ECLIPSE 201

More about Eclipses

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Agenda

- The Saros cycle: Solar eclipses come in families
- Eclipse season: When can eclipses occur?
- Solar eclipses in science: General Relativity and the speed of the Earth's rotation
- Eclipses in Jewish law

The Saros Cycle

- The relative positions of earth, moon, and sun recur (almost) exactly every 18 years, 11 days, 8 hours; this period of time is called a **saros**.

- So for any eclipse, there's an (almost) identical eclipse 18 years, 11 days, and 8 hours later.

- The solar eclipses separated by this period form a group called a **saros series**. Monday's eclipse is in Saros Series 145.

Trout Lodge in 2035?

Eclipses in the same Saros Series differ because…

- …the saros is 6585 days *and 8 hours*, so the earth's rotation pulls each eclipse about a third of the way farther around the world.

- …the recurrence isn't exact, so the location of eclipses in a Saros Series progresses slightly, north to south or the reverse. The eclipses also change character as they progress, partial to total and back.

Progression of a Saros

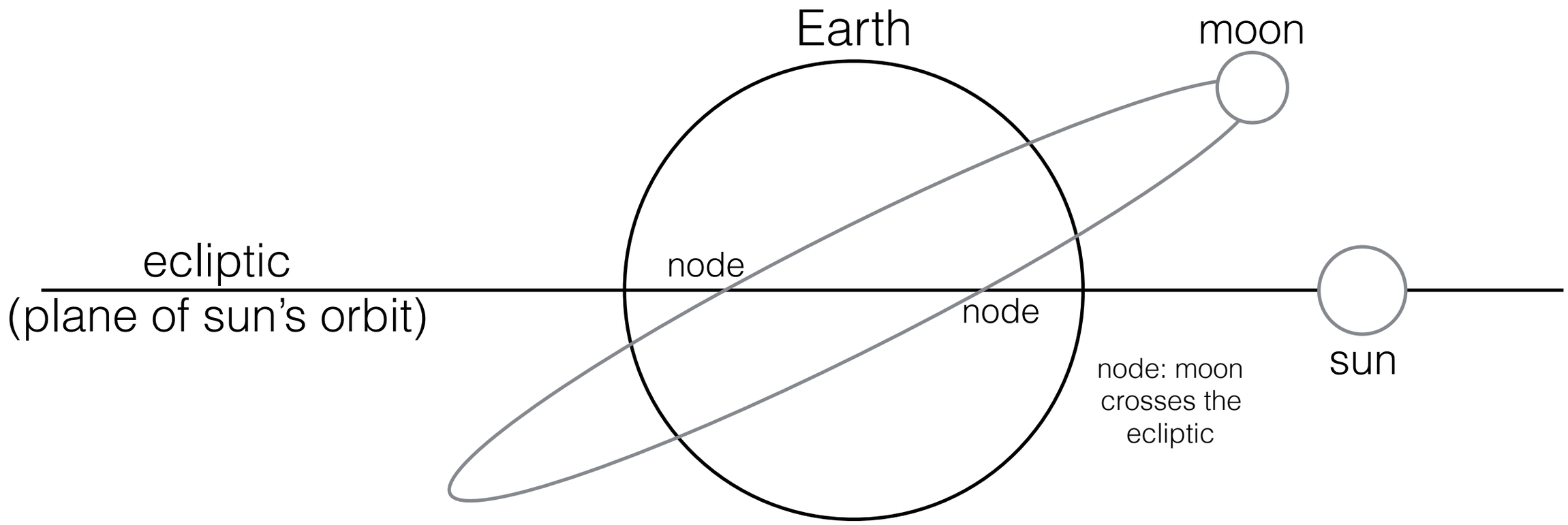
- Every Saros Series starts with a partial eclipse near the North Pole and ends with one near the South Pole (or the reverse, for even-numbered Series).

- Monday's eclipse is #22 of Series 145, which started with the partial eclipse of 1/4/1639 and will end with #77 on 4/17/3009. Don't wait up for me.

- #21 of this Series was the eclipse of 8/11/1999, which Karen, Rachael, and I saw in Bucharest (1/3 of the way around the world) and some here saw in Turkey.

The Eclipse Season

Picture a stationary Earth, with the moon in tilted orbit, and the sun moving around the Earth once per year.



Eclipses can occur only when sun and earth line up with a node, essentially twice per year. This time is called the **eclipse season**.

Eclipse Season, cont.

- The length of the eclipse season, about 34 days, depends on the sizes of the sun and moon. (If both were points, the eclipse season would be zero.)

- *Every new moon during eclipse season yields a solar eclipse; every full moon yields a lunar eclipse*.

- But the moon makes a full orbit in 28 days[*]! So *every eclipse season has at least one solar and one lunar eclipse*, and there can be a third (of either type).

[*] synodic vs. draconic complication elided

Eclipse Season, cont.

- Eclipse seasons don't occur twice per year due to the **regression of the lunar nodes**; the nodes move with respect to the sun's position.

- Result: There are two eclipse seasons, not per year, but per **eclipse year**, which is about 347 days.

- Hence a calendar year can have (a piece of) a third eclipse season, enough to slip in one more eclipse.

- Bottom line: *Every calendar year has at least 4 and at most 7 eclipses*; with at most 5 of any one type.

Einstein Proven Correct

- Newton knew that light rays bend near big objects. General Relativity predicts twice as much bending.

- The biggest nearby object is the Sun, and even there the bend predicted by G.R. is only 1.75 arcseconds.

- When a star is near the Sun, the latter is too bright for the star to be visible—except during an eclipse!

- During an eclipse in 1919 the bend in the light from a star near the sun was measured and found to be in accordance with the G.R. prediction.

The Length of the Day

- We can calculate the location and time of eclipses precisely for a couple thousand years forward and back.

- We find, e.g., that a total solar eclipse of 720 BCE would have been visible in the western Atlantic.

- But in fact, historical records of Babylon (now Iraq) report that the eclipse was visible there, in the wrong place!

- Conclusion: The speed of the Earth's rotation (i.e. the length of the day) is changing, and in fact is slowing down by about 2 ms / 100 years.

Eclipses and Jewish law

- Observant Jews say a blessing when eating, seeing a wise man, recovering from illness, getting bad news, etc.
  Is there a blessing for seeing an eclipse?

- The obvious choice is “oseh ma’aseh b’reishit”; praise to God for the works of creation, said upon seeing oceans, mountains, tornados, lightning, comets, shooting stars.

- But there is no blessing for an eclipse, which in the Talmud was considered an omen of evil, or trying times.

- Succah 29a gives the evil causes of eclipses, among them unprevented rape and two brothers killed together.

QUESTIONS?