PHYS 162 Elementary Astronomy

- Instructor: Mary Anne Cummings, macc@niu.edu
- Book: Discovering the Essential Universe, Neil Comins (5th edition but can use 4th Ed.)
- Recommended: The Cosmic Perspective Fundamentals, Bennett et al
- Grading   - 4 exams, each 100 points. Lowest one dropped. You can drop the final problems plus extra credit curve on syllabus

MAIN WEB PAGE

- nicadd.niu.edu/~macc/162/162.html
- Syllabus
- Example Tests (and answers)
- lecture transparencies
- Can e-mail inquiries to: macc@nicadd.niu.edu
- Google "Mary Anne Cummings" to find web page
- bcs.whfreeman.com/deu5e for book; nothing on this page is required for the course
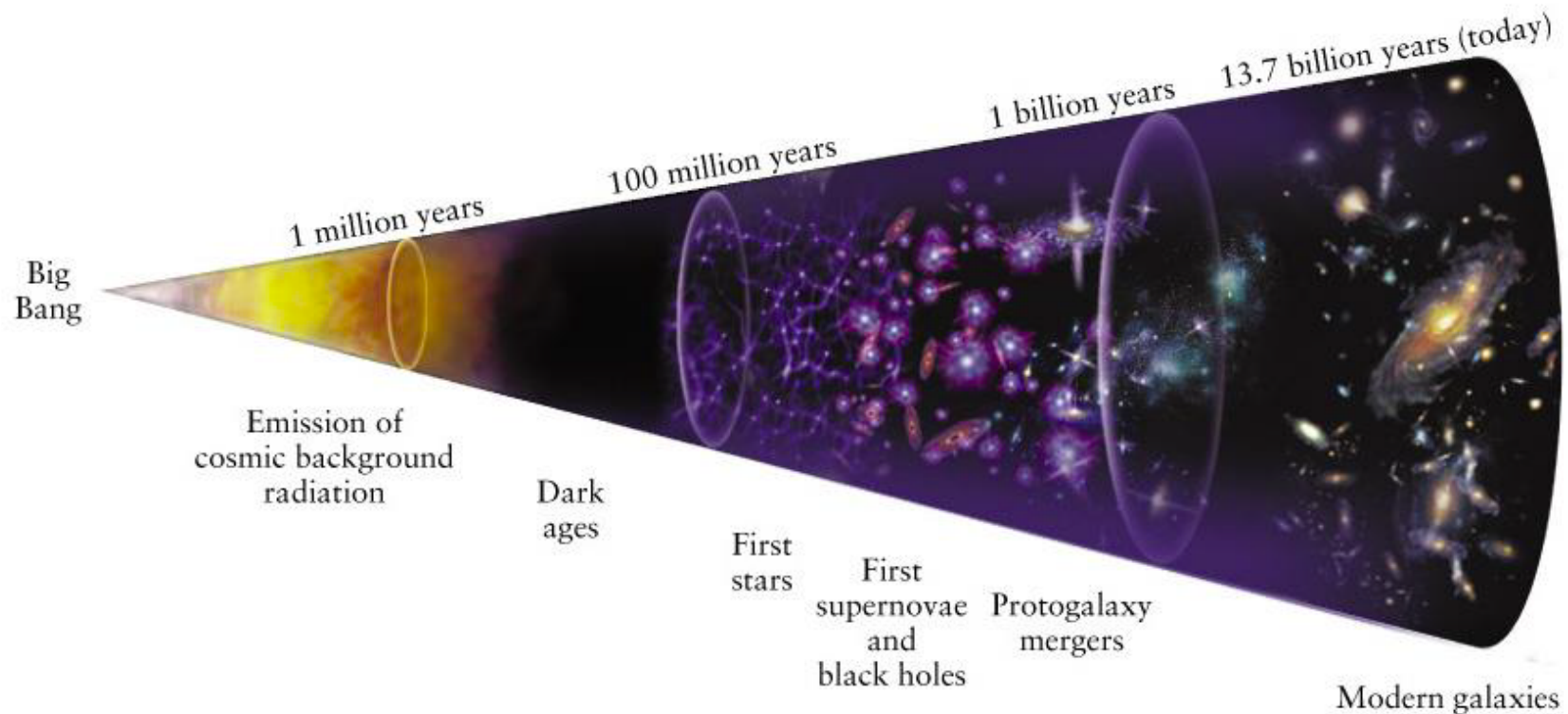
Blackboard Page

Still working on this…

- Points on exams will be posted here

- Points for "problems plus extra credit" will be put in 1 category with 52 points maximum (24 for problems and 28 for extra credit)

- Grade assigned by Blackboard is meaningless – just ignore

- If you take 4 exams Blackboard won't know to drop the lowest score and so Blackboard point sum is then meaningless

Observatory

- www.physics.niu.edu/~observatory for info on the observatory → often clear skies in January and February

- Open Thursday and Friday 7-11. While open rain or shine best to go when clear

- Fall objects: Mars (evening), Jupiter (later/early morning), Saturn (evening early), Double Cluster in Perseus, Moon, Andromeda Galaxy, Globular Cluster M22, some double stars, and later in term Orion Nebula and Pleiades Cluster

- October solar and lunar (Oct 8) eclipses!

The arc of this course…

1 million years

100 million years

1 billion years

13.7 billion years (today)

Big Bang

Emission of cosmic background radiation

Dark ages

First stars

First supernovae and black holes

Protogalaxy mergers
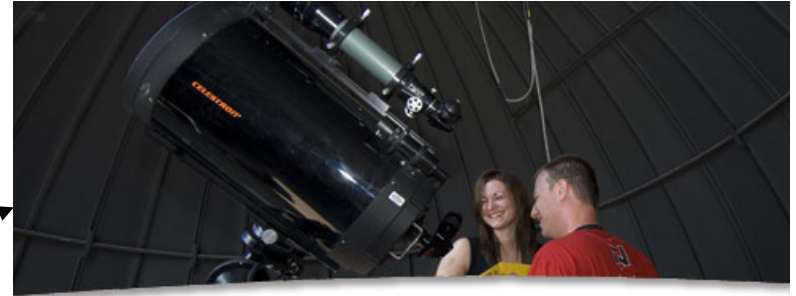
Modern galaxies

- Local planets => exoplanets
- Sun => stars
- Milky Way galaxy => other galaxies
- Known physics => help explain the universe

PROBLEMS

- Due day of test…
- go over the period preceding the time of the test …
- "easy" points

EXTRA CREDIT

- observatory visit. sign-in → up to 10 points for observatory report
- will show several movies in class. sign-in → 2 EC points each movie
- write a 2.5-4 pages report on 1 or 2 movies → up to 10 points each report
- up to TWO 10-point extra credits can be turned in. Due BEFORE final. DO NOT e-mail; print out a copy for me
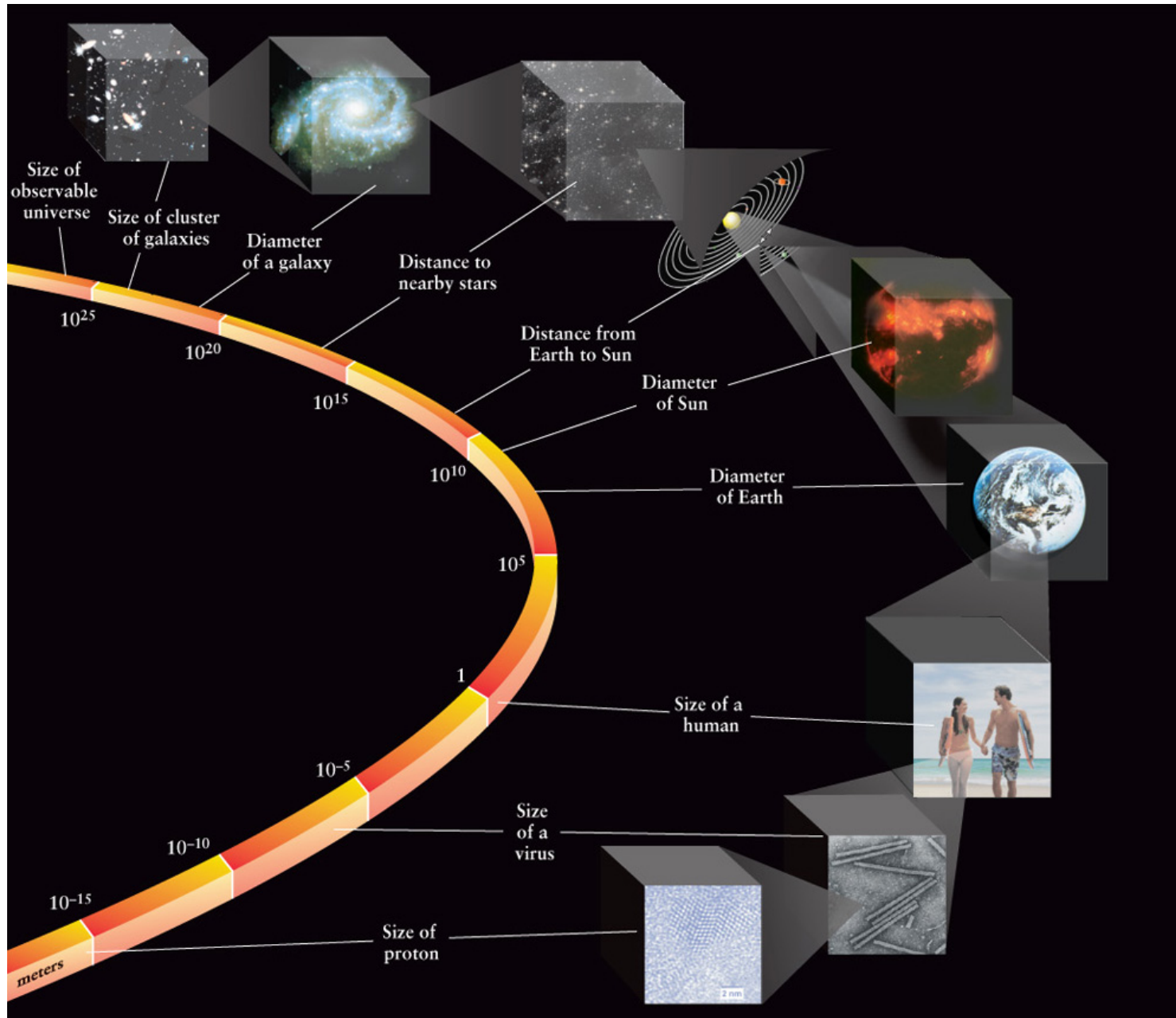
Hints on taking this course

- Print out and look at example tests early

- Transparencies are on web page and can be printed out.

- Do the review questions

- Do well on early test and then skip the final (which is harder as it covers more material)

- Do extra credit (observatory tour, movies)

Course Content

- Definition of astronomy - the science of the stars and other heavenly bodies

- We use our knowledge of physics, chemistry, and geology to understand PLANETS, STARS, GALAXIES,UNIVERSE

- Planets/stars/etc also serve as "laboratories" for conditions beyond human-built experiments and studying them increases understanding of sciences

- Early studies of planetary motion lead to understanding of gravity and forces (physics and in this course). Modern studies of planets concern geology and weather (not in this course). Studies of stars, the formation of galaxies and the universe depend on the properties of basic matter and forces (physics in this course) Also include astrobiology as interesting.

Sizes in Astronomy

- Astronomy examines objects that range in size from the parts of an atom ($\sim 10^{-15}$ m) to the size of the observable universe ($\sim 10^{28}$ m).

- Scientific notation is a convenient shorthand for writing very large and very small numbers

Size of observable universe

Size of cluster of galaxies

Diameter of a galaxy

Distance to nearby stars

Distance from Earth to Sun

Diameter of Sun

Diameter of Earth

10^{25}

10^{20}

10^{15}

10^{10}

10^{5}

1

10^{-5}

10^{-10}

10^{-15}

meters

Size of a human

Size of a virus

Size of proton
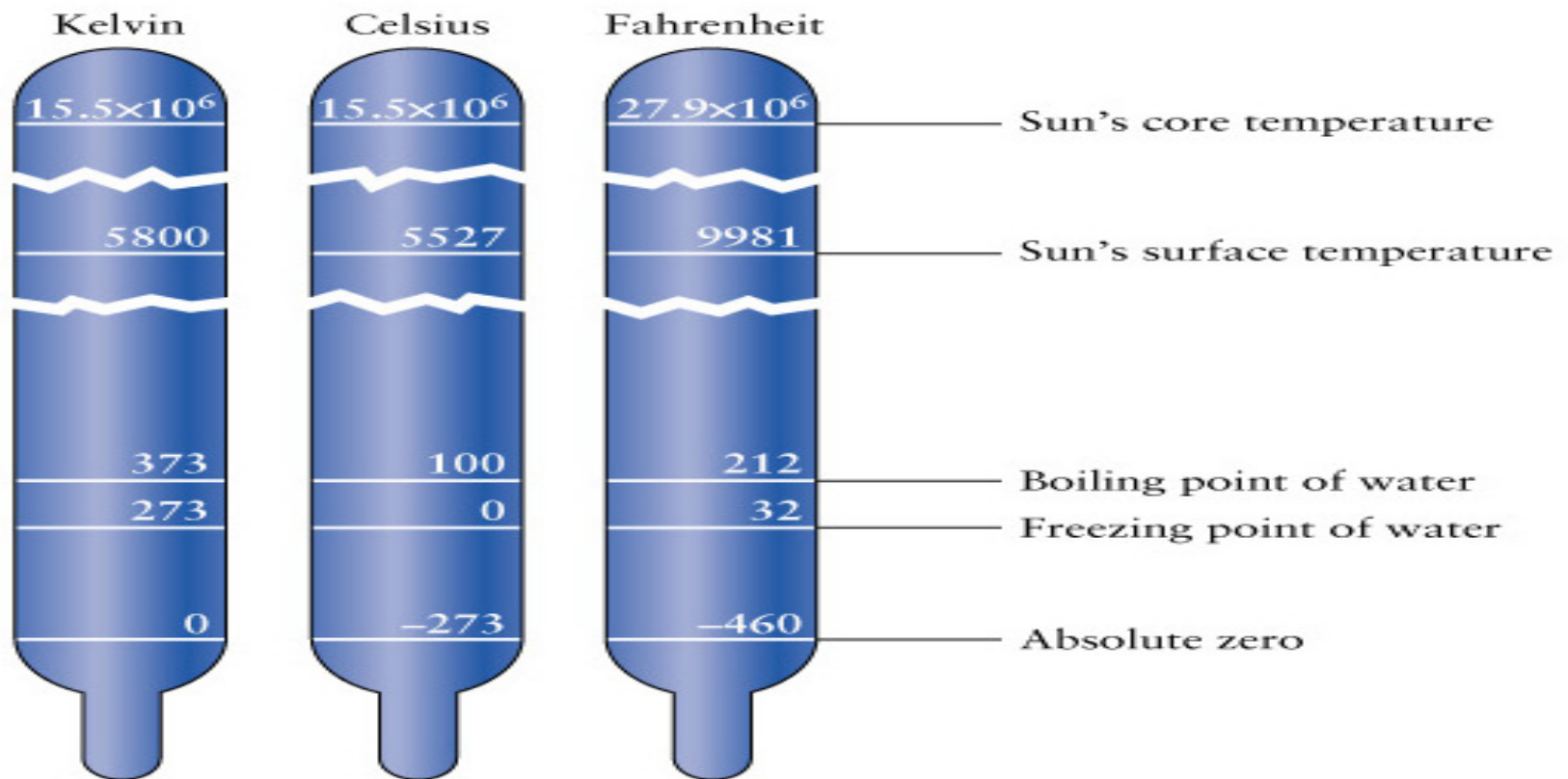
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PHYS 162 Class 1a

10

Units and Powers of 10

- We won't use much "math" and you don't have to remember these values, just don't get lost. Use AU and LY for most distances

- Solar radius = 700,000 km = 7×10^5 km

- Distance Earth-Sun = 1 Astronomical Unit (AU) = 150,000,000 km = 1.5×10^8 km   (= 8 light-minutes)

- Distance to the closest star = 4×10^{13} km = 4 Light Years = 4 LY

  1 LY = distance that light travels in one year

  = velocity x time

  = 3×10^5 km/sec x 3.12×10^7 sec/year

 = 10^{13} km

- 1 parsec = 3.3 LY

USE

AU and LY

Temperature Scale

- again don't really worry about this but don't get lost

- we use Kelvin Scale → temperature of space is almost 0 degrees Kelvin (actually 3 degree K)

	Kelvin	Celsius	Fahrenheit	
	15.5×10^6	15.5×10^6	27.9×10^6	Sun's core temperature
	5800	5527	9981	Sun's surface temperature
	373	100	212	Boiling point of water
	273	0	32	Freezing point of water
	0	−273	−460	Absolute zero

Easy/Early Observations

- Sky is dark at night (means the universe is finite – and not static - Olber's paradox)

- Sun produces light and heat

- Moon 'produces' light but relative to Sun's position

- Earth, moon, Sun all spherical objects 'suspended' in space
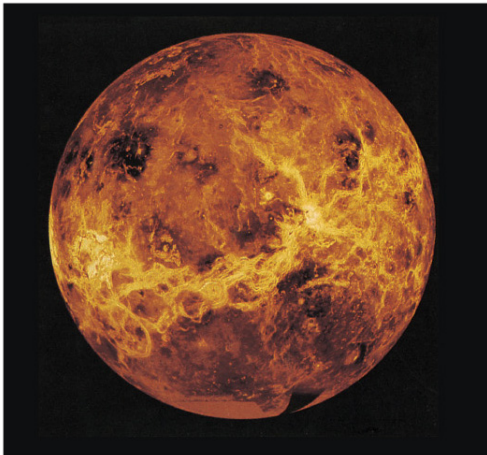
Easy/Early Observations

- Regular predictable motion

  sun,moon,stars   Daily

  moon   Monthly

  stars   Yearly
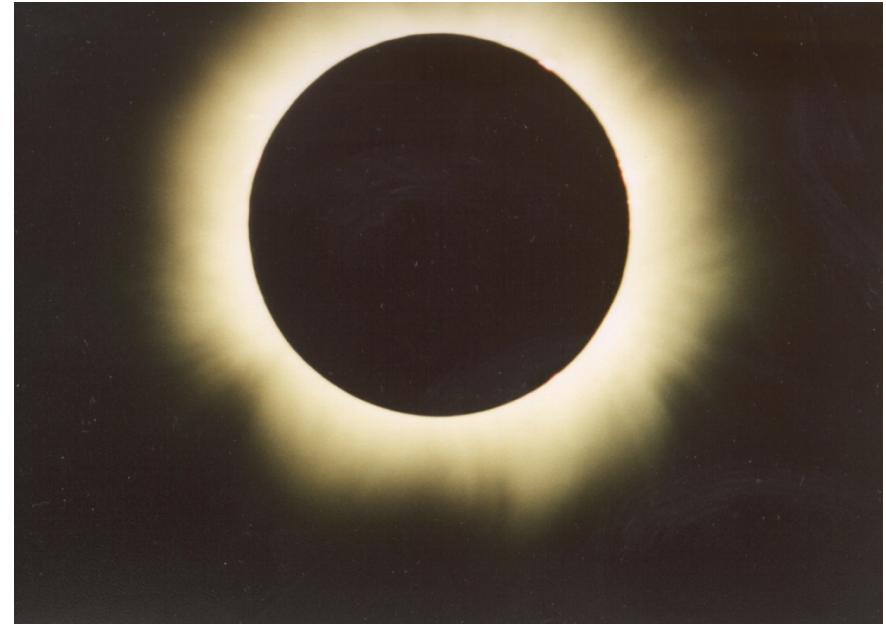
  seasons   Yearly

which are readily explained by having the Earth spin (daily) and orbit the Sun (yearly)

- unpredictable motion (comets,novas) considered disturbing/evil

Star Motion during One Night

Phases of Moon (skip tides)

Eclipses

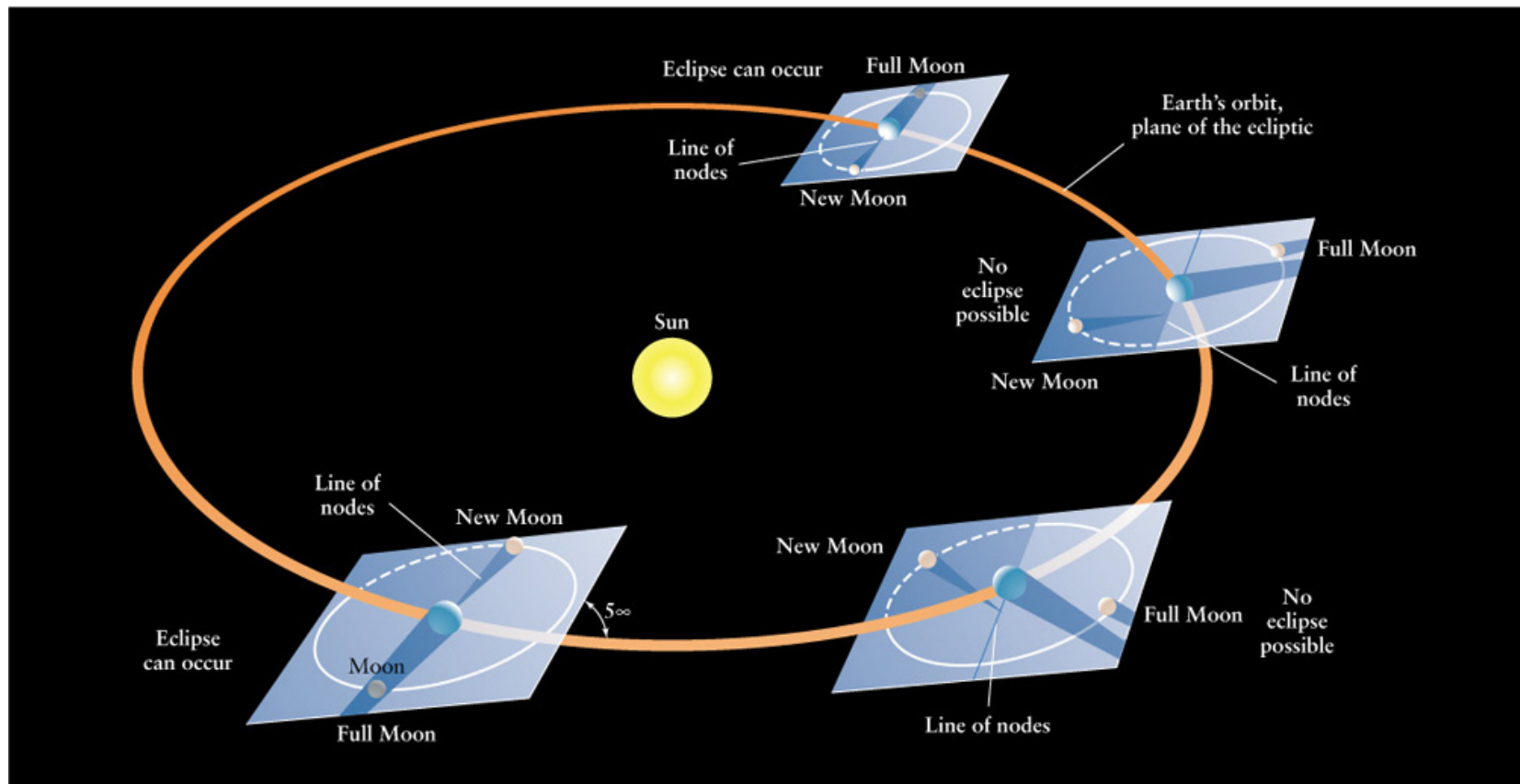Eclipse occurs when Sun-Moon-Earth aligned. Total→ Sun 100% blocked

Total Solar eclipse – Turkey 8-11-1999 (NIU sponsored trip)

Next US total eclipse → 8-21-2017

Partial eclipse 10-21-2014 in Illinois

Eclipses

Apparent size of Moon and Sun from Earth are accidentally almost the same. Moon was closer and so bigger in the past → dinosaurs saw more total eclipses

Markers of Time

DAY: Sun at maximum height

MONTH: length of time it takes for the moon to make an orbit around the Earth (repeats phase every 29.5 days)

Most early cultures use the day and month to mark time

moon-month-measure-man   may all have the same root

Length of Day and Month are changing

- Friction between the Earth and the Moon   (seen daily in tides)

- Day becomes .002 seconds longer each century

- Moon receding from the Earth by 4 cm each year

500,000,000 years ago there were

      22 hours in a day

      400 days in a year

Billions of years in the future there will be

    1 "day" = 47 present days

    1 "month" = 1 "day"

Earth-Moon frozen with no additional spin for the Earth alone

The Year

Two Indicators

- Due to the Earth's tilt:

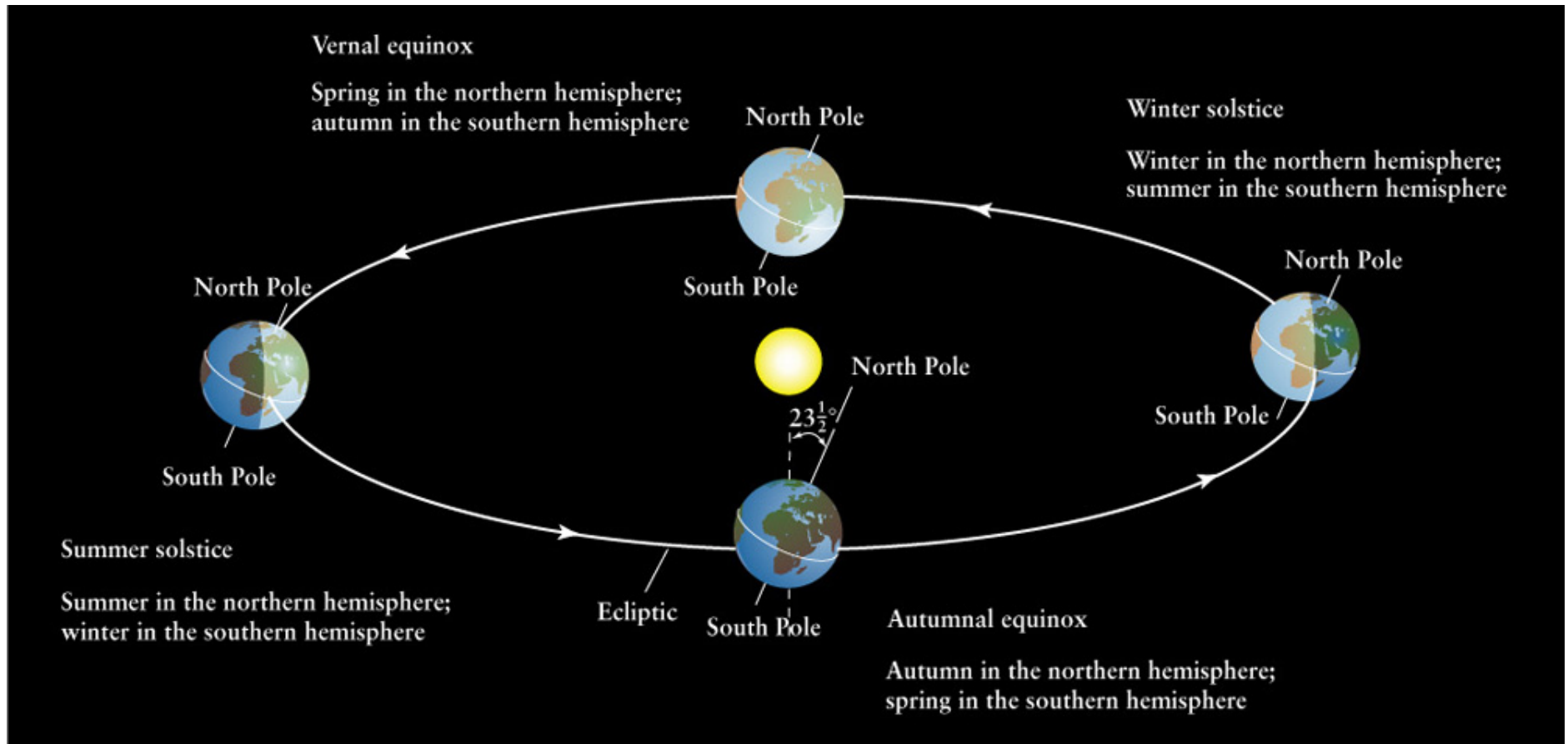 Length of the Day and Sun's path through the sky vary. One year = returns to the same spot

More dramatic further north (Stonehenge)

- Which stars are overhead changes with seasons. Gives passage of year

  Passage of time at night also given by stars' apparent motion

Stars = Calendar and Clock

Yearly Motion: Earth orbits Sun

Vernal equinox

Spring in the northern hemisphere; autumn in the southern hemisphere

North Pole

South Pole

Winter solstice

Winter in the northern hemisphere; summer in the southern hemisphere

North Pole

South Pole

North Pole

South Pole

North Pole

$23\frac{1}{2}°$

Summer solstice

Summer in the northern hemisphere; winter in the southern hemisphere

Ecliptic

South Pole

Autumnal equinox

Autumn in the northern hemisphere; spring in the southern hemisphere

Stonehenge

365.242 days in a year - not on tests

- "Ancient" calendars were Lunar

  Babylon - 12 months 6 with 29 days and 6 with 30. Add 13th month occasionally (also used in India and similar in China)

  Egypt - 12 months each 30 days plus 5 extra

  Polynesia - 13 lunar months drop 1 occasionally

- Priests would determine when to add extra months and day

- Very tempting to have 360 days in a year and 12 months of 30 days. "nice" numbers

  Lack of correlation between day-month-year "bothered" philosophers and theologians. Understanding this "random" motion (and the planets were even worse) by Copernicus, Kepler, Galileo, Newton gave us modern science

365.242 days in year- not on tests

- If normal year has 365 days need extra 24 days/century and extra 2 days/millennium

- 46 BC Julius Caesar (really Sogigula an Egyptian) - Julian calendar with leap day every 4 years. But 8 too many days every 1000 years so….

- Gregorian calendar adopted

  Spain and Catholic Europe   1582

 England   1751

 Russia   1918

  which immediately skipped 10 days (in 1582). No leap day on century years 1700, 1800, 1900, 2100, 2200 (just those divisible by 400 like 2000)

Larger Cycles

As the Earth spins around its axis and orbits around the Sun, several quasi-periodic variations occur due to gravitational interactions. The dominant effects are:

      1. Orbital shape (eccentricity)

      2. Axial tilt (obliquity)

   3. Axial precession

Orbital shape (eccentricity)
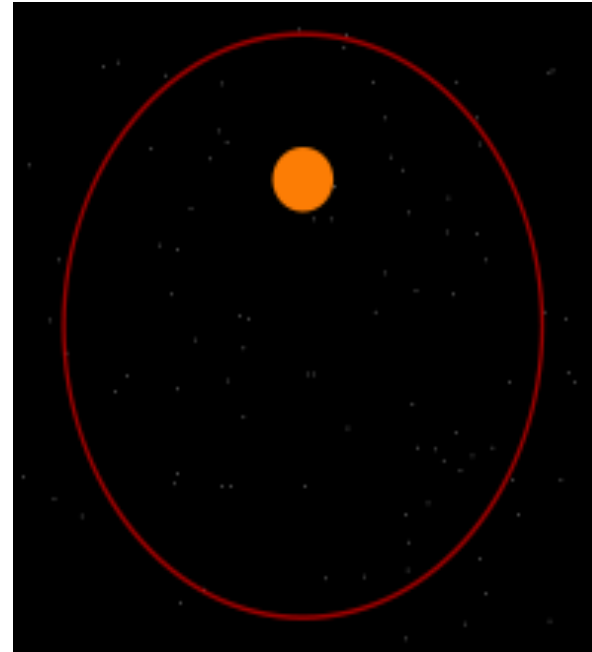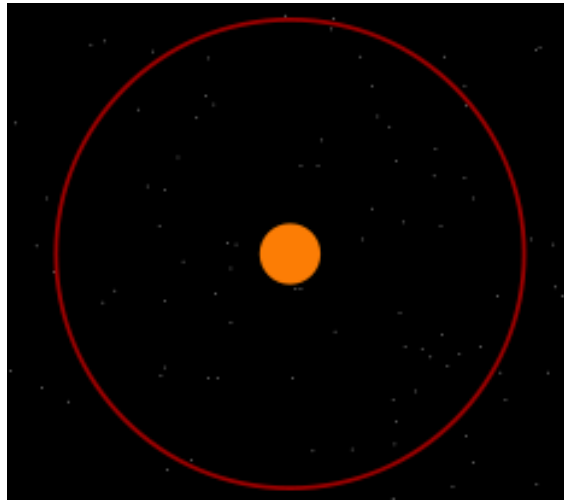
The Earth's orbit is an ellipse. The shape of the Earth's orbit varies in time between nearly circular (low eccentricity of 0.005) and mildly elliptical (high eccentricity of 0.058) with the mean eccentricity of 0.028. Several effects loosely combine to a 100,000-year cycle.

Axial tilt (obliquity)
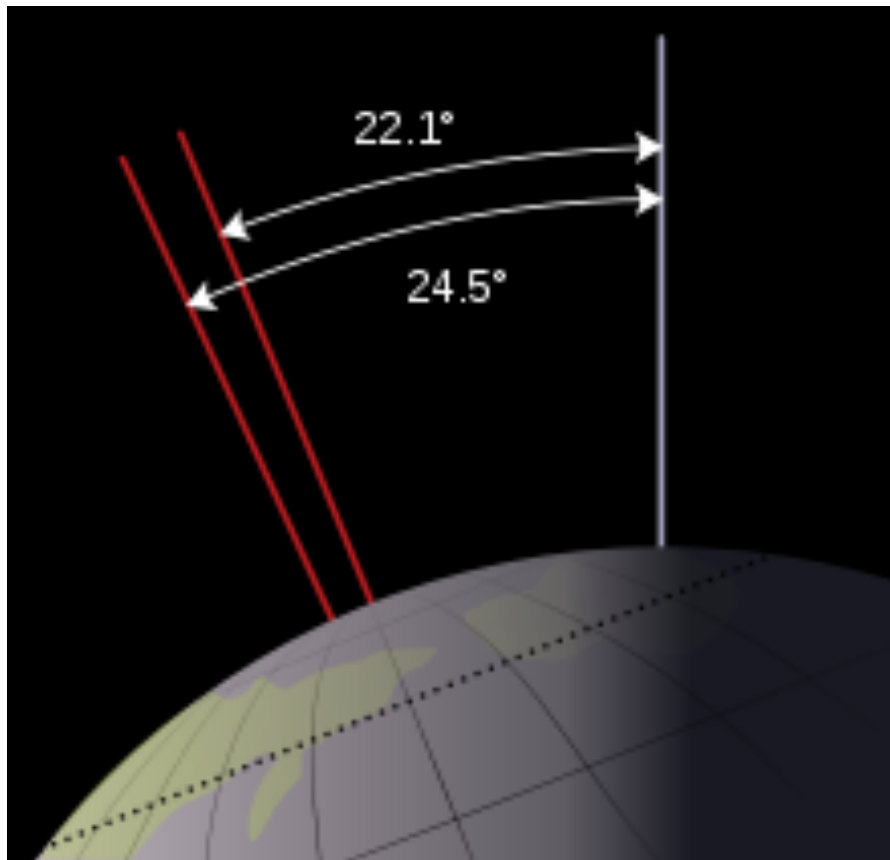
The angle of the Earth's axial tilt (obliquity of the elliptic)varies with respect to the plane of the Earth's orbit. These slow 2.4° obliquity variations are roughly periodic, taking approximately 41,000 years to shift between a tilt of 22.1° and 24.5° and back again..

Axial precession
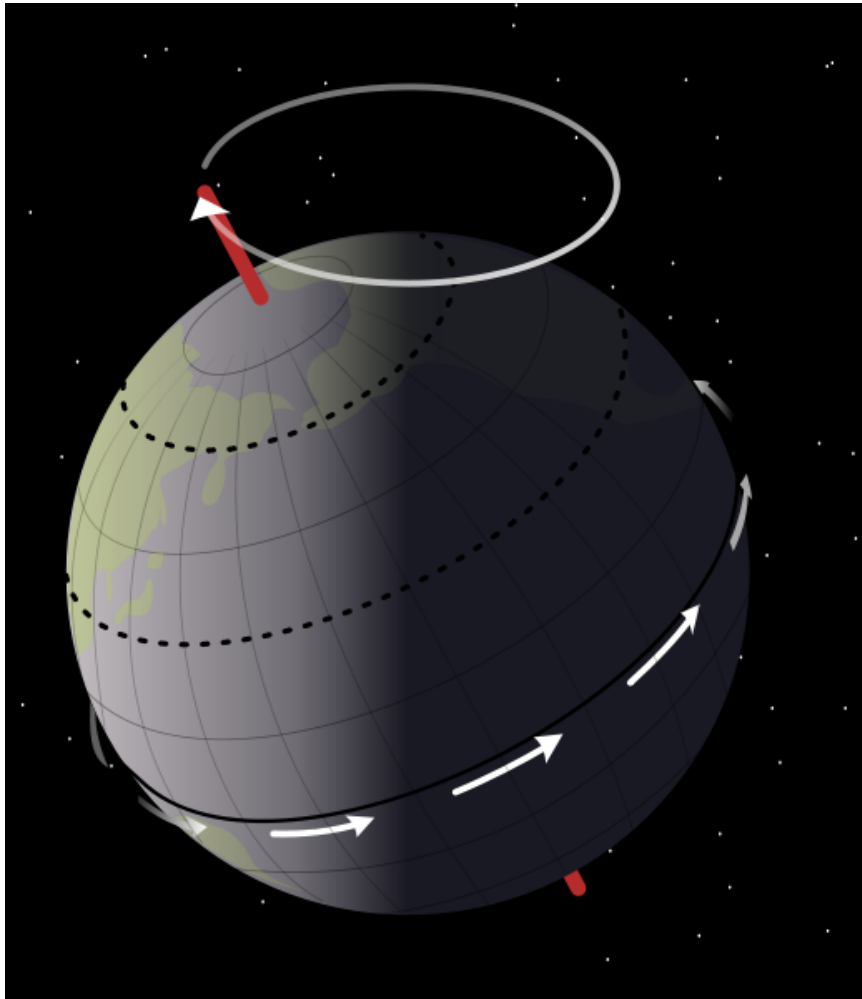
Precession is the trend in the direction of the Earth's axis of rotation relative to the fixed stars, with a period of roughly 26,000 years. This gyroscopic motion is due to the tidal forces exerted by the Sun and the Moon on the solid Earth, which has the shape of an oblate spheroid rather than a sphere. The Sun and Moon contribute roughly equally to this effect.