Exploring the Cosmos since 1790

A Level Physics Astronomy

Armagh Observatory and Planetarium
2018
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Programme

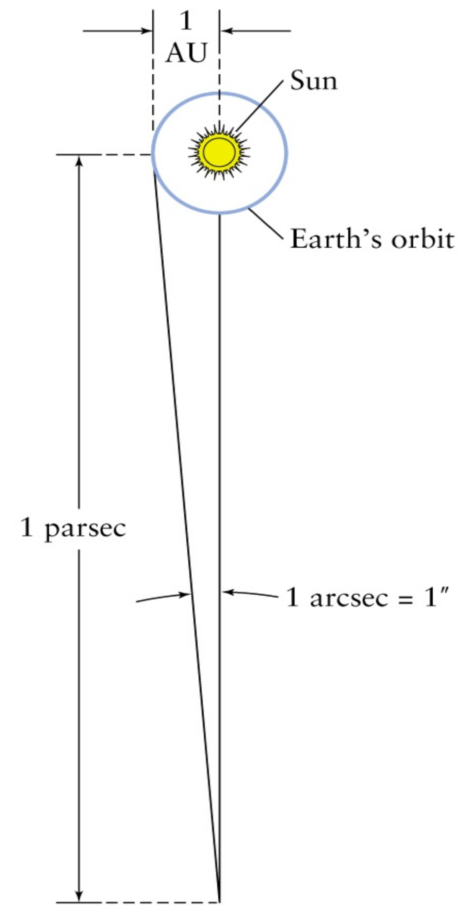
Week	Class	Tutorial	Planetarium
1	Doppler Redshift & Stars	Doppler Redshift for orbit of planet	Our Solar System
2	Cosmological Redshift & Galaxies	Expansion of the Universe	Our Galaxy
3	Cosmology & the Age of the Universe	Age of the Universe	Galaxies and Large Scale Structure

Lecture 1

Doppler Redshift and Stars

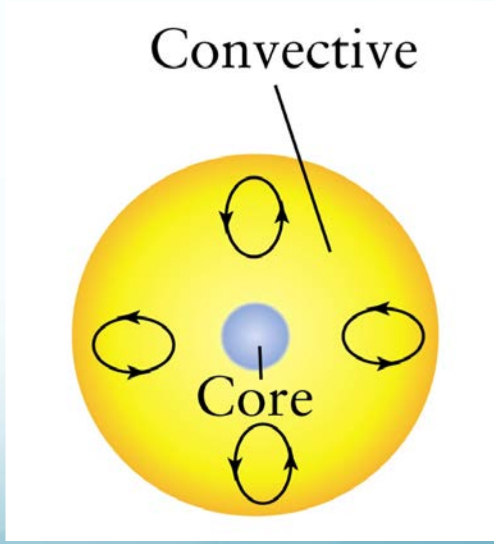
Distances in Astronomy

- Astronomical Unit
  - Average distance from Earth to Sun
  - 1 AU = 1.5×10^{11} m
- Light Year
  - Distance light travels in 1 year
  - 1 lyr = 9.5×10^{15} m
- Parsec
  - Distance to star with a parallax angle of 1 arcsecond on a 1 AU baseline
  - 1 pc = 3.0×10^{16} m



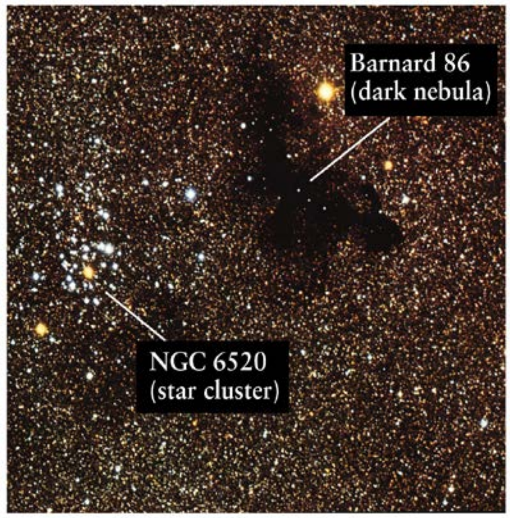
Stars

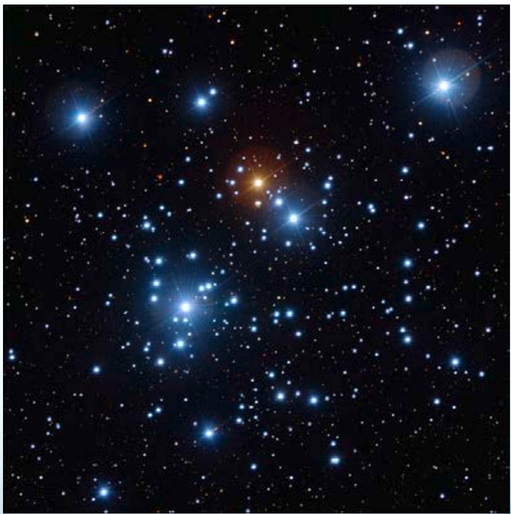
- The basic components of the Universe!
- Balls of gas undergoing nuclear fusion in their cores



Star Clusters

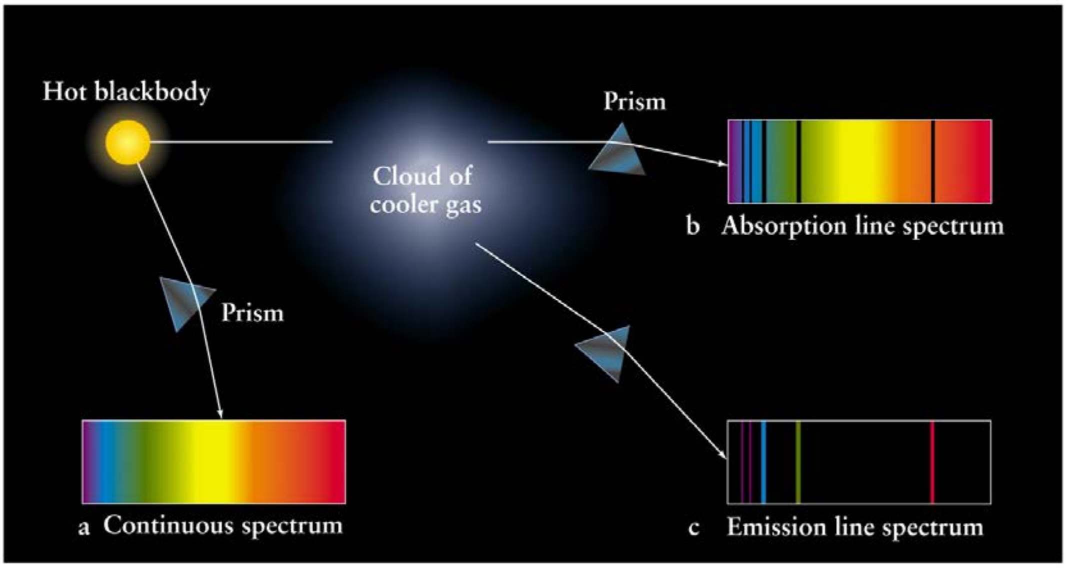
- Stars are often found in clusters





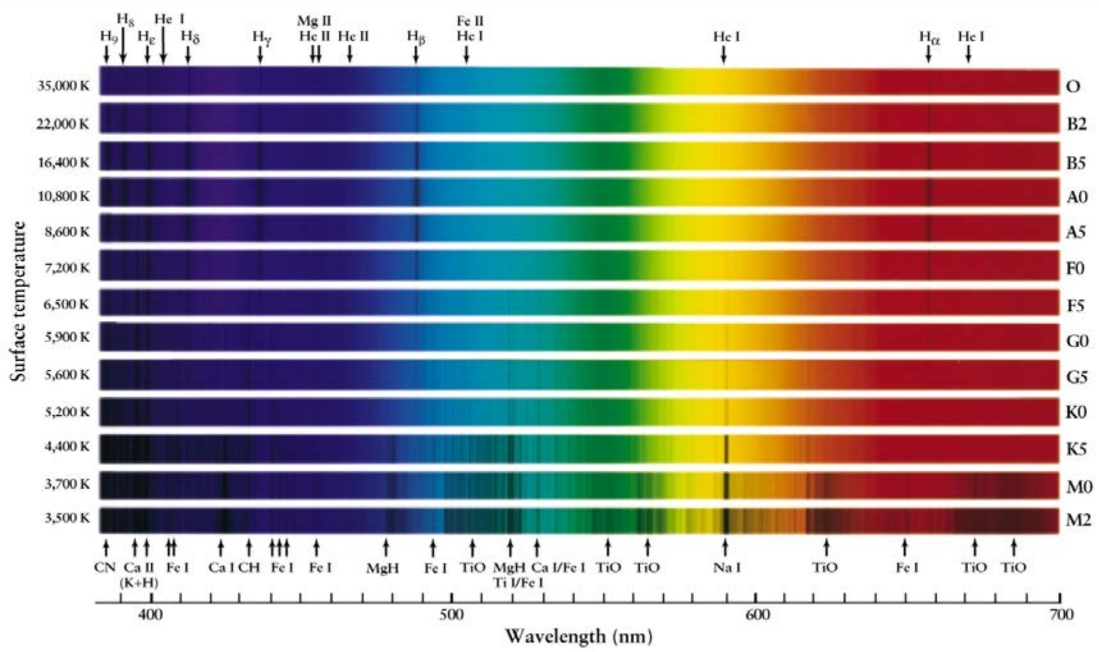
Spectra

- "Continuum" spectrum of stars produces the "colours"
- Absorption – by elements in star surface – dark lines
- Emission – by hot gas – bright lines



Spectra of Stars

- Dark lines in the continuum spectrum of stars

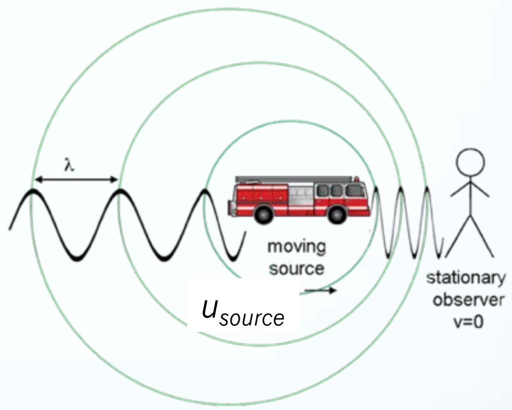


Doppler Effect

- The change in frequency of a wave when there is relative motion between the source and observer
- Also applies to wavelength
  - Since speed = wavelength x frequency
- When there is a medium (e.g. air, water), the Doppler effect depends on whether the source is moving, the observer is moving, or both.
  - *This is a little tricky. Fortunately you will only need to apply the Doppler effect for light rather than sound, which turns out to be a little easier to understand.*

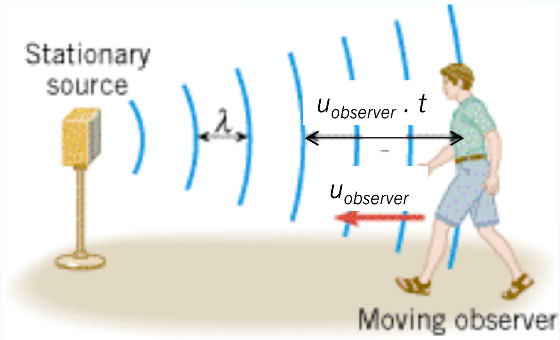
Moving Source, Stationary Observer

- Approaching:
  - Waves are squashed
  - Frequency increases
    - $f' = \frac{c}{c - u_{source}} f$
- Receding:
  - Waves are stretched
  - Frequency decreases
  - $f' = \frac{c}{c + u_{source}} f$

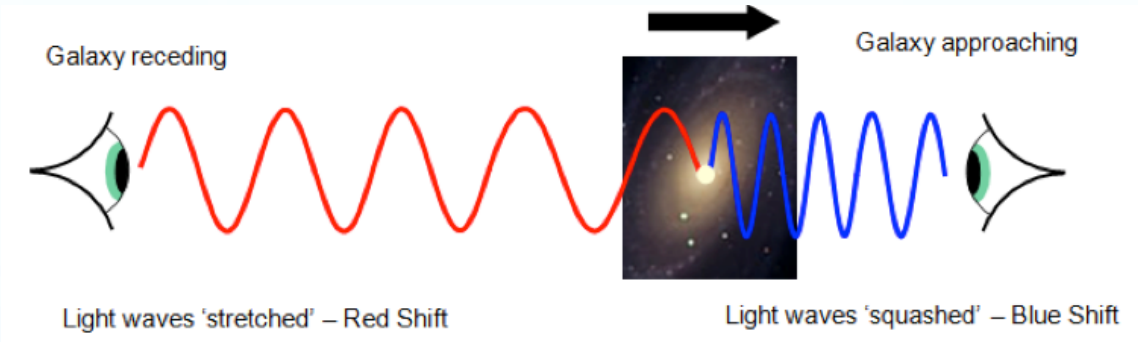


Stationary Source, Moving Observer

- Approaching
  - Wavefronts encountered more frequently
  - Shorter **λ**, Higher ***f***
    - $f' = \frac{c+u_{observer}}{c} f$
- Receding
  - Wavefronts encountered less frequently
  - Longer **λ**, Lower ***f***
    - $f' = \frac{c-u_{observer}}{c} f$



Doppler Effect for Light



- No medium – light travels in a vacuum
- Only the relative speed between source & observer matters
- Receding: $f' = \frac{c}{c+v} f$ and $\lambda' = (1 + \frac{v}{c})\lambda$
- Approaching: $f' = \frac{c}{c-v} f$ and $\lambda' = (1 - \frac{v}{c})\lambda$

This is the one you need to learn for A-level Physics!

The Redshift Parameter, *z*

- Change in wavelength: $\Delta\lambda = \lambda' - \lambda = \frac{v}{c}\lambda$
- Thus $\frac{\Delta\lambda}{\lambda} = \frac{v}{c}$
- Define the Redshift Parameter, *z*, as the fractional change wavelength
  - i.e. $z = \frac{\Delta\lambda}{\lambda} = \frac{v}{c}$
- $z = \frac{v}{c} > 0$ when source is receding: Doppler "redshifted"
- $z = \frac{v}{c} < 0$ when source approaching: Doppler "blueshifted"