

Chapter 15. The electromagnetic spectrum

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New word list:

3.3 Electromagnetic spectrum

Core

- 1 Know the main regions of the electromagnetic spectrum in order of frequency and in order of wavelength
- 2 Know that all electromagnetic waves travel at the same high speed in a vacuum
- 3 Describe typical uses of the different regions of the electromagnetic spectrum including:
 - (a) radio waves; radio and television transmissions, astronomy, radio frequency identification (RFID)
 - (b) microwaves; satellite television, mobile phones (cell phones), microwave ovens
 - (c) infrared; electric grills, short range communications such as remote controllers for televisions, intruder alarms, thermal imaging, optical fibres
 - (d) visible light; vision, photography, illumination
 - (e) ultraviolet; security marking, detecting fake bank notes, sterilising water
 - (f) X-rays; medical scanning, security scanners
 - (g) gamma rays; sterilising food and medical equipment, detection of cancer and its treatment
- 4 Describe the harmful effects on people of excessive exposure to electromagnetic radiation, including:
 - (a) microwaves; internal heating of body cells
 - (b) infrared; skin burns
 - (c) ultraviolet; damage to surface cells and eyes, leading to skin cancer and eye conditions
 - (d) X-rays and gamma rays; mutation or damage to cells in the body

Supplement

- 6 Know that the speed of electromagnetic waves in a vacuum is 3.0×10^8 m/s and is approximately the same in air

continued

3.3 Electromagnetic spectrum continued**Core**

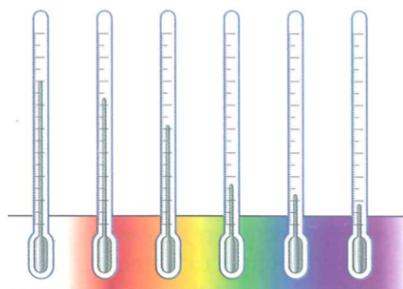
- 5 Know that communication with artificial satellites is mainly by microwaves:
- some satellite phones use low orbit artificial satellites
 - some satellite phones and direct broadcast satellite television use geostationary satellites

Supplement

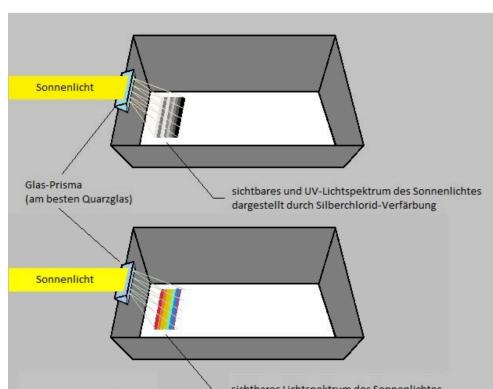
- 7 Know that many important systems of communications rely on electromagnetic radiation including:
- mobile phones (cell phones) and wireless internet use microwaves because microwaves can penetrate some walls and only require a short aerial for transmission and reception
 - Bluetooth uses radio waves because radio waves pass through walls but the signal is weakened on doing so
 - optical fibres (visible light or infrared) are used for cable television and high-speed broadband because glass is transparent to visible light and some infrared; visible light and short wavelength infrared can carry high rates of data
- 8 Know the difference between a digital and analogue signal
- 9 Know that a sound can be transmitted as a digital or analogue signal
- 10 Explain the benefits of digital signaling including increased rate of transmission of data and increased range due to accurate signal regeneration

15.1 Electromagnetic waves

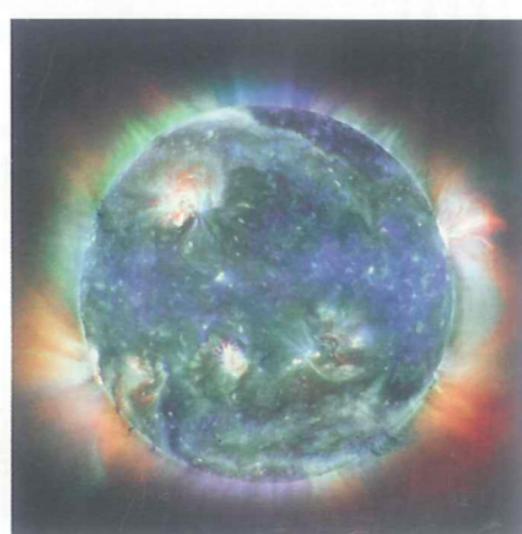
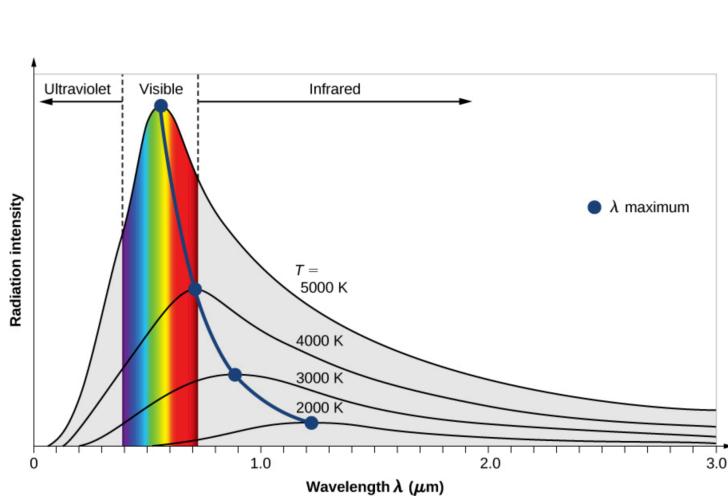
1. In 1799, William Herschel discovered **infrared**(*infra* means below) light.



2. In 1801, Johan Ritter discovered **ultraviolet**(*ultra* means beyond) light.

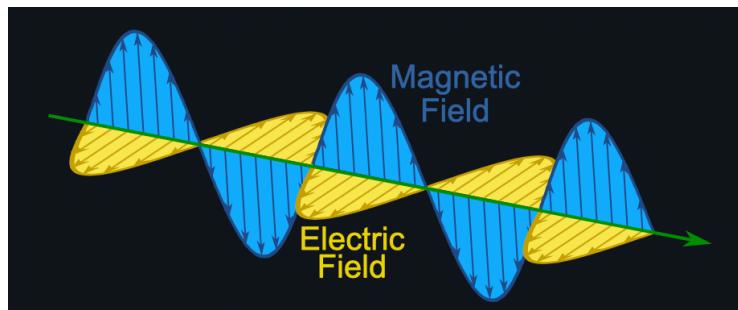


3. Radiation spectrum from the Sun and black body radiation



5. EM Wave model of light — James Clerk Maxwell

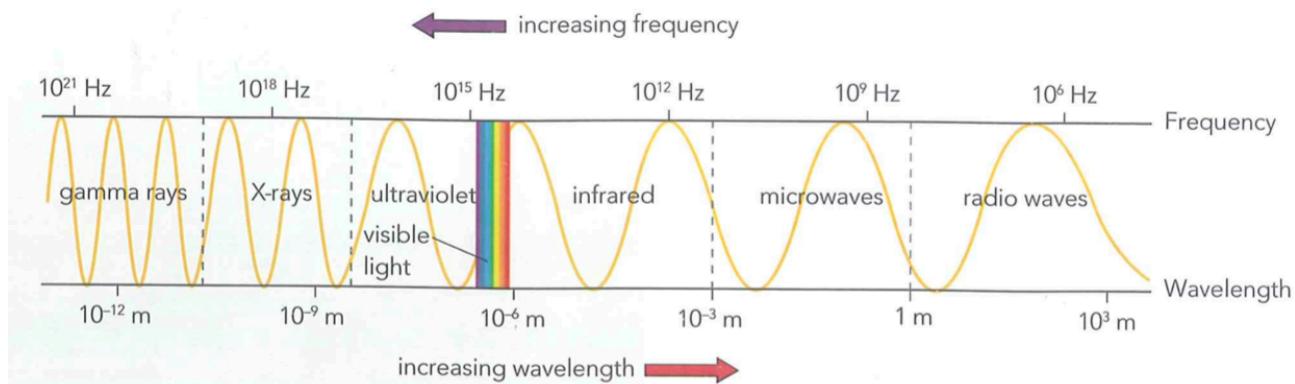
Description:



Light is a transverse wave!!!

Prediction of Maxwell's EM wave model:

6. Electromagnetic spectrum



Exercise 15.1

Draw and label two waves to show the difference between red light and violet light.

15.2 Different types of EM waves and their uses

1. **Radio waves:** (long wavelength, transfer in long distance)

- a. Radio, television and microphone transmission
- b. Radio astronomy
- c. RFID

| | Frequency / Hz |
|--------------|------------------------------------|
| Broadcast | AM: 500 – 1600 K FM: 80 – 110 M |
| TV | 10-1000 M |
| Mobile phone | 1000 - 3000 M |

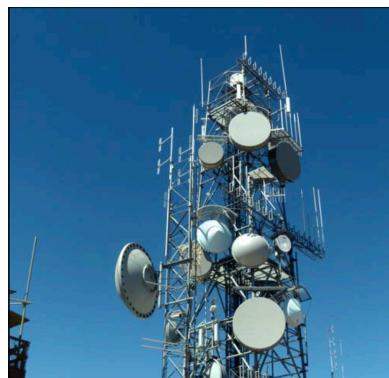


2. Microwave:

a. Satellite TV

b. Transfer mobile phone signal between masts

c. microwave oven

**3. Infrared radiation**

a. Remote controller

b. Grills or toasters

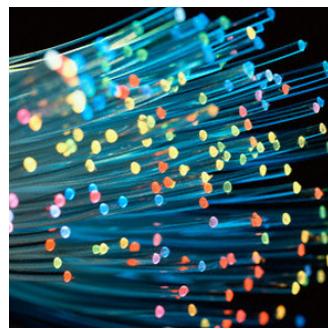
c. Intruder alarm



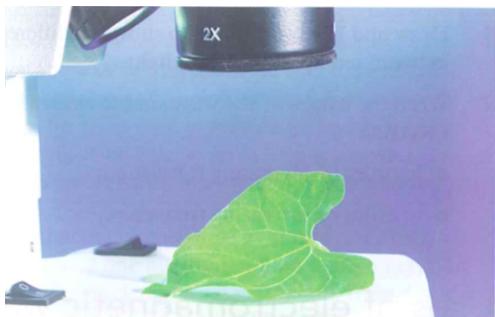
e. Infrared imaging

f. Optical fibre(endoscope)

g. Infrared scanner

**4. Visible light**

a. vision b. illumination c. photography d. photosynthesis



5. Ultraviolet(UV) light

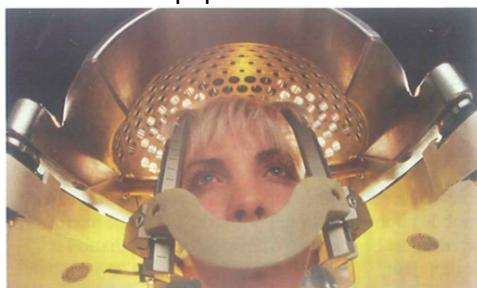
- a. Security marking/detecting fake banknote b. Sterilising water

**6. X-rays**

- a. Medical scanning b. Security scanners

**7. Gamma rays**

- a. Sterilising food and medical equipment b. Detection of cancer and its treatment

**Exercise 15.3**

Name two types of electromagnetic radiation that are used to cook food

Exercise 15.4

Name three types of electromagnetic radiation that have medical uses

Exercise 15.5

A girl phones her friend on her mobile phone while watching TV by a log fire. Explain how infrared radiation, microwave, visible light and radio waves are involved in this.

15.3 Electromagnetic hazards

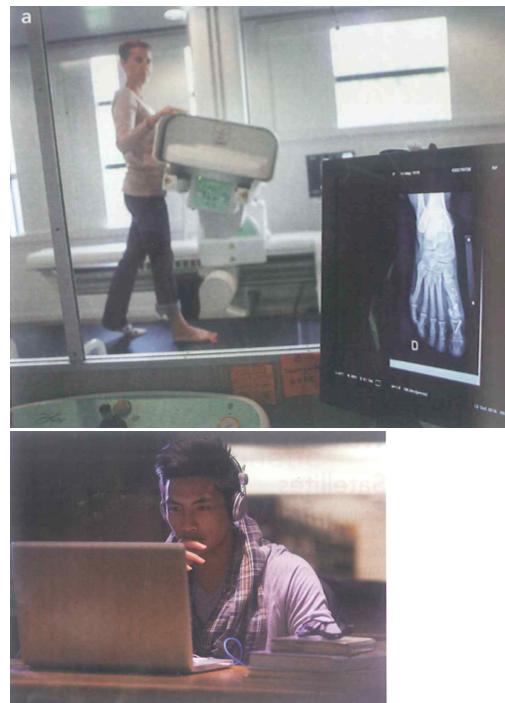
Shorter wavelength, more dangerous

Microwaves:

Infrared:

Ultraviolet:

X-ray and gamma ray:



15.4 Communications using EM waves

Artificial satellite

1. Geostationary satellite

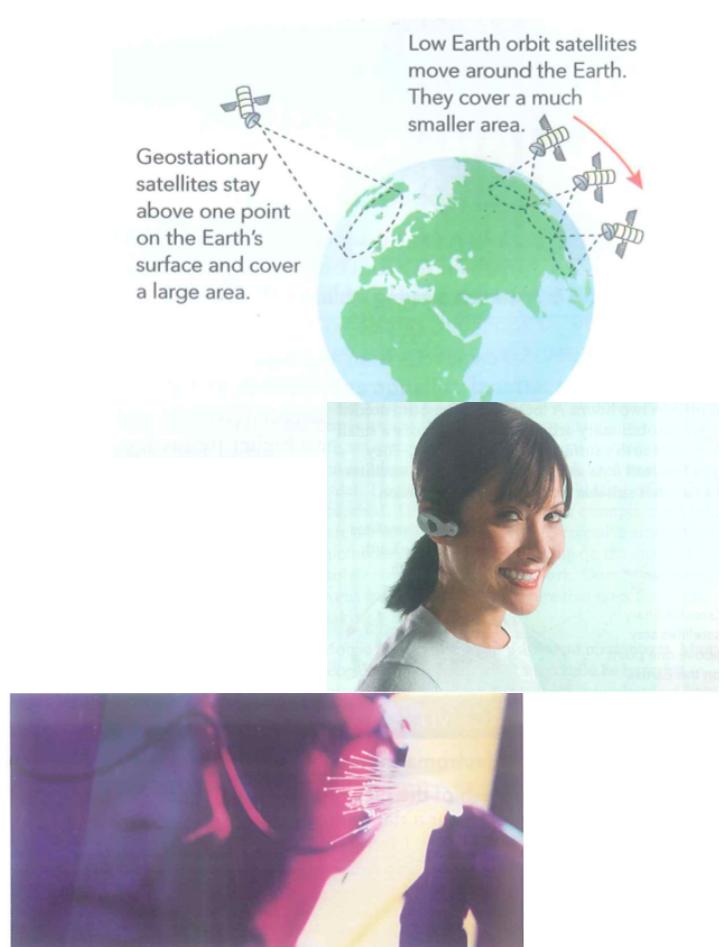
2. Low Earth satellite

The right wave for the job

1. Mobile phone/wireless internet

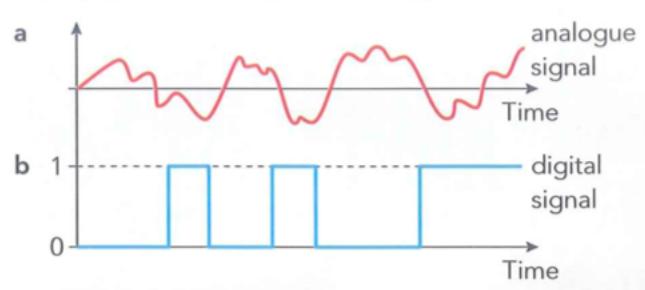
2. Bluetooth

3. Optical fibre

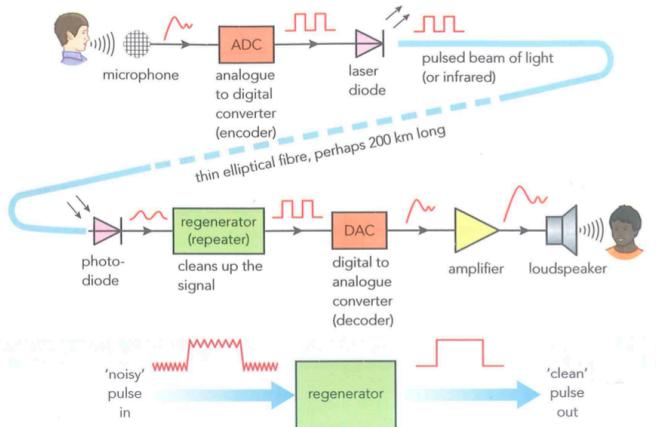


Analogue and digital signals

1. Difference



2. Making a digital phone call



3. Benefits of digital signaling

