Astro 210

Lecture 2

Jan 19, 2018

Announcements

- pick up HW1; due online next Friday 5pm–submit as pdf
- **register** your iClicker; link on course webpages
- pick up Syllabus if you didn't get one last time
- If this is your first time to class:
  - ▷ Welcome!
  - ▷ talk to instructor after class
  - ▷ read syllabus

Last time: Overview and Appetizer

Today: The Great Work begins!

iClicker Poll: Homework Printout

HW1 is posted online; printouts also available.

You are welcome to printouts, but some prefer paperless

Would you like a printout of the homework and other assignments?

A yes

B no

Online Notes

Class notes will be posted online and available all semester

Astro-Tip:
Each class meeting has a webpage and notes like these
They will remain on the course website throughout the semester
So no need to write what's in this file...
also: when printing out pdf notes, you may find *2 or 4 slides per page* is legible, saves paper

Notes are posted right before each class
but best to wait about 1 hour after class:
updated/corrected notes posted

Class Notes Online: A Good Thing?

Pros:

- you are not a stenographer–can use your brain to think and not transcribe
- don't have to read my bad handwriting

Cons:

- tempting to be astro-hypnotized
  so: I'll ask Socratic questions and iCliker polls throughout
- might give incorrect impression that there's no reason to come to class
  but: I'll give extra pearls of wisdom verbally
  ...and you'll miss the *required & easy* iClicker participation points
  not to mention demos, music, and movies

Bargain:
- I'll avoid railroading you
- you pay attention, ask questions when confused/interested

Building a Scientific Cosmology: The Night Sky

Cosmologies

Cosmology: study of/ideas about the big picture
$\longrightarrow$ origin and nature of "the world/the universe"

A big subject! And many possible ways to approach it...

ASTR210: *Scientific* or *Physical* Cosmology
Q: what does this mean?
Q: what other kinds could there be? [turtle story]

Observing the Sky

Science begins with collection of **data**

Astronomy began with naked-eye observations
of day and night sky

The Shape and Contents of the Sky

Q: What is geometry of the sky as observed from Earth's surface?

...recalling that the eye can't tell
depth/distance to celestial objects

Q: What coordinate system(s) might be useful to describe the sky?

Geometry of the Sky

In reality: celestial objects arranged in 3-D space
But: your eye can't tell distance to these objects
no "sense of depth"
So observationally: the sky "flattened" into a 2-D surface

⋆ **Crucial fact of life in science:**
have to connect
(a) what you can actually *observe/measure: data*
(b) with what is "really" going on–*models/theory*

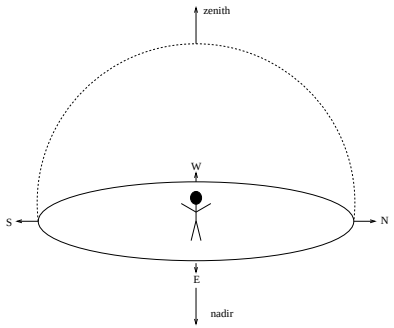
In astronomy: observe objects in sky
can measure position = direction on sky
→ 2-number "address" ⇔ 2-dimensional sky but sky gives *no* direct information about distance
→ observed sky flattens the 3-dimensional arrangements down to **2-D sphere** projection: "cosmic roadkill"

Geometry problem: have to always go between

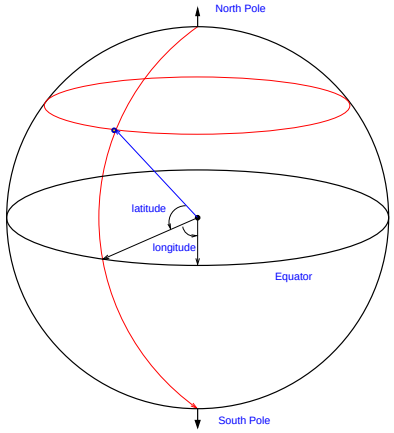
- observed 2-D sky view: projected
- underlying arrangement in 3-D space

Mapping the Sky: Coordinates

local coordinates (*observer*-centered):



compare to *global* coordinates, origin at *Earth's center*



Q: What are the main naked-eye *"citizens" of the sky?*
How might these be classified?

can classify celestial objects into
sun, moon, planets, "fixed" stars

what changes and what doesn't:
- "fixed" stars–same patterns relative to one another
- sun, moon, planets move w.r.t. stars, each other

ancients: "seven wanderers"–days of week (Sun, Mon...)

The Fixed Stars

grouped in "constellations"; e.g., Orion
constellations: *regions* in the sky
  → not just stars in "connect the dots" patterns
constellations fill sky like states on a US map
⇒ any point in the celestial sphere lies in
  exactly one constellation

Big Dipper (subgroup = "asterism" of Ursa Major):
diagram: big dipper, 'pointer stars", Polaris
Q: how quantify constellation size, star spacings on sky?

Q: do the stars move at all relative to each other? Do they move on the sky (i.e., relative to the horizon)? is change noticeable daily? yearly?

can't say anything (yet) about *distances*
only can measure **angles** between objects
label: pointer stars: 5° *apart; to Polaris:* 25° *separation*

Don't seem to move w.r.t. each other
i.e., constellations don't morph – move as if
rigid structure on sky

Daily motion w.r.t. horizon: rise in east, set in west

In more detail:
Imagine a dark night sky in Chambana
and an expensive, magic machine:
makes each star leave a "*trail*" behind as it moves

iClicker: Star Trails

Imagine you could see all trails made by all stars
over one night, as seen from Champaign-Urbana.
What pattern would you see?

A arcs of circles

B arcs of ovals

C parallel line segments

D none of the above

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science: to test prediction, do experiment! *Q: how?*

The Experiment

fix a camera on a tripod, open lens and expose to night sky
as each star moves, leaves "trail" on film

Many such images exist online:

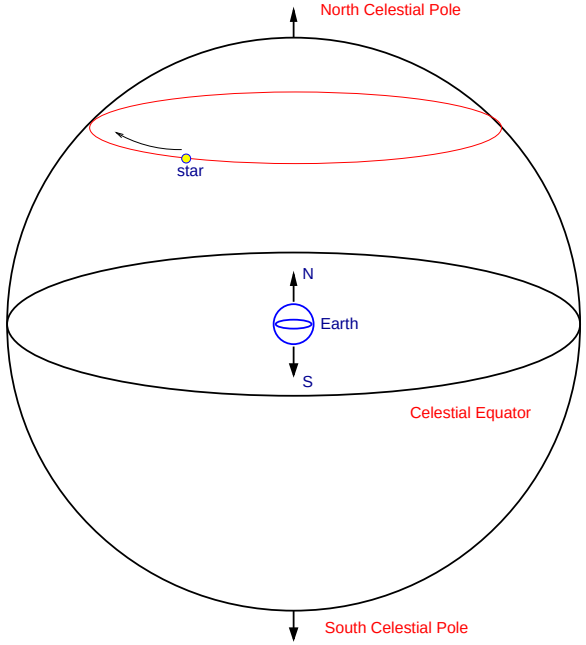
`www: image of star trails`

Q: why do we get this pattern?
Q: what does it mean that it repeats daily?
Q: what does it tell us? special points/regions?
Q: why do telescopes have motors on them?

Celestial Sphere

stars seem to be attached to surface
of enormous "**celestial sphere**" – this is geometry of the sky
(at any moment, see only hemisphere–Earth hides half)

diagram: observer on globe, enclosed by cel sph globe



celestial equator, poles, typical star path

daily cycle $\rightarrow$ earth spins with period $P = 1$ day
but Earth-based observer sees celestial sphere spin with period $P = 1$ day

circumpolar stars: never set (=never below horizon)
Q: do these exist? where are they on diagram?

`www: Mountaintop star trail`
Q: what is latitude at which these were taken?

iClicker: Star Trail Exposure Time

`www: image of star trails`

About how long was the image exposed?

A 2 hours

B 4 hours

C 6 hours

D 8 hours

E no way to tell from this image alone

Sun Motion

daily motion w.r.t. horizon: rise in east, set in west
when at highest point: noon
fundamental measure of time: **solar day**
$\Rightarrow$ interval from one noon to next (*Earth spin period*)

maximum angular elevation varies with seasons
in Chambana:
$\sim$ June 21, summer solstice: 73.5°
$\sim$ March 20, Sept 23, equinoxes: 50°
$\sim$ Dec 22, winter solstice: 26.5°
$\rightarrow$ variation is *periodic*, with period *same* as seasons

Sun Motion: Annual Pattern

yearly movement: sun moves east w.r.t. fixed stars
along a specific path: the **ecliptic**

- a *great circle* (*Q: what's that?*) on celestial sphere
- passes through 13 constellations: **Zodiac**

sketch: ecliptic on celestial sphere

`www: Sun path diagram, Sun motion animation`

Q: how can we figure out observationally where sun is if can't see surrounding stars during the day?

Q: what does Sun's path on 2-D sky imply for 3-D nature of Earth-Sun motion?