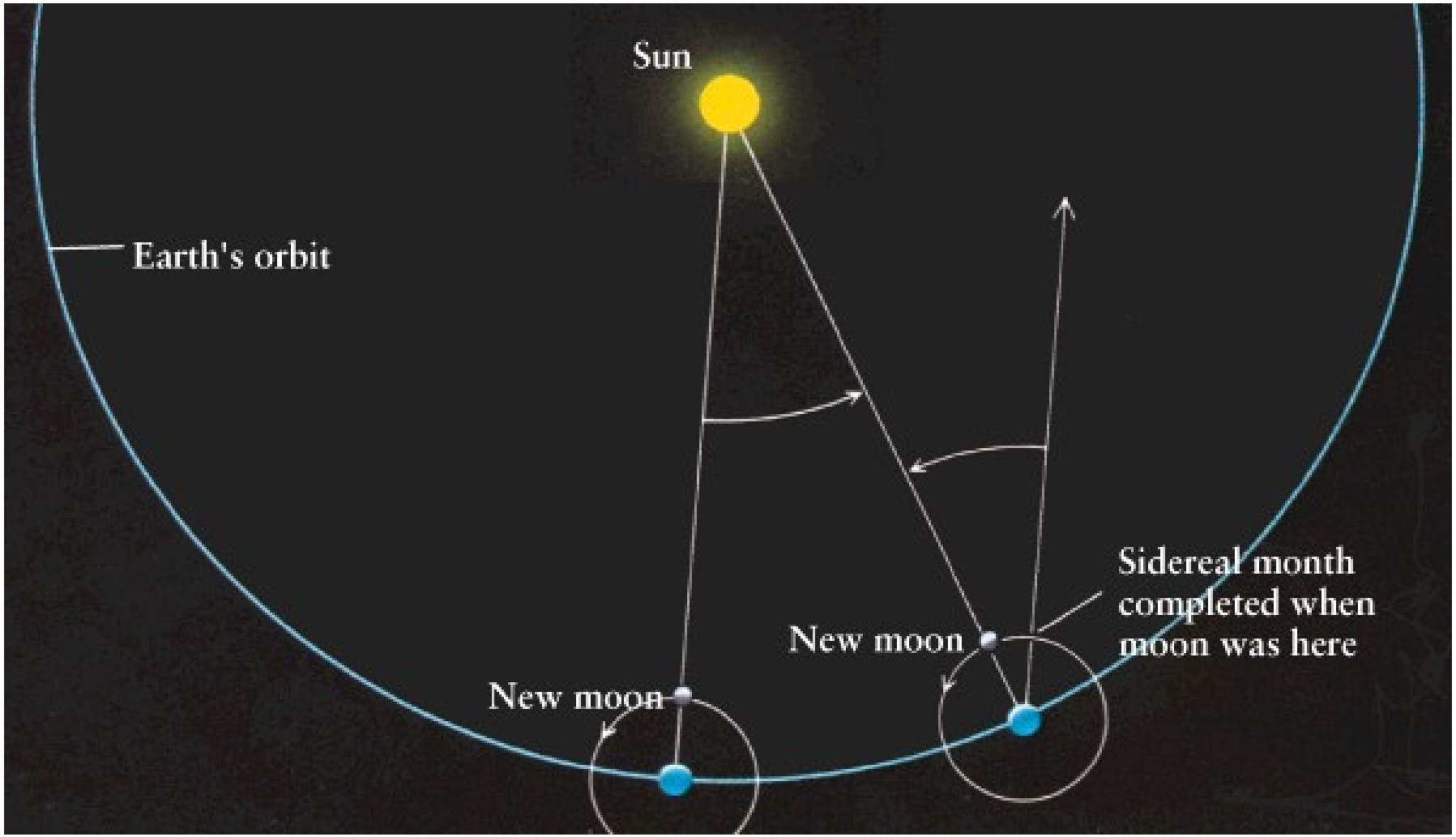
Sidereal versus Solar Day



Sidereal and Civil Day Lengths

Could the sidereal day have been longer than a solar day?

Sidereal versus Synodic Month



Most lunar calendars use the Synodic month

Julian Day

- the interval of time in days and fractions of a day, since 4713 B.C. January 1, Greenwich noon.
- note that Julian day starts at noon. Why?
- Astronomers often use modified Julian day (MJD; starts at midnight!) or reduced Julian day (RJD)

Sunrise, Sunset

the times at which the apparent upper limb of the Sun is on the astronomical horizon. In The Astronomical Almanac they are computed as the times when the true zenith distance, referred to the center of the Earth, of the central point of the disk is 90 deg 50 min, based on adopted values of 34 arcmin for horizontal refraction and 16 arcmin for the Sun semidiameter.

Twilight

the interval of time preceding sunrise and following sunset during which the sky is partially illuminated. Civil twilight comprises the interval when the zenith distance, referred to the center of the Earth, of the central point of the solar disk is between 90 deg 50 min and 96 deg, nautical twilight comprises the interval from 96 to 102 deg, astronomical twilight comprises the interval from 102 to 108 deg

Year

- **Tropical year** (or solar year): the period of revolution of the Earth around the Sun with respect to the *dynamical equinox*. The tropical year comprises a complete cycle of seasons, and its length is approximated in the long term by the civil (Gregorian) calendar. It is approximately 365 days, 5 hours, 48 minutes, 45 seconds (365.2422 days).
- **Sidereal year**: the period of revolution of the Earth around the Sun in a fixed reference frame. It is the mean period of the Earths revolution with respect to the background stars. The sidereal year is currently approximately 20 minutes longer than the tropical year. Will our night sky in January 10000 AD look very different? Will it still be winter in January?
- **Anomalistic Year**: the period between successive passages of the Earth through perihelion. The anomalistic year is approximately 25 minutes longer than the tropical year.

Gregorian calendar

- The calendar introduced by Pope Gregory XIII in 1582 to replace the Julian calendar. This calendar is now used as the civil calendar in most countries. In the Gregorian calendar, every year that is exactly divisible by four is a leap year, except for centurial years, which must be exactly divisible by 400 to be leap years. Thus 2000 was a leap year, but 1900 and 2100 are not leap years.
- (365 * 400 + 100 - 3)/400 = 365.2425

Equation of time - the fictitious mean sun

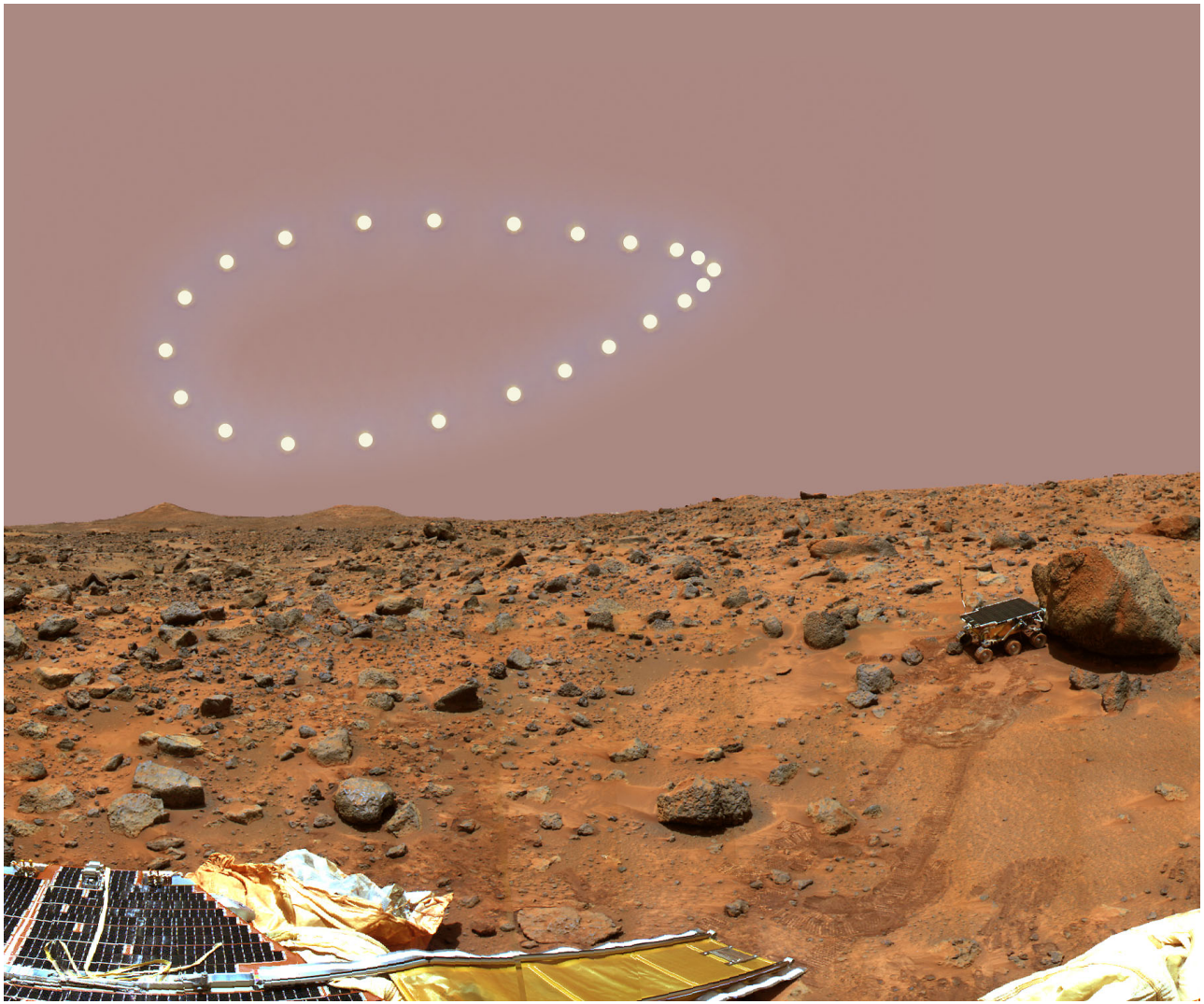
Some questions to ponder

- What is the shortest day of the year?
- When is the earliest sunset?
- When is the latest sunrise?
- Why are these 3 dates not coincident?
- And how is this connected to the fact that the time shown by any sundial needs a correction that depends on the time of year?

Equation of time

The equation of time describes the discrepancy between two kinds of solar time. These are apparent solar time, which directly tracks the motion of the sun, and mean solar time, which tracks a *fictitious mean sun* with noons 24 hours apart.
There seems to be no convention for the sign (+-) of the equation of time.
Why is there a non-zero equation of time?

Mars analemma

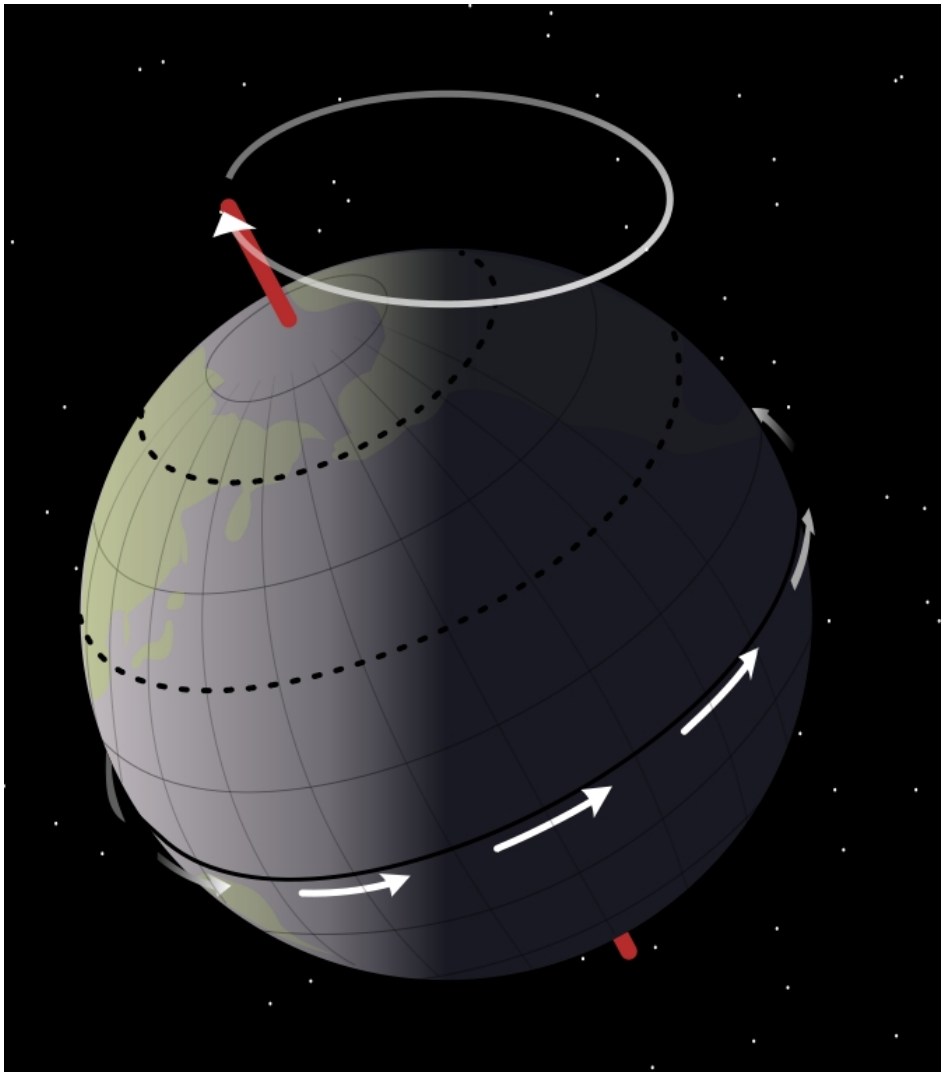


Read: http://scienceblogs.com/startswithabang/2009/08/26/why-our-analemma-looks-like-a/

Summary

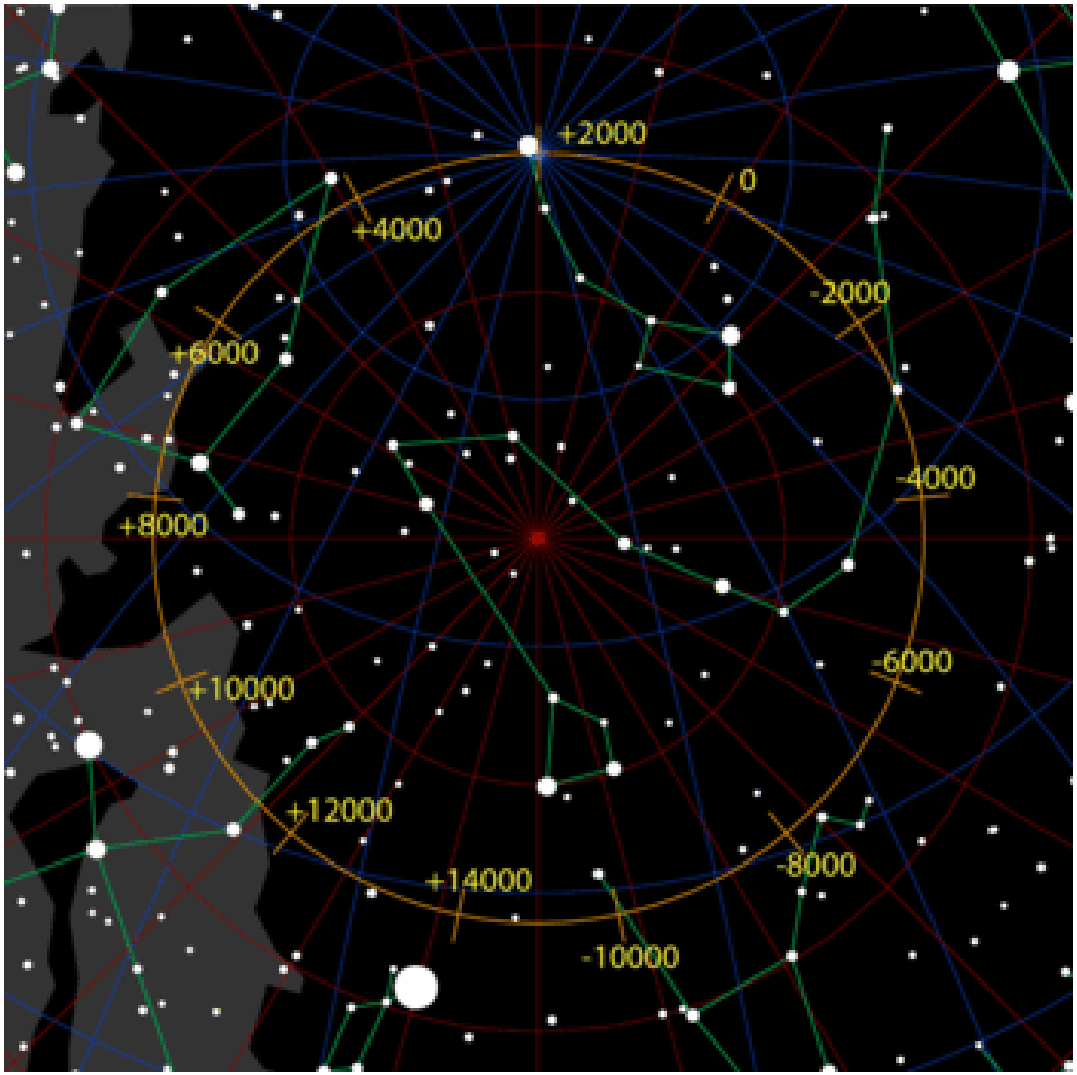
solar time, universal time, sidereal time, sidereal/synodic months, sunrise, sun set, twilight, equation of time.

Earth precession - 25800 year cycle



Note direction of precession

Earth precession changes the pole star



Altazimuth coordinates