Astro 210

Lecture 13

Feb 14, 2018

Announcements

- **Hour Exam 1 in class Friday Feb 16**
  info and old exams online
  brief review at end of today's class
- HW1&2 grades visible at last (curse you Moodle)
  all HW solutions posted before exam
- OTOH: *No HW this week!*
- **Office Hours:** Instructor–2:00-3:00 today, or by appointment
  TA–3:30-4:30 tomorrow
- final Planetarium show **tomorrow**
  online: **reservations**, schedules, directions, **report form**

Last Time: Kirchoff Explained

blackbody radiation

Q: what's a blackbody?

Q: what's blackbody/thermal radiation? Flux F? Spectrum?

Q: how does thermal radiation + atomic properties explain Kirchoff?

Astronomer's toolbox

Q: what measurements give composition?

Q: what measurements give temperature?

Q: how do these depend on distance to the object?

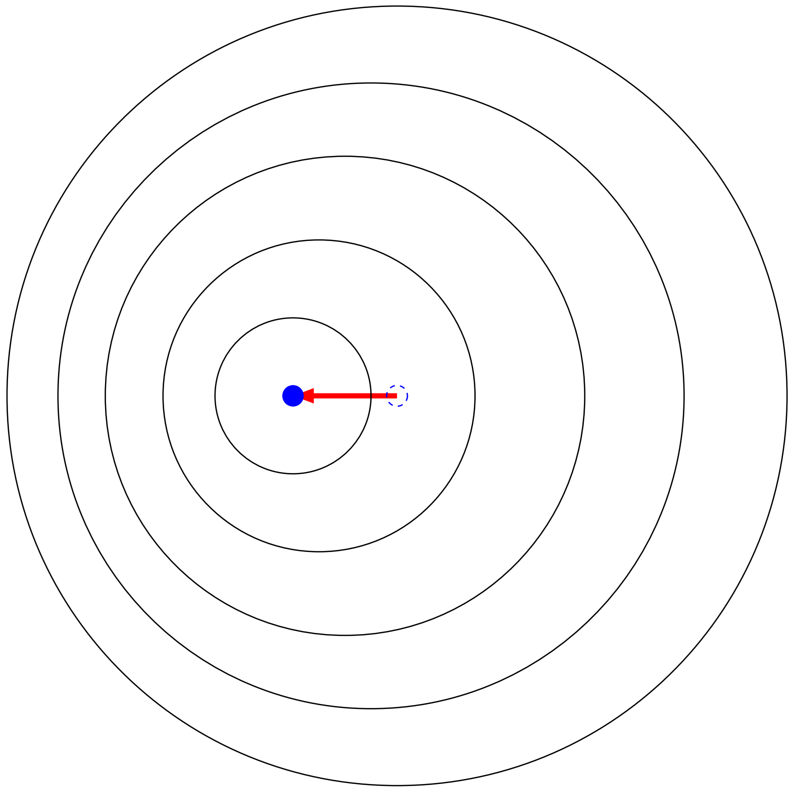
Doppler Effect

consider a moving light source

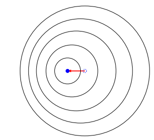
- moves at constant speed v
- emits light of wavelength λ_{em}
  as measured in emitter's rest frame

Each wave crest propagates spherically from emission point
but emission points move, so...
Q: how does this affect observed wavelength λ_{obs}?
Q: does the effect depend on viewing angle? how or why not?

Wave Crests from Moving Emitter



in front of emitter: wave crests "bunch up"

$\longrightarrow$ approaching objects observed at smaller wavelength  

$\longrightarrow$ shorter λ: "blue shift"

behind emitter: wave crests "stretched out"

$\longrightarrow$ receding objects observed at longer wavelength

$\longrightarrow$ longer λ: "red shift"

shift depends only on

relative motion in **radial** direction ("line of sight")

$$\frac{\lambda_{\text{obs}} - \lambda_{\text{em}}}{\lambda_{\text{em}}} = \frac{\Delta\lambda}{\lambda} = \frac{v_r}{c} \tag{1}$$

where $v_r > 0$ means moving away

Observer's Scorecard

Doppler effect: speed $\leftrightarrow$ λ shift

redshifts/blueshifts $\rightarrow$ speedometer

namely: measure λ_{obs}, know λ_{em} $\rightarrow$ find $v_r = \frac{\Delta\lambda}{\lambda}\, c$

Q: but how does it work in practice?
how do you know a line is shifted?

TELESCOPES

Prelude: Divisions of Astro-Labor

Astro-researchers usually specialize in their expertise

Vote your conscience:

You instructor is which of these?

A **theorist**

builds models, makes predictions

B **observer**

targets and collects data from telescopes

tests models/theories

C **instrument builder**

develops new detectors, optics, control systems for telescopes

Telescopes

so far: how light encodes information
today: how to collect & decipher it

Telescopes:
1. collect/concentrate photons
2. detect photons

Q: collection methods–naked eye? scopes?

Light Collection: bring to focus, form image

1. lens "*refractor*"
Snell's law: light bent due to change in index of refraction
i.e., change of speed–slower in glass.
With curved surface, can concentrate rays

problems:

- spherical aberration
- chromatic aberration
- lens "sag" increases with size $\longrightarrow$ limits lens size

2. mirror “reflector”

mirrors: angle of incidence = angle of reflection.

With curved surface, can bring to focus.

merits:

- no chromatic abberation
- no sag *Q: because?*

problems:

- spherical abberation

$\boxed{\text{all modern research telescopes are reflectors}}$

Hour Exam 1: Review