# Looking into Space

Putting a telescope in space isn't the only way to see past the atmosphere.
You can also try looking at different kinds of EM wave...

## *Different telescopes detect different types of EM wave*

To get as full a picture of the Universe as possible, you need to detect different kinds of EM wave.

1) To see very distant, faint objects, you need a very big telescope or lots of smaller ones linked up — a bigger telescope 'collects' more light per second, making a brighter image.

2) Astronomers are usually keen to have images with good resolution (i.e. a lot of detail). The important thing here is how big the telescope is compared to the wavelength of the radiation. The longer the wave, the bigger the telescope you need to get the same level of detail.

## *Radio telescopes*

Radio telescopes need to be very large — because radio waves are very long. But they're not too badly affected by the Earth's atmosphere, and they let astronomers observe objects which are too faint for optical telescopes (see below) to detect.

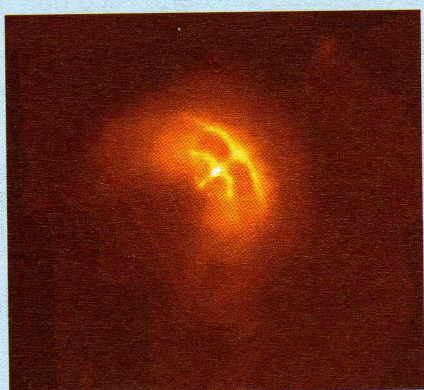
## *Optical telescopes*

Optical telescopes detect visible light. They're used to look at objects close by and in other galaxies (though they are hampered by the Earth's atmosphere).

## *X-ray telescopes*

X-ray telescopes are a good way to 'see' violent, high-temperature events in space, like exploding stars. But X-ray telescopes will only work from space, since the Earth's atmosphere absorbs X-rays. They're also very expensive, so there aren't many about.

An X-ray image of a compact nebula around the Vela pulsar

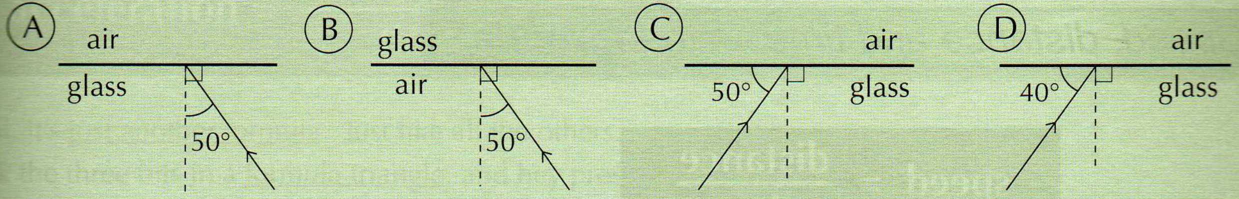


CHANDRA X-RAY OBSERVATORY/ NASA/ SCIENCE PHOTO LIBRARY

# Revision Summary for Physics 1b

The only way that you can tell if you've learned this section is to test yourself. Try these questions, and if there's something you don't know, it means you need to go back and learn it. And don't miss any questions out — you don't get a choice about what comes up in the exam.

1) Electromagnetic waves don't carry any matter. What <u>do</u> they carry?
2) Draw a diagram to illustrate frequency, wavelength and amplitude.
3) Sketch the EM spectrum with all its details. Put the lowest frequency waves on the left.
4)* Convert to SI units (m, m/s, Hz, s): a) 500 kHz, b) 35 cm, c) 4.6 MHz, d) 4 cm/s, e) 2½ mins.
5)* Find the speed of a wave with frequency 50 kHz and wavelength 0.3 cm.
6) What happens to the energy of an EM wave when it is absorbed? What two effects can this have?
7) Describe the different ways that short and long-wave radio signals 'get around'.
8) Describe two uses of microwaves, and explain why microwaves are suitable for these uses.
9) a) Which types of EM wave are commonly used to send signals along optical fibres?
   b) Explain why sending data by optical fibre might be better than broadcasting it as a radio signal.
10)* In which of the cases A to D below would the ray of light be totally internally reflected?
   (The critical angle for glass is approximately 42°.)




11) Which is generally more hazardous — low frequency or high frequency EM radiation?
12) Describe the main <u>known</u> dangers of microwaves, infrared, visible light, UV and X-rays.
13) Explain how X-rays can be useful in hospitals.
14) Draw diagrams illustrating analogue and digital signals. What advantages do digital signals have?
15) Sketch an atom, showing its protons, neutrons and electrons.
16) Explain what isotopes are. What does it mean when an isotope is 'unstable'?
17) Oxygen atoms contain 8 protons. What is the difference between oxygen-16 and oxygen-18?
18) Radioactive decay is a totally random process. Explain what this means.
19) Describe in detail the nature and properties of the three types of radiation: α, β and γ.
20) The data below shows the count rate for a radioactive source at various times.

| Time (mins) | 0 | 20 | 40 | 60 | 80 | 100 | 120 |
|---|---|---|---|---|---|---|---|
| Count/minute | 750 | 568 | 431 | 327 | 247 | 188 | 142 |

   a)* Plot a graph of this data and use it to find the half-life of the substance.
   b) The source is a γ emitter. Would it be most suitable for use in A, B or C? Explain your answer.
   A — as a medical tracer   B — in a smoke detector   C — to sterilise medical instruments
21) Explain how radiation damages the human body — a) at low doses; b) at high doses.
22) Explain what precautions you should take to protect yourself from
   a) X-rays, if you are a radiographer   b) alpha radiation, in a school laboratory
   c) gamma rays, if you work at a nuclear reprocessing plant
23) Describe the 'Big Bang' theory for the origin of the Universe. What evidence is there for this theory?
24) How long ago do we think the Universe began?
25) How are space telescopes better than telescopes on Earth?
26) Why are space telescopes so expensive and sometimes so troublesome?
27) Describe one advantage and one disadvantage of optical, radio and X-ray telescopes.

* Answers on page 222

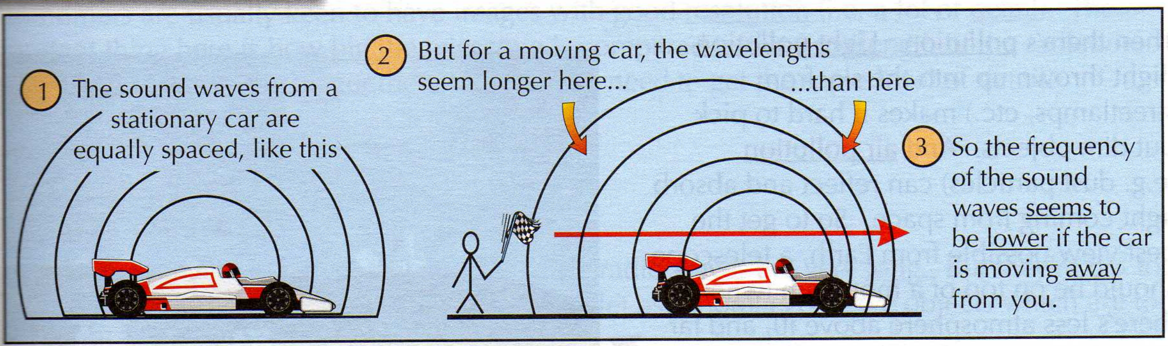
# The Origin of the Universe

Once upon a time, there was a really Big Bang — that's the most convincing theory we've got.

## Light from other galaxies is red-shifted


1) When we look at light from distant galaxies we find that the frequencies are all slightly lower than they should be — they're shifted towards the red end of the spectrum.
2) This is called the red-shift. It's the same effect as the vrrroomm from a racing car — the engine sounds lower-pitched when the car's gone past you and is moving away from you. This is called the Doppler effect.

### The Doppler effect



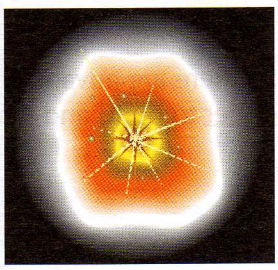

3) Measurements of the red-shift suggest that all the galaxies are moving away from us very quickly — and it's the same result whichever direction you look in.

## The further away a galaxy is, the greater the red-shift

1) More distant galaxies have greater red-shifts than nearer ones.
2) This means that more distant galaxies are moving away from us faster than nearer ones.
3) This provides evidence that the whole Universe is expanding.

## The Big Bang theory — the universe is expanding

1) Right now, all the galaxies seem to be moving apart at great speed. But something must have got them going. That 'something' was probably a big explosion — the Big Bang...
2) According to this theory, all the matter and energy in the Universe must have been compressed into a very small space. Then it exploded and started expanding, and the expansion is still going on now.
3) The age of the Universe can be estimated from the current rate of expansion. We think the Big Bang probably happened about 13.7 billion years ago.
4) But... it's difficult to estimate this because it's hard to tell how much the expansion has slowed down since the Big Bang.



## The Big Bang seems to explain most evidence

Most scientists accept the idea of the Big Bang — it's the best way to explain the evidence we have at the moment. But if new evidence turns up, the theory could turn out to be rubbish. After all, there wasn't anyone around 14 billion years ago, taking photos and writing things down in a little notebook.

# Looking into Space

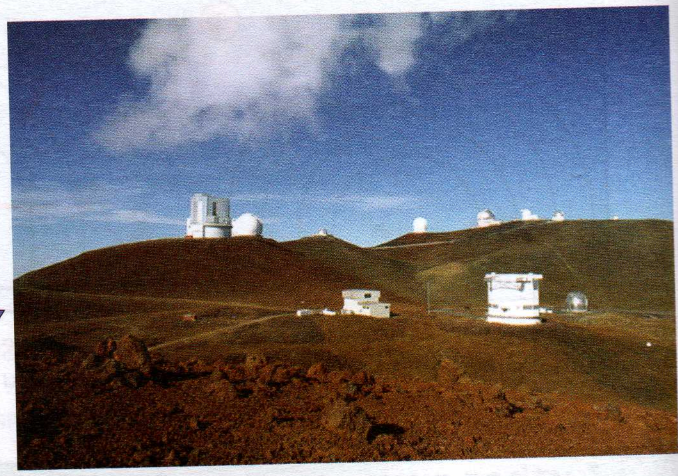
There are various objects in space, and they emit or reflect different frequencies of EM radiation. And that's what you need to detect if you want to find out what's going on 'out there'. You have two basic options — stay here on Earth, or send something into space to get a closer look.

## ***Space telescopes*** *have a* ***clearer view*** *than those on* ***Earth***

Telescopes help you to see distant objects clearly. But there can be problems...

1) If you're trying to detect light, Earth's atmosphere gets in the way — it absorbs a lot of the light coming from space before it can reach us.

2) Then there's pollution. Light pollution (light thrown up into the sky from streetlamps, etc.) makes it hard to pick out dim objects. And air pollution (e.g. dust particles) can reflect and absorb light coming from space. So to get the best view possible from Earth, a telescope should be on top of a mountain (where there's less atmosphere above it), and far away from any cities (e.g. on Hawaii).



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3) But to avoid the problem of the atmosphere, the thing to do is put your telescope in space, away from the mist and murk down here. The first space telescope (called Hubble) was launched by NASA in 1990. It can see objects that are about a billion times fainter than you can see unaided from Earth.

4) Hubble is an optical telescope (see the next page) and has a mirror. But because it gets a clear view into space, the mirror can be a lot smaller (and easier to make) than you'd need for a similar telescope on Earth.

5) It's not all plain sailing though. Getting a telescope safely into space is hard. And when things go wrong, it's difficult to get the repair men out. Hubble's first pictures were all fuzzy, because the mirror was the wrong shape. NASA had to send some astronauts up there to fix it.

6) So there are advantages to Earth-based telescopes — especially the fact that they're cheaper and easier to build and maintain.

### *Getting a telescope into space isn't easy*

Most telescopes contain a lot of delicate, easily damaged parts. This is why it's so expensive to put them in space — they've got to be strong enough to withstand all the shaking on board the vehicle which takes them into orbit, but they need to be lightweight too.