Keeping time; oddballs in the sky

Astronomy 101
Syracuse University, Fall 2020
Walter Freeman

September 17, 2020

Announcements and questions

- If you've not gotten a project to evaluate by this point
  - Submit an evaluation saying that you didn't receive a submission
  - Describe briefly how you tried to contact the submitting group
- If you've not heard back from your evaluating group:
  - Send them a note and ask them where their evaluation is
  - Don't worry if you don't hear back; you'll get credit
- Project 2 has been posted
- We are in the middle of updating group rosters based on people's requests
- As before, if we change something in response to a request, you can work with either your new group or your old one

Please make an effort to work with your groupmates as adults. If you're having issues still after Lab 2 (if people don't show up to lab or contribute to Project 2), we will reassign you.

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The orientation of the Earth's tilt makes one rotation every 26,000 years.

Same deal:

- Tropical (seasonal) year: solstice to solstice
- Sidereal year: one orbit around the Sun; 1/26,000 less than a seasonal year

Now what do we have?

The year

Sidereal year

- One Earth orbit around Sun
- 365.26 24-hour days (1/26,000 *more* than a seasonal year)
- Sun returns to same place relative to stars

The day

Sidereal day

- One Earth rotation
- 23 hours 56 minutes (1/365 *less* than a solar day)
- Stars return to the same places in the sky

The moonth

Sidereal moonth

- One Moon orbit around Earth
- 27.3 days (about 1/12 *less* than a synodic moonth)
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Seasonal year

- One cycle of the seasons (solstice to solstice)
- 365.24 24-hour days (1/26,000 *less* than a sidereal year)
- Sun does not quite return to same place relative to stars!

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- One Earth rotation
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Solar day

- Noon to noon / midnight to midnight
- 24 hours (1/365 *more* than a sidereal day)
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- One cycle of the Moon phases
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Difference caused by wobble of Earth's axis; seasonal year about 1/26,000 shorter

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- Don't worry about it
- Intercalation: add extra days to a month, days to a year, or months to a year sometimes

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- ... the “12.35 moonth problem” (number of moon cycles in a year not even)
  - We don’t make any attempt to have our months match the moonths – we don’t care about the Moon.
- ... the “29.5 day problem” (number of days in a moon cycle not even)
  - We don’t care about the Moon, so this doesn’t matter

The Gregorian calendar was designed by Europeans. Why might they give primacy to the solstices and not the Moon?

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... we insisted that a year have 12 months *and* they line up with the lunar cycles?

... we needed the days to *exactly* match the rotation of the Earth, which varies a little bit?

Your first paper

The full thing is on the website. In brief:

- Choose a historical calendar
- Research it
- Write one page (or more) on how it describes the motion of the sky
- First draft due September 28 by end of day
- Potential for significant extra credit
- Some special assignments for particular calendars; read the whole thing

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... they're unpredictable!

We've long used the immutability of the sky as a symbol for constancy. The cycles of the Sun, Moon, and stars don't ever change, but some things do!

These unexpected things in the sky once terrified people; now we know why they happen.

Eclipses

You know that during a new moon, the Moon lies roughly between the Earth and the Sun.

However, the Moon's orbit is tilted just a bit, so it usually passes over or under the Sun.

If it passes in front, you get a solar eclipse!
This terrified many of the ancients – "the Sun got eaten! We're doomed!"

Eclipses

You know that during a full moon, the Earth lies roughly between the Moon and the Sun.

Same deal: usually the Earth's shadow misses the Moon. Sometimes it doesn't!

Here some light is refracted by the atmosphere. The blue component is scattered away by the atmosphere; the red component bends and hits the Moon.

Meteors

Orbits of things in the Solar System are not always close to circular.

There are lots of small things in the Solar System, many of which have elongated orbits that sometimes cross ours.

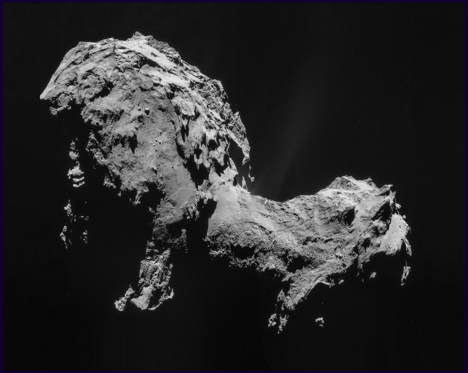
Meteors:

- Little rocky or metallic bits of matter that orbit the Sun
- Sometimes they get to Earth and glow as atmospheric drag heats them
- Sometimes they hit the surface, and we get chunks of space-slag
- Historical cultures sometimes used them as easy access to metal

Comets

Comets are “dirty snowballs”. Most stay in the outer edges of the Solar System (100+ AU), but some have orbits that are *highly* elongated and come close to the Sun (remember we are 1 AU away).

- Mostly made of ice
- When they get close to the Sun, the heat melts bits off of them
- This stream of stuff reflects sunlight and makes the comet’s “tail”
- Historical cultures were often terrified of them, but they’re just space-snowballs



The planets: what has gone wrong?

Demo on *Stellarium*

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Sometimes some planets appear to go backwards ("retrograde motion").

This tells us that celestial sphere model can't be literally true. Why does it work for everything else?

- The celestial sphere model works if things appear to only rotate around the Earth.
- The stars are so far away that only the Earth's rotation matters
- The Earth orbits the Sun, so we just pretend that the Sun is on a different sphere turning a bit slower, taking into account both our revolution around it and our rotation
- The Moon orbits the Earth, so we again put the Moon on a different sphere, turning slower
- ... but how can we get a sphere to go forwards and backwards?
- **The celestial sphere model gets the motion of the planets badly wrong**