Lecture Outlines
PowerPoint

Chapter 23

Earth Science 11e

Tarbuck/Lutgens

Earth Science, 11e

Light, Astronomical Observations, and the Sun
Chapter 23

The study of light

- Electromagnetic radiation
  - Visible light is only one small part of an array of energy
  - Electromagnetic radiation includes
    - Gamma rays
    - X-rays
    - Ultraviolet light
    - Visible light
    - Infrared light
    - Radio waves

The study of light

- Electromagnetic radiation
  - All forms of radiation travel at 300,000 kilometers (186,000 miles) per second

The study of light

- Light (electromagnetic radiation) can be described in two ways
  - Wave model
    - Wavelengths of radiation vary
      - Radio waves measure up to several kilometers long
      - Gamma ray waves are less than a billionth of a centimeter long
    - White light consists of several wavelengths corresponding to the colors of the rainbow

The study of light

- Light (electromagnetic radiation) can be described in two ways
  - Particle model
    - Particles called photons
    - Exert a pressure, called radiation pressure, on matter
    - Shorter wavelengths correspond to more energetic photons

The study of light

- Spectroscopy
  - The study of the properties of light that depend on wavelength
  - The light pattern produced by passing light through a prism, which spreads out the various wavelengths, is called a spectrum (plural: spectra)

A spectrum is produced when white light passes through a prism

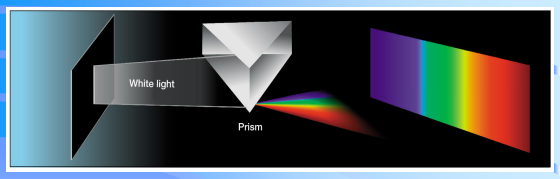


Figure 23.2

The study of light

- Spectroscopy
  - Types of spectra
    - Continuous spectrum
      - Produced by an incandescent solid, liquid, or high pressure gas
      - Uninterrupted band of color
    - Dark-line (absorption) spectrum
      - Produced when white light is passed through a comparatively cool, low pressure gas
      - Appears as a continuous spectrum but with dark lines running through it

The study of light

- Spectroscopy
  - Types of spectra
    - Bright-line (emission) spectrum
      - Produced by a hot (incandescent) gas under low pressure
      - Appears as a series of bright lines of particular wavelengths depending on the gas that produced them
    - Most stars have a dark-line spectrum
    - Instrument used to spread out the light is called a spectroscope

Formation of the three types of spectra

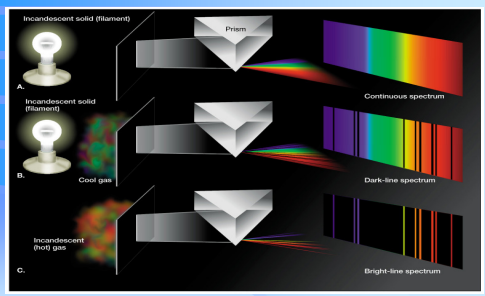


Figure 23.3

The study of light

- Doppler effect
  - The apparent change in wavelength of radiation caused by the relative motions of the source and observer
  - Used to determine
    - Direction of motion
      - Increasing distance – wavelength is longer ("stretches")
      - Decreasing distance – makes wavelength shorter ("compresses")
    - Velocity – larger Doppler shifts indicate higher velocities

The Doppler effect

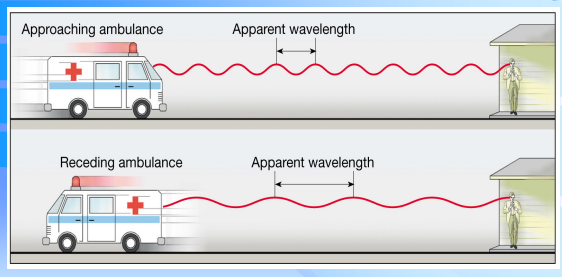


Figure 23.4

Astronomical tools

- Optical (visible light) telescopes
  - Two basic types
    - Refracting telescope
      - Uses a lens (called the objective) to bend (refract) the light to produce an image
      - Light converges at an area called the focus
      - Distance between the lens and the focus is called the focal length
      - The eyepiece is a second lens used to examine the image directly
      - Have an optical defect called chromatic aberration (color distortion)

A simple refracting telescope

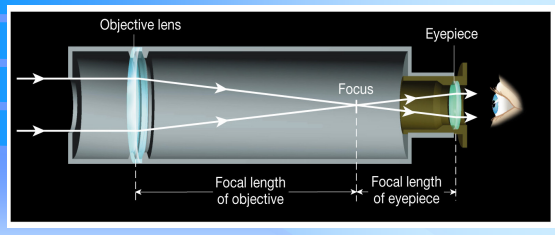


Figure 23.7

Astronomical tools

- Optical (visible light) telescopes
  - Two basic types
    - Reflecting telescope
      - Uses a concave mirror to gather the light
      - No color distortion
      - Nearly all large telescopes are of this type

A prime focus reflecting telescope

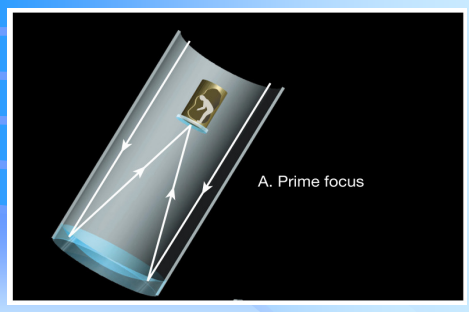


Figure 23.9 A

Cassegrain focus reflecting telescope

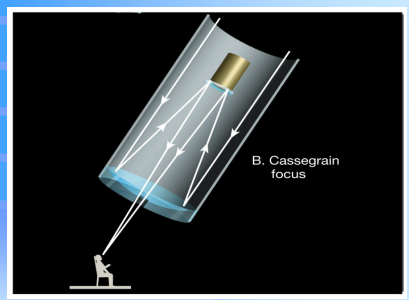


Figure 23.9 B

Newtonian focus reflecting telescope

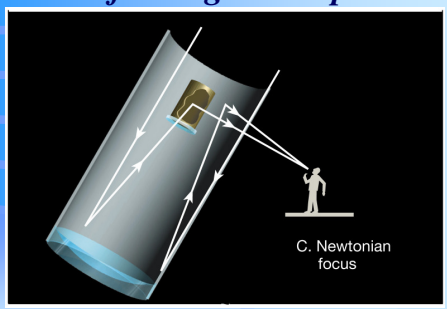


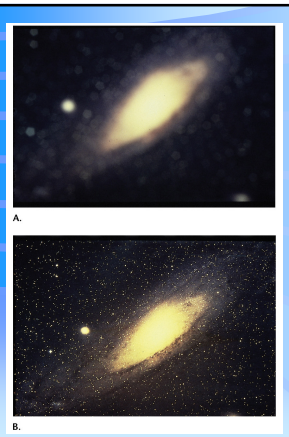
Figure 23.9 C

Astronomical tools

- ❖Optical (visible light) telescopes
  - Properties of optical telescopes
    - Light-gathering power
      - Larger lens (or mirror) intercepts more light
      - Determines the brightness
    - Resolving power
      - The ability to separate close objects
      - Allows for a sharper image and finer detail

Astronomical tools

- ❖Optical (visible light) telescopes
  - Properties of optical telescopes
    - Magnifying power
      - The ability to make an image larger
      - Calculated by dividing the focal length of the objective by the focal length of the eyepiece
      - Can be changed by changing the eyepiece
      - Limited by atmospheric conditions and the resolving power of the telescope
      - Even with the largest telescopes, stars (other than the Sun) appear only as points of light



Appearance of a galaxy in the constellation Andromeda using telescopes of different resolution

Figure 23.12

Deployment of the Hubble Space Telescope in Earth orbit, April 24, 1990

Figure 23.13

Astronomical tools

- ❖Detecting invisible radiation
  - Photographic films are used to detect ultraviolet and infrared wavelengths
  - Most invisible wavelengths do not penetrate Earth's atmosphere, so balloons, rockets, and satellites are used
  - Radio radiation
    - Reaches Earth's surface

Astronomical tools

- ❖Detecting invisible radiation
  - Radio radiation
    - Gathered by "big dishes" called radio telescopes
      - Large because radio waves are about 100,000 times longer than visible radiation
      - Often made of a wire mesh
      - Have rather poor resolution
      - Can be wired together into a network called a radio interferometer

A steerable radio telescope at Green Bank, West Virginia

A.

Figure 23.14 A

Astronomical tools

- ❖Detecting invisible radiation
  - Radio radiation
    - Gathered by "big dishes" called radio telescopes
      - Advantages over optical telescopes
        - Less affected by weather
        - Less expensive
        - Can be used 24 hours a day
        - Detects material that does not emit visible radiation
        - Can "see" through interstellar dust clouds

The 300-meter radio telescope at Arecibo, Puerto Rico

Figure 23.15

Sun

- ❖One of 200 billion stars that make up the Milky Way galaxy
- ❖Only star close enough to allow the surface features to be studied
- ❖An average star
- ❖Structure can be divided into four parts
  - Solar interior

Sun

- ❖Structure can be divided into four parts
  - Photosphere
    - "Sphere of light"
    - Sun's "surface" – actually a layer of incandescent gas less than 500 kilometers thick
    - Grainy texture made up of many small, bright markings, called granules, produced by convection
    - Most of the elements found on Earth also occur on the Sun
    - Temperature averages approximately 6000 K (10,000˚F)

Granules of the solar photosphere

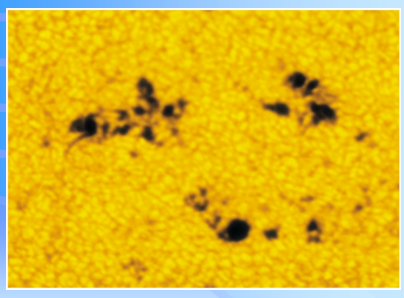


Figure 23.19

The solar structure

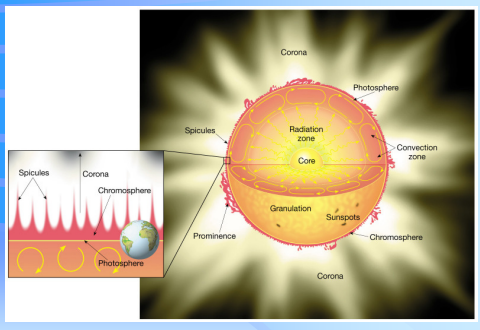


Figure 23.18

Sun

- Structure can be divided into four parts
  - Chromosphere
    - Just above photosphere
    - Lowermost atmosphere
    - Relatively thin, hot layer of incandescent gases a few thousand kilometers thick
    - Top contains numerous spicules – narrow jets of rising material

Spicules of the chromosphere

Figure 23.20

Sun

- Structure can be divided into four parts
  - Corona
    - Outermost portion of the solar atmosphere
    - Very tenuous
    - Ionized gases escape from the outer fringe and produce the solar wind
    - Temperature at the top exceeds 1 million K

Sun

- Solar features
  - Sunspots
    - On the solar surface
    - Dark center, the umbra, surrounded by a lighter region, the penumbra
    - Dark color is due to a cooler temperature (1500 K less than the solar surface)
    - Follow an 11-year cycle
    - Large spots are strongly magnetized
    - Pairs have opposite magnetic poles

Sun

- Solar features
  - Plages
    - Bright centers of solar activity
    - Occur above sunspot clusters
  - Prominences
    - Huge arching cloudlike structures that extend into the corona
    - Condensations of material in the corona

A huge solar prominence

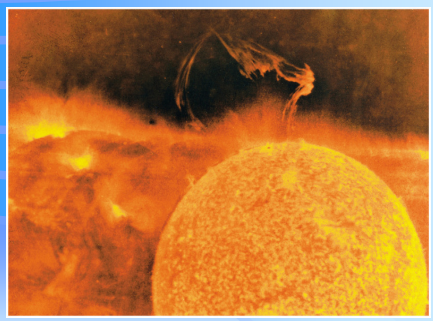


Figure 23.23

Sun

- Solar features
  - Flares
    - Explosive events that normally last an hour or so
    - Sudden brightening above a sunspot cluster
    - Release enormous quantities of energy
    - Eject particles that reach Earth in about one day and interact with the atmosphere to cause the auroras (the Northern and Southern Lights)

Solar interior

- Cannot be observed directly
- Nuclear fusion occurs here
  - Source of the Sun's energy
  - Occurs in the deep interior
  - Nuclear reaction that produces the Sun's energy is called the proton-proton reaction

Solar interior

- Nuclear fusion occurs here
  - Nuclear reaction that produces the Sun's energy is called the proton-proton reaction
    - Four hydrogen nuclei are converted into a helium nuclei
    - Matter is converted to energy
    - 600 million tons of hydrogen is consumed each second
  - Sun has enough fuel to last another five billion years

End of Chapter 23