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Chapter 6: The universe

Pages 139–154

Teacher notes

Introducing the chapter

In Year 7, students learned about the Earth and its place in the solar system. In Year 10, the scope is much larger. This chapter deals with the structure of our massive universe and the Earth’s place in it. An evidence-based approach is adopted, starting with recent findings of the existence of early Indigenous Australian astronomy, leading up to the latest evidence in support of the Big Bang theory. Along the way, stars and their life cycles and galaxies are studied to build a picture of the universe as we know it today.

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6.1 The Universe was studied by early Australians

Pages 140–141

Introducing the topic

This topic introduces students to a historical view of astronomy, focusing mainly on early Indigenous Australian astronomers and the link with Aboriginal culture, spirituality, and calendar. Students are also introduced to the work of some modern-day Australian astronomers.

Teaching tip: Bridging with previous astronomy work

A good place to start this unit would be to get the students to recall what they remember from their previous encounter with astronomy. Since the last time they met this area of science was in Year 7 – with the Earth, Sun and Moon module – they may not remember very much. This could be done by brainstorming and writing their contributions on the board. Alternatively, a short-answer quiz could be given and the students could mark their partner’s answers.

Teaching tip: Constellations in different cultures

The idea that star constellations look like animals and objects is not always convincing to students. When they look to the heavens, it can be difficult for them to understand why certain patterns have been accepted as particular objects. It is worth reminding students that historically, entertainment was very different, and as stories passed from generation to generation, the most plausible patterns evolved and were agreed upon. Interestingly, different cultures have different patterns and associated objects threading them, especially where there has been little contact with other cultures (e.g. within Australia).

Additional activity: Student questions

Many students find the topic of the universe fascinating and they will have many questions, even at the start. A good activity to commence this module would be to ask the students what questions about the universe they would like to find the answers to in this unit. These questions could be written on cards and collected. Rather than try to deal with everything at once by answering all of their questions immediately, the cards could simply be read out and then put aside for now. Subsequently, at the end of the module, the questions on the cards could be revisited to find out how many were answered during the unit. Depending on your knowledge or preference, you could answer the unsolved questions at this point or set the students a research task to find the answers. A limit could be set for the number of words and the students could feed back to the class with their answers.

Additional activity: Modelling astronomical observations

Ask students how they think that astronomers have produced images and models of where Earth and our solar system fit within the expanse of the universe. Then, try an activity whereby they imagine that the classroom they are sitting in is their world and they cannot leave it, but only look out through the windows and doors. This was the case with the Earth until very recently. What can they deduce about the room/building they are in and how do they go about this? Show an image of the Milky Way and ask how the picture was taken. Note that it is impossible for us to photograph the Milky Way, as we are within this galaxy.

Differentiation:

Ask the students to write a list of astronomical events that the people of ancient times would have had difficulty explaining. The list could comprise three columns:

• Event

• Possible ancient explanation

• Modern-day explanation.

The types of astronomical events people of ancient times would have difficulty explaining could include: the setting of the Sun; the movement of planets and stars across the sky; how the planets move relative to each other, the recurrence of Halley’s comet; ‘shooting stars’; supernovae, and so on.

For less able students:

• The entries for the three columns could be given to the students. They would then match them up correctly.

For more able students:

• Only the format is given and they have to come up with the events and their ancient and modern explanations.

For both abilities, access to the internet would be helpful.

Going further: Aboriginal Astronomy

Students can find out more about Indigenous astronomy by visiting the Australian Aboriginal Astronomy website, which is constantly being updated. The website was created by Ray Norris and his wife Cilia. Ray is an astrophysicist at the CSIRO Australian Telescope National Facility.

<http://www.emudreaming.com/about.htm>

Teacher notes

6.2 The Earth is in the Milky Way

Pages 142–143

Introducing the topic

The Earth is one of the planets in our solar system orbiting around the Sun. The Sun is just one of the billions of stars in our galaxy, the Milky Way. The Milky way is just one of the billions of galaxies in our vast universe. Stars exist in different sizes and last different lengths of time, but they are all powered by nuclear fusion reactions.

Teaching tip: The Sun is a star

Because it looks so different from other stars, many students do not know that the Sun is a star, just like the ones we see in the night sky. It is also common to confuse stars and planets. It is important to establish a good understanding of the difference between these objects before discussing them in the context of the universe as a whole. As previously mentioned in the teachers notes for 6.1, effective bridging with prior Year 7 knowledge will help. It is also important that the students appreciate the hierarchy of structure in the universe and the scale involved.

Teaching tip: Comparing the Sun with other stars

For those students who do know that the Sun is a star, they may have the misconception that the Sun is a big star, since it appears to be so much brighter than all the other stars that they can see, which appear as dots of light. They need to be reminded that this is because the Sun is so much closer to us than all the other stars. In fact, although the Sun is about a million times bigger than the Earth, compared with other stars it is relatively small. There are stars which are much larger than our Sun. Photographs showing the Sun compared to other larger stars (some much larger) can easily be found on the internet (see the teaching program for an example website).

Teaching tip: Star temperature and colour

Students are usually familiar with red hot objects, but less so with the idea that blue hot objects are even hotter. The colours of hot objects are often misunderstood, as blue is commonly described as a cool colour and red as a warm colour. The opposite is actually true. If you heat a black-coloured piece of metal from room temperature, it will first appear red, then orange, yellow, white and then blue. This is because the light at the blue end of the visible spectrum is of a higher frequency, so it has more energy. It would melt before becoming blue, but you can see the misconception. Therefore, in reality, the hottest stars appear blue and the coolest ones appear red.

Teaching tip: Star temperature and brightness

Star colour is a measure of surface temperature, not a measure of core temperature. Generally, a brighter star has a higher temperature, but this is not always the case. This is true on the main sequence as this is where stars are all fusing hydrogen into helium in their core. Once stars move off the main sequence they change size and can give off more or less energy. Then their temperature changes. This is why there are groupings on the Hertzsprung-Russell diagram other than the main sequence. These other groupings are older stars.

Teaching tip: A light year is a measure of distance

The idea that a light year is a measure of distance (not time) often needs some explaining. It may be useful to start with a closer object, like our Sun, and explain that if someone could stand on the Sun and wave, then we would see this happen 500 seconds later on Earth (approximately eight minutes later). If we waved back instantly, then the person on the Sun would need to wait over 16 minutes to get a response. The distance of the Earth to the Sun could then be described as 500 light seconds, because this is how far the light travelled in 500 seconds. This means that a light year is really quite a long distance. Light is used to measure such huge distances because it has a constant speed through space and, therefore, is predictable.

Teaching tip: Illustrating the vast number of stars in the universe

It comes as a surprise to many students, even by Year 10 (and sometimes beyond for that matter!), just how many stars there are in the universe, and it is difficult for them to comprehend just how many stars there are just from using numbers. Adding more and more zeros to a number can become meaningless after a while. Therefore, it is helpful to model this on something that can be visualised. One comparison states that there are more stars in the universe than there are sand grains on every beach in the world. A visual way of illustrating this fact is to get a handful of sand and let it slowly slip through your fingers. As thousands of grains drop from your hand every second, remind students that each single grain represents a star like our Sun. Also while doing this, explain that this handful represents a small fraction of the 100 billion stars in the Milky Way, and that there are another 100 billion galaxies in the universe (figures are approximate).

Teaching tip: Explaining stellar parallax

This relies on basic trigonometry. Ask students to close their left eye and line up their index fingers in front of their face (approximately 50 cm apart). Then, they should open their left eye and close their right eye. If they repeat this, they will see that their closest finger seems to move left and then right. This is the basis of the stellar parallax: by measuring the amount of movement of a star when viewed from two different positions, the distance to it can be calculated.

Additional activity: Devising a scale for distances in the universe

The vast scale of the universe is difficult for anyone to comprehend. Therefore, using relative distances can be useful. Get the students to devise a scaled-down version of some distances in the universe. Perhaps give them a starting point of the distance from the Earth to the Moon represented by 1 cm (or even 1 mm!). Then using this scale, they can calculate the scaled down distances from the Earth to the Sun; to the edge of the solar system; to the next nearest star (Proxima Centauri); to the edge of the Milky Way galaxy; and to one of the galaxies next to the Milky Way. The students may want to represent their scale on paper. If they do this activity correctly, they will soon realise that they will need a very long piece of paper!

Additional activity: Quiz – Our place in the universe

A fun way to introduce this topic is with a general knowledge quiz about space. Here is a suggested set of questions that can be used:

1 How far is it to the edge of the solar system (or at least Neptune)?

2 How long would it take a present-day spacecraft to get to the edge of the solar system?

3 What is the name of the next nearest star to us?

4 How far away is this star?

5 How long do you think it would take a present day spacecraft to get to this star?

6 What is a galaxy?

7 What galaxy do we live in?

8 How many other stars are in our galaxy?

9 How many other galaxies are there?

10 How long would it take for a spacecraft to get to the edge of our galaxy?

11 How far away is the nearest galaxy?

12 Do you think we are ever going to travel to another galaxy?

These questions set the stage for discussing the difference in scale between distances within the solar system and distances between stars and galaxies. Answering the questions to this quiz helps to remediate a massive misconception for students of all ages regarding the vast scale of the universe. They just don’t realise how big space is!

Differentiation

For less able students:

• Some of the maths activities in this section may be too challenging – for example, those requiring an understanding of trigonometry and logarithms, found on the accompanying worksheet. Therefore, concentrate on the more basic maths calculations – for example, how far light travels in a given period of time.

For more able students:

• Even higher-ability students may struggle with applying some of the more difficult maths skills and will probably need help. However, encouraging them to stretch themselves in this area will be good preparation for those who chose the physical (or chemical sciences) in Years 11 and 12.

Going further: NASA Website

Many students are fascinated by this topic and there won’t be enough class time to answer all the interesting questions that they may have. A great place for them to find out more is NASA’s website. This has a section for students of different ages, including grades 9–12.

<https://www.nasa.gov/audience/forstudents/9-12/index.html>

Teacher notes

6.3 Stars have a life cycle

Pages 144–145

Introducing the topic

Stars have a life cycle: they are born, they pass through different stages in their life and they eventually die. The sequence of stages of their life cycle depends on the size of the star. After the end of their life, the matter they are made from may subsequently be involved in the birth of a new star, and the cycle continues.

Teaching tip: You were once part of a star!

It is motivating to continually relate the universe and its history back to the individual student. Discussing questions like, ‘Where did I come from?’ and ‘Are we alone?’ are great ways to do this, and can result in some interesting conclusions. For example, the universe is composed of a finite amount of matter. It is interesting to consider that this same matter is not only involved in the life cycle of stars, but is also involved in the cycle of living things – including us. The logical conclusion is that the atoms in our body were once part of a star. Students should be able to deduce that the atoms in their bodies were once involved in one of the biggest explosions in the universe – a supernova!

Teaching tip: Possible star life cycle paths

The life cycle of the stars should follow one of the following pathways, depending on mass:

Path 1: gas nebula, protostar, main sequence star, red giant, variable star, white dwarf.

Path 2: gas nebula, protostar, main sequence star, supergiant, supernova, black hole.

Path 3: gas nebula, protostar, main sequence star, supergiant, supernova, neutron star.

Teaching tip: Equilibrium between forces in a star

Equilibrium is a recurring theme in physics, regardless of the nature of the two forces involved.A more familiar example of the equilibrium position reached between opposing forces can be used to illustrate the balance of forces in a main sequence star. For example, ask the students, ‘If two tug-o-war teams were equally balanced, what would be the result?’. ‘What would happen if one of the teams had less people or they even let go of the rope?’ This can be linked with Chapter 7, where forces in equilibrium are encountered in more familiar situations.

Teaching tip: Nuclear reaction in stars

Deal with the misconception regarding the nature of the reaction occurring in stars like our Sun. When we talk about the Sun burning its fuel (hydrogen), it needs to be clarified that this is not a chemical reaction like burning a lump of coal. Remind students what they discovered about chemical reactions in Year 9. They learned that it was only the electrons that were involved, not the nucleus. However, in nuclear reactions, the nucleus itself changes. In the case of stars, hydrogen nuclei fuse to form helium. Nuclear reactions can produce roughly a million times more energy than chemical reactions, which accounts for the vast amount of energy produced by stars and also their long life. It might also be worth mentioning the future potential for using controlled fusion as a power source here on Earth, similar to how many countries currently use fission reactions in nuclear power plants to produce energy.

Teaching tip: Density of neutron stars

An understanding of the formation of neutron stars can be linked to existing chemistry knowledge regarding the structure of atoms. Students will know that electrons orbit the nucleus which contains protons and neutrons. Therefore, most of the volume of an atom is due to the empty space between the nucleus and the electrons. In the formation of a neutron star, electrons and protons fuse to form more neutrons (an understanding of how this can happen is beyond the scope of this course). Consequently, the amount of empty space in the atom is drastically reduced. Therefore, the density is so great because the same mass is contained is a vastly smaller volume.

Additional activity: Gravity misconception

Gravity has many associated misconceptions. Many students think that there is no gravity in space. This often comes from movies and the use of the terms ‘weightlessness’ or ‘zero gravity’. For example, these words may be used when describing the sensation of free-fall experienced by astronauts in orbit. In reality, the astronauts only appear to be weightless as they are falling to Earth at the same rate that the Earth is falling (curving) away from them. Gravity is a force which operates throughout the universe. However, rather than just give them the answers on this one, to permanently eradicate this lingering misconception, get students to investigate for themselves why these statements appear to be correct, but aren’t. They can report their findings back to the rest of the class.

Additional activity: Calculating the increase in density of neutron stars

Linked to the teaching tip above, an interesting activity for higher ability students is to calculate how many times greater the density of an atom is if the space between the electrons and the nucleus is removed. They will need to do some research to find out the approximate volume of a typical small atom compared to the volume of its nucleus alone. If the mass of the atom remains roughly constant, the ratio of these two volumes will also be the ratio of the increase in density of the atom. Consequently, the students will have calculated a reasonable approximation for the increase in density of a main sequence star if it turns into a neutron star.

Additional activity: Finding a new place to live

While it is comforting to know that although the Sun is only halfway through its life cycle and has another five billion years to go as a stable main sequence star, students will also find it disconcerting to discover that the Sun will eventually die, and that Earth will either be destroyed at worst or rendered uninhabitable at best. Therefore, our descendants in the distant future will need to find somewhere else to live if the human race is to continue. Students could investigate finding a new place to live!

This could include researching:

• limitations of present technologies

• requirements of future technologies

• difficulties associated with space travel

• history of manned space flight

• planned manned mission to Mars.

This presents a good opportunity to introduce students to the history of space travel and the need for continuing our exploration of space, despite the major difficulties associated with space travel (the immense distances involved and the inhospitable nature of space). Ask students to watch the movie *Interstellar*. Some students may even be inspired to read the accompanying book, *The Science of Interstellar*.

Going further: Einstein research

This is an ideal time to introduce the students to Albert Einstein. He is one of the few scientists that probably all of them have heard of. Einstein predicted that supermassive black holes existed almost a century ago. He also predicted the existence of gravity waves, which have recently been discovered (and it is hoped will help unravel many of the mysteries of the cosmos). It is amazing that his predictions were based entirely on theory with no observed events to support them. Students can be encouraged to find out more about Einstein’s predictions including introducing them to the fascinating topic of Einstein’s theory of relativity.

Teacher notes

6.4 The galaxies are moving apart

Pages 146–147

Introducing the topic

This topic describes the Doppler effect and also how stars produce absorption and emission spectra. These concepts are then used to help explain how Edwin Hubble discovered that the light from distant galaxies is red shifted, leading to the conclusion that galaxies are moving away from each other.

Teaching tip: Bridging with Year 9 physics

Explaining how emission and absorption spectra are produced can be bridged with student’s physics knowledge from Year 9. Teaching this topic can be started by getting them to recall their understanding of the electromagnetic spectrum.

Teaching tip: Link with Year 9 and 10 chemistry

Explaining how emission and absorption spectra are produced can also be linked with student’s chemistry knowledge from Year 9 and Year 10 (if this has been covered at this point). The lines in these spectra result from electrons jumping between energy levels in the atom. The black lines in an absorption spectrum are produced when a particular wavelength of light (energy) is absorbed to promote an electron to a higher level. A coloured line on an emission spectrum results from an electron dropping down to a lower level and releasing energy as light of a particular wavelength. The position of these energy levels is unique for each element. Therefore, the pattern of wavelengths of light absorbed or emitted is also unique. An explanation of photons is not necessary at this stage in physics, but can be included.

Teaching tip: Looking back in time

As we discuss light reaching us from distant galaxies in this section, this might be a good point to encourage students to reflect on the fact that even though the speed of light is a 300,000,000 m/s, it does have a finite speed and is not instantaneous. Therefore, this light may have has been travelling through space for a very long time. Just as we look at the Sun and see it as it was about eight minutes ago, we are looking at these distant galaxies as they were millions – or even billions – of years ago. We may be looking at a distant galaxy seeing it as it was when dinosaurs were on the Earth, long before the presence of mankind. The idea that by looking at the stars we are looking back through time is one that can really engage students, both philosophically and scientifically.

Teaching tip: Explaining red shift

A common mistake made by students in describing red shift is that they inaccurately state that ‘the star is red shifted’ rather than ‘the *light* from the star is red shifted’. It also needs to be made clear that the light from the star doesn’t become redder as such, rather all the lines in the spectrum are shifted (move) towards the red end of the spectrum – whether it is the black lines on an absorption spectrum or the coloured lines on an emission spectrum. This can be illustrated by drawing a line spectrum on the board. To represent the light from a distant galaxy, the same spectral pattern can be re-drawn below the original, with all the lines moved the same distance to the right. To check students’ understanding of the relationship between the amount of red shift and the speed and distance of a galaxy (Hubble’s Law), you can then draw a third spectrum with the same pattern of lines as the original, but this time moved even further to the right. This represents the same spectrum from a different galaxy. Ask the students to compare the speed of the two galaxies from which the spectra have emerged and also their relative distance from Earth. They should respond that the spectrum with the greater red shift comes from the faster and, therefore, more distant galaxy.

Teaching tip: Space is expanding

A common misconception is that we must be at the centre of the universe if all the galaxies are moving away from us. The movement is caused by the fact that It is space itself that is expanding. Therefore, anyone in any galaxy will see all other distant galaxies moving away from them.

Teaching tip: Spectra analogy

A useful analogy to explain the absorption and emission spectra of different elements is to compare the patterns to fingerprints. Just as fingerprints (or DNA profiles for that matter) are unique and can be used to identify a person, spectral analysis can be used to identify elements here on Earth and in the rest of the universe. This could be illustrated by showing a range of fingerprints, DNA profiles and spectral patterns for a variety of elements. Examples can be easily found on the internet.

Teaching tip: Explaining blue shift

Some students may be confused with the concept of blue shift and perhaps think this has something to do with the contraction of the universe. Emphasise that the universe is just expanding out in the way as evidenced by red shift. However, there may be other examples of red shift or blue shift due to local movements of stars and galaxies which are not related to the expansion of space in the universe. It may also be a good point to remind students that, even though we don’t feel like we are moving, we are all living on a planet that is rotating on its axis (at 1600 km/h) as it moves in an orbit around the Sun (at 107 000 km/h). Furthermore, the Sun is part of the Milky Way galaxy that is rotating at about 2 million km/h. We don’t feel anything, of course, because these speeds are constant.

Teaching tip: Clarifying the Doppler effect

To illustrate the Doppler effect, it is worth using the analogy of the sound heard when an ambulance passes – that the person inside the ambulance won’t hear the effect. The Doppler effect is only observed by someone who is moving relative to the source of the sound. Someone inside the ambulance is moving, but not relative to the ambulance, which is the source of the sound.

Additional activity: Edwin Hubble biography

Some students may have heard of the Hubble Space Telescope and the Big Bang theory. However, they probably will not be familiar with the scientist Edwin Hubble – after whom the telescope is named. Most likely, they will also not know that the law which bears his name has provided much of the evidence to support the Big Bang theory. Therefore, students could carry out research and write a short biography on this important scientist. This biography could include information about his background, his discoveries and what further findings his work has led to.

Differentiation

For less able students:

Understanding some of the concepts in this section involves piecing together quite a lot of prior and new scientific understanding. Students have to apply some concepts they have learned previously in new and challenging contexts: the electromagnetic spectrum and absorption and emission spectra; and, properties of waves and the Doppler effect. They then have to tie these two concepts together to help explain red shift. Students will find this challenging. Therefore, effective modelling, and also carrying out the practical activities suggested, is important to help to reinforce these concepts.

For less able students:

If the abler students are grasping these concepts adequately, this is a good time to extend their understanding of some fascinating areas of physics. A more complete grasp of spectral analysis requires an understanding of photons. Students could be asked to investigate the fascinating dual wave-particle nature of light and the formula *E = hf*. This will also lead them to learn about photons and the photoelectric effect, which was the discovery that Einstein won his Nobel Prize for – not the theory of relativity, as many people believe!

Going further: The Hubble Space Telescope

One of the most important devices used in recent years for studying the universe is the Hubble Space Telescope. This has provided mankind with a wealth of information about the universe we live in. It is named after Edwin Hubble, in honour of his equally impressive contribution to our understanding of the universe. A vast amount of news and short videos will keep those students with a budding interest in astronomy very busy. In addition, there are thousands of spectacular colour images taken by the Hubble Space Telescope available.

[http://www.spacetelescope.org](http://www.spacetelescope.org/)

Teacher notes

6.5 The Big Bang theory is supported by evidence

Pages 148–149

Introducing the topic

This section describes the Big Bang theory and the evidence which supports it. In addition to red shift which was described in the last section, the presence of cosmic microwave background radiation and the abundance of light elements in the universe contributes more compelling evidence in support of this theory. Theories are constantly being refined in the light of new evidence.

Teaching tip: Explaining CMBR

The idea of background cosmic radiation can be thought of as a type of ‘background noise’. This can be detected quite easily and is the cause of the appearance and hissing noise of an analogue TV screen when the aerial is unplugged.

Teaching tip: Big Bang misconception

One common misconception is that the Big Bang was an explosion. However, an explosion needs something to explode into. The universe did not exist before the Big Bang so there was nothing to explode into. The Big Bang was the creation of space and time and not an explosion.

Teaching tip: New evidence refines or changes existing theories

This area of physics in particular underpins the fact that ideas and theories are constantly being reworked and evaluated as new evidence is found. The discovery of cosmic microwave background radiation (CMBR) is a good example to illustrate how new discoveries in science can help refine conflicting theories. At the time of the discovery, there were two possible theories for the existence of the universe: The Big Bang theory and the Steady State theory. The latter predicted that the universe has always existed and is unchanging. This theory was thought to be very robust until the discovery of CMBR, which was the first major piece of evidence that led to most cosmologists rejecting this theory in favour of the Big Bang theory. Subsequently, as evidence is gathered, there are aspects of the Big Bang theory that cannot explain all of the new observations: predictions of quantities of dark matter and dark energy are constantly being revised. This may lead to a reworking of this theory.

Teaching tip: Accidental discovery of CMBR

The discovery of CMBR is a good opportunity to demonstrate that scientific discoveries sometimes happen by accident. Similar to the manner in which Fleming discovered penicillin, Penzias and Wilson were not looking for CMBR. In fact, they initially thought that the faint signal they were detecting might have resulted from the pigeons which they found nesting in their antenna. This accidental discovery resulted in them winning the Noble Prize!

Additional activity: Compare the Steady State and Big Bang theories

Students can create a table that compares and contrasts the features of the Steady State and Big Bang theories. An internet search will easily provide the information to carry out this activity.

Additional activity: Timeline of the Big Bang

The Big Bang wasn’t a one-step process – bang! As stated previously, it wasn’t even a bang. A lot happened, especially in the first fraction of a second. Students can appreciate more of the detail of the stages in the evolution of the universe from a very hot and dense single point in space by creating a timeline of the stages of the Big Bang. This can be done using words and pictures or even in a cartoon format. An internet search will provide the information required.

Differentiation

For less able students:

• Break down the content into manageable pieces: for example, for the ‘comparing theories’ task mentioned above, a matching activity where evidence is classified as supporting a theory or not.

• Physical modelling to demonstrate the concepts in this topic is essential. The concepts become too abstract, even for the best learner. They need to be demonstrated in a concrete way as often as possible.

• Concentrate on the conceptual activities and cut back on the numerical ones. The use of mathematics is inevitable in science, so students must appreciate its value, but not all of it is needed at this stage.

For more able students:

• There are endless complexities relating to the Big Bang. Students can explore these by finding out more about things like, ‘How was matter made from energy?’, ‘Why are we made of matter and what is antimatter?’ and ‘What is the fate of the universe?’.

• There are observations of the universe that are not explained by the Big Bang theory. This could imply that more refinements are needed. What are these observations?

• There are some difficult mathematical activities in this section: In particular, the calculation of the age of the universe from the Hubble constant is challenging. Students will probably still need some help.

Going further: ‘The Little Book of the Big Bang’

The Science and Technology Facilities Council has produced a small booklet, ‘The Little Book of the Big Bang: A big science adventure’. This is a very colourful and visually engaging resource which presents quite complex ideas about particle physics and the Big Bang theory in a very accessible format for students of all ages. It also introduces students to the Large Hadron Collider, which is trying to recreate conditions similar to those at the time of the Big Bang. The booklet is available as a pdf which can be viewed on screen. Alternatively, it can be printed out (ideally in colour) and made into a physical booklet for the students to read.

<http://ippog.web.cern.ch/resources/2011/little-book-big-bang-big-scientific-adventure>

Teacher notes

6.6 Technology aids cosmological research

Pages 150–151

Introducing the topic

This topic discusses how new technology is advancing our understanding of the cosmos. It focuses on the Australian Kilometre Array Pathfinder and the Square Kilometre Array radio telescopes.

Teaching tip: Telescopes in the digital age

The romantic idea of an astronomer sitting at the eyepiece of a telescope on a remote mountain top is now just not true. Astronomy is now done remotely from a desk with a computer. It may be done using a telescope that is orbiting the Earth. Increasingly, it is being done by mining huge volumes of data and imagery stored on computer. The universe is being measured, digitised and searched by computers. What was once missed is now found automatically.

Additional activity: Student questions revisited

Revisit ‘Student questions’ additional activity from 6.1 (see previous description of the activity).

Additional activity: Student questions revisited

The end of this module is an ideal time to encourage the keener students who have a real sense of awe about this area of Physics and want to find out more about cosmology. They should try to read one of the many popular science books available. Suggested authors include Michio Kaku, Brian Green, Brian Cox, Neil de Grasse Tyson and Stephen Hawking. Some of the students will recognise these names as they often also present popular science TV programmes. Most, of course, will have heard of Stephen Hawking, probably the most famous living scientist in the world. These books are also good preparation for those students who will choose Physics in Years 11 and 12. As well as being really interesting reads, some of them also include a lot of Year 11 and 12 curriculum -elevant content, aswell as other very interesting theorised (though as yet unproven) concepts.

Additional activity: Technology research assessment

There are many important pieces of technology that have contributed to our understanding of the cosmos: for example, the Cosmic Background Explorer (COBE), the Wilson Microwave Anisotropy Probe (WMAP) and a long list of other space probes. Some devices which are still contributing include the Hubble Space Telescope, Planck satellite, Kepler telescope, International Space Station and the Large Hadron Collider.We can also look forward to future planned devices such as the James Webb Telescope and the Square Kilometre Array radio telescope. Students could investigate how technology aids cosmological research by researching the past, present and expected future benefits of these devices to our understanding of the universe. This could also be an ideal choice to set as an assessed assignment. There are so many that it might be best limiting this activity to a few of the devices chosen by you or the students.

Going further: Research unanswered questions

To end this unit, encourage the students to investigate questions about the universe that have not been answered as yet or are not fully answered. As a starting point to this activity, discuss the fact only 5% of the mass of the universe has been accounted for by the ‘normal’ matter’ which we can see. The other 95% has not been fully explained. This has been attributed to dark matter and dark energy. Although these two phenomenon have been named, they are called ‘dark’ not only because we can’t see them, but also because they have yet to be explained! It would be apt to introduce this activity by looking again at one of the Australian scientists discussed at the beginning of this unit – Professor Brian Schmidt – who won a Nobel prize for discovering dark energy. The following NOVA web link is a good place to start.

<http://www.nova.org.au/space-time/dark-stuff-our-universe>