

# STEM club

*LET'S EXPLORE THE  
UNIVERSE TOGETHER!*

**MEASURE THE SPEED OF  
LIGHT**

**PLAN OBSERVATIONS**

**LIFE CYCLE OF STARS**

**AND MORE...**

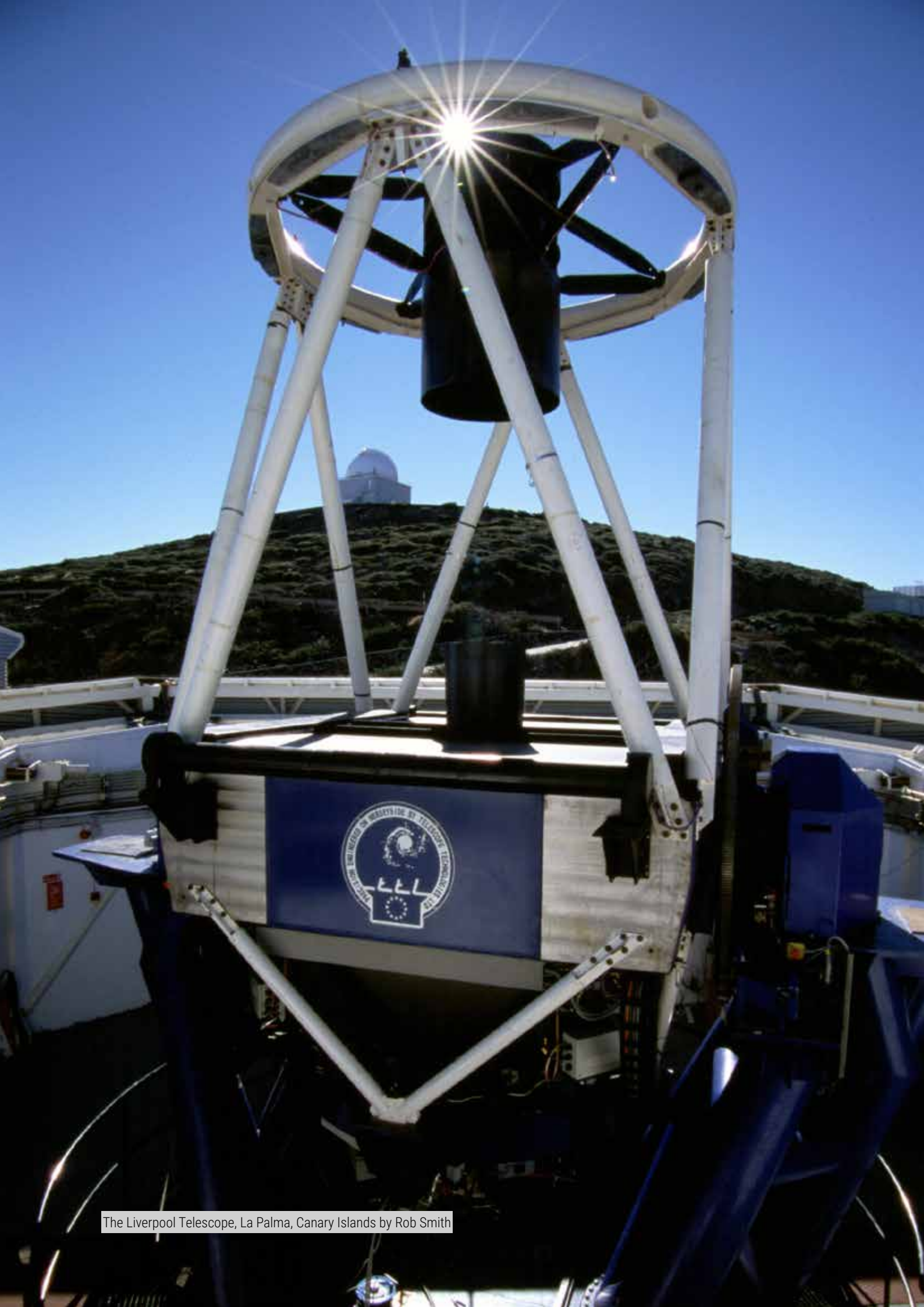
*PROUD TO BE PART OF*



Crab Nebula by Goran Nilsson & The Liverpool Telescope

**SILVER**  
SECONDARY EDITION





The Liverpool Telescope, La Palma, Canary Islands by Rob Smith

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Secondary STEM Club - Silver Award

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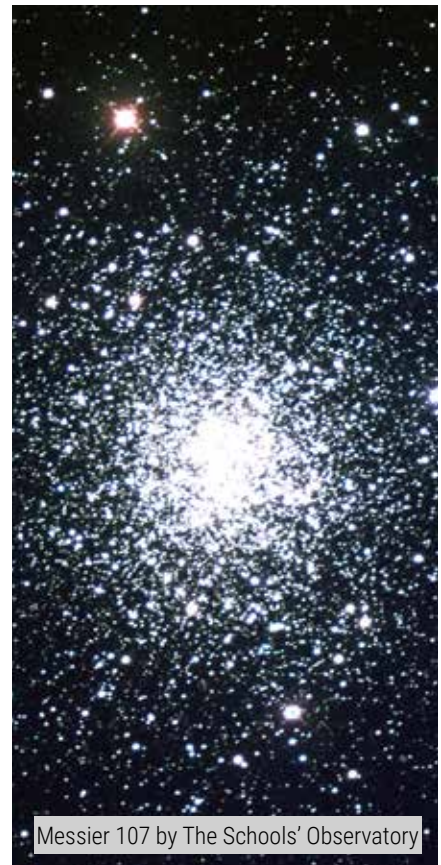
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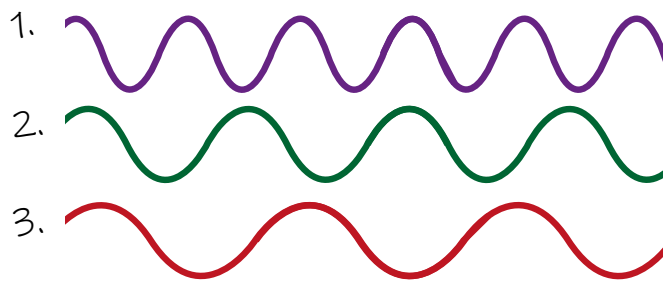
# SESSION 1: SPEED OF LIGHT

In this session you will be creating waves and measuring the Speed of Light using a microwave oven and a chocolate bar!

Light travels as a wave (it sometimes behaves like a particle but for this experiment we don't need to think about that!).

Light is made up of different colours. They all travel at the same speed - the speed of light. But each colour has its own wavelength. One wavelength is the distance between two peaks.

The wavelength for the colours we can see with our eyes are between 400 and 700 nm. The unit 'nm' stands for nanometre and is 0.000000001 metres - very very small!



Wavelengths by The Schools' Observatory

1. Violet: 400 nm
2. Green: 550 nm
3. Red: 700 nm

## REQUIRED RESOURCES

★ Rope

★ Microwave oven

★ Microwavable plate or dish\*

★ Ruler

★ Bar of chocolate

\*The plate needs to be large enough so that the chocolate bar is able to lie flat on the plate.

## WARNING

**Make sure there is only food in the microwave oven and no foil wrappers! Check the guidance of your microwave oven.**



Einstein showed that the speed of light is a universal constant, which means that it always travels at the same speed and nothing can travel faster than it. This is true for light in a vacuum.

The speed of light is expressed as the constant 'c' and is related to the frequency, f, and wavelength  $\lambda$  (Greek symbol lambda).

$$c = f\lambda$$

Microwave ovens produce light waves at a microwave wavelength that we cannot see with our eyes. We can only see the optical part of the electromagnetic spectrum.

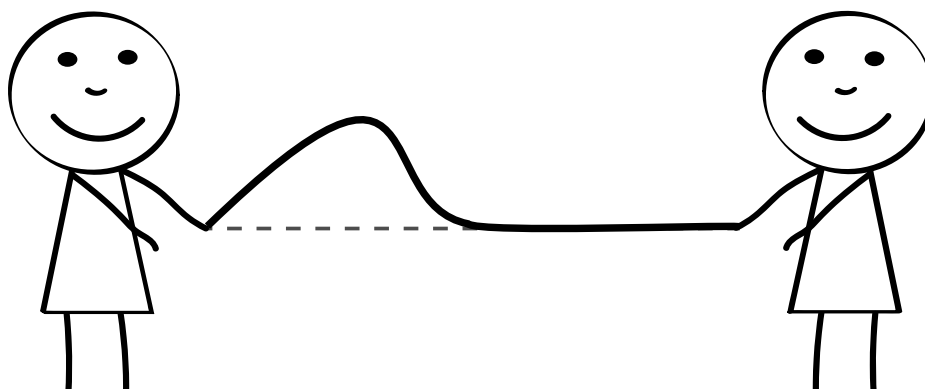
The speed of light is the same for all the different types of EM waves (in a vacuum) and therefore we can use a microwave oven to measure the speed of light. All we need is chocolate!

Firstly, let's look at how waves are generated in a microwave oven.

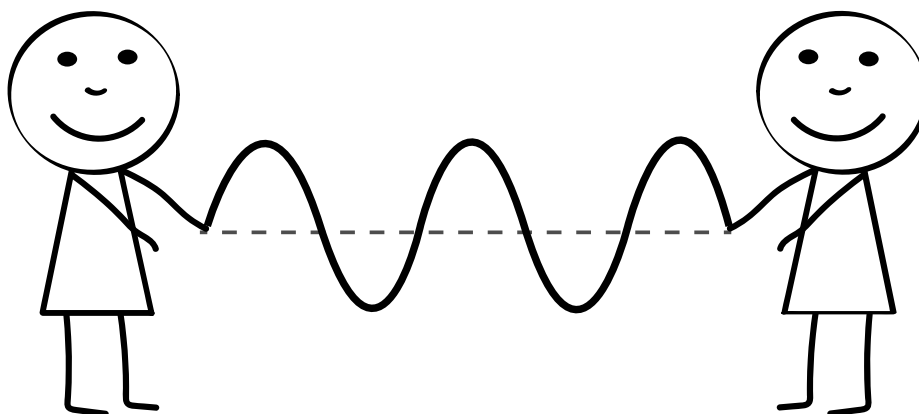


## ACTIVITY 1: WAVES

1. **Create a travelling wave:** two people hold the rope at either end. Person A sends a single pulse along the rope to person B. This is called a travelling wave. The energy travels from person A to person B.



2. **Create a standing wave:** two people hold the rope at either end. Person A creates a standing wave by continuously moving the rope up and down. It should make a pattern like the one below. This is called a standing wave.



You should notice that there are some points in your standing wave that do not move and some points that change from peaks to troughs. The points that do not move are called 'nodes'.

The points on the wave that move the most are called 'antinodes'.

*How many antinodes are there in your standing wave?* \_\_\_\_\_

At the antinode the amplitude is largest. In a microwave oven, all waves are standing waves. The location of the antinodes receive the most amount of heating. We can find these hot spots by seeing which points on a block of chocolate melt first.



## ACTIVITY 2: CHOCOLATE HOT SPOTS

1. Remove the microwave plate and rotating stand. You might need to use a small upside down plate or bowl to cover the rotating mechanism.
2. Remove the wrapper and place the chocolate bar on the plate in the microwave oven upside down (bottom side up).
3. Turn the microwave oven on for 10 seconds at a time, until the chocolate just starts to melt (this is about 10-30 seconds but each microwave oven will be different). Make sure you don't melt all the chocolate.
4. Take the chocolate out of the microwave oven and find the hot spots on the chocolate. Dabbing your finger lightly over the chocolate will make it easier to find the soft and hard spots. The location of the soft spot is an antinode.

### IMPORTANT



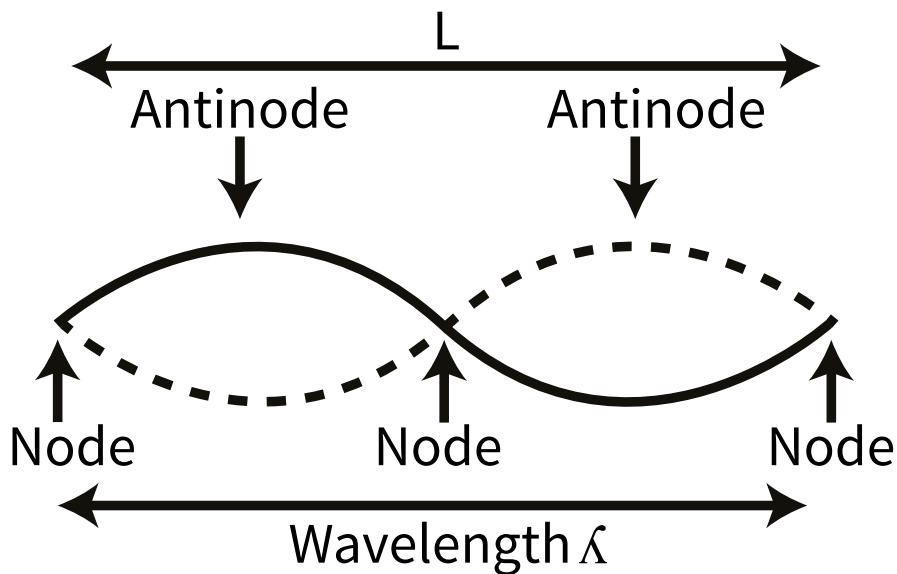
***Make sure the rotating mechanism is free to move so you do not burn out the motor.***

- Ask your STEM Club Leader to share a photo of your melted chocolate bar with us.
5. Measure the distance using a ruler between two neighbouring antinodes.



Distance between two hot spots: \_\_\_\_\_ (in cm)

Distance between two hot spots: \_\_\_\_\_ (in m)



The distance between the two melted points is the distance from an antinode to another antinode, this is only half a wavelength. You need to multiply your answer by 2 to calculate the wavelength of the microwave waves.

Wavelength ( $\lambda$ ) = 2 x distance: \_\_\_\_\_ (in m)

6. We also need to know the frequency of the microwaves – this can usually be found on a label on the microwave oven. The standard unit of frequency is Hz (per second) but your microwave oven may provide it in different units. Below you can find some example conversions.

1 kHz	1000 Hz
1 MHz	1,000,000 Hz
1 GHz	1,000,000,000 Hz
2.5 GHz	2,500,000,000 Hz

What is the frequency of your microwave oven? \_\_\_\_\_

What is the frequency ( $f$ ) of your microwave oven in Hz? \_\_\_\_\_

7. Calculate the speed of light ( $c$ ) using the formula  $c=f\lambda$  in m/s

Speed of Light ( $c$ ) = \_\_\_\_\_

Can you write  $c$  in scientific notation? \_\_\_\_\_

Check your answer against the measured speed of light in a vacuum: **299,792,458 m/s**  
Approximately we say it is  **$3 \times 10^8$  m/s**

Why might your answer be different to 299,792,458 m/s?

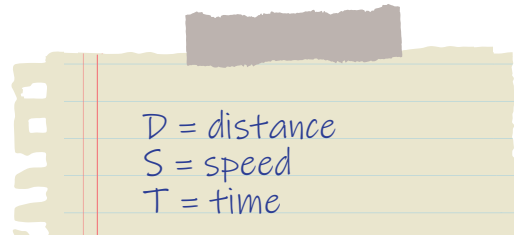
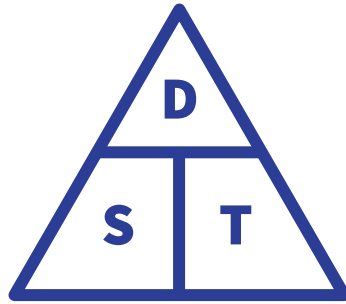
\_\_\_\_\_  
\_\_\_\_\_



## ACTIVITY 3: DISTANCES IN SPACE

Distances to objects in space are very, very large. The nearest star (excluding the Sun), Alpha Centauri, is 41.32 trillion km, or 41,320,000,000,000 km!!!

Therefore, astronomers use a unit called 'light-year' which is the distance that light can travel in a year. Now we know the speed of light, we can calculate the distance of a light year.



1. Rearrange the equation for distance: \_\_\_\_\_

2. Calculate the time in seconds of 1 year: \_\_\_\_\_ (in s)

$$\text{Time in seconds of one year} = \text{Days in one year} \times \text{Hours in one day} \times \text{Minutes in one hour} \times \text{Seconds in one minute}$$

3. 1 light-year = \_\_\_\_\_ (in m)

4. How many light-years away is Alpha Centauri? \_\_\_\_\_





# SESSION 2: LIFE CYCLE OF STARS

In this session you will be learning about the stages of a star throughout its lifetime.

*Are all stars the same? Write down any differences you can think of here:*

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## Where do stars come from?

Stars are born in clouds of gas and dust, which then clump together by way of gravitational attraction. If the resulting clumps attract enough mass, they will begin to heat up and glow, eventually creating a new star.

## What will happen to the Sun next?

The Sun is currently in its 'main sequence phase'. At the core of main sequence stars, hydrogen is converted to helium in a process called nuclear fusion. This nuclear reaction provides enough energy for main sequence stars to shine brightly for many years. The Sun is about halfway through its life as a main sequence star. It will be a main sequence for another 5 billion years (5,000,000,000).

## ACTIVITY 1: BALLOON GAME

You are all going to become stars! Your STEM Club Leader will give everyone a balloon. Some of you will be given red balloons, some yellow balloons, some white and one of you will receive a blue balloon. Follow the instructions from your STEM Club Leader then try and answer the following questions:

1. *What colour are stars that are hottest?*

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2. *What colour are stars that are coldest?*

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3. *Which stars will live the longest?*

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## REQUIRED RESOURCES

- ☆ Red balloons x8
- ☆ Yellow balloons x5
- ☆ White balloons x2
- ☆ Blue balloon x1
- ☆ Pin to pop the balloon

## WARNING

***Be careful with the pin used to pop the balloon.***



## ACTIVITY 2: CARD SORT GAME - LOW MASS STARS

Your STEM Club Leader will give you some cut-out's, place them in the correct order here:

Stage 1 - All stars are born in clouds of gas and dust

Stage 2 - As the dust and gas contracts, it will begin to heat up and start to glow.

Stage 3 - If the centre of the dust and gas cloud contains enough matter it will become hot enough that nuclear fusion can take place. This is the birth of the star! These stars release energy which stop them from contracting and cause them to shine brightly. The Sun is one of these stars.

Stage 4 - The star is running low on hydrogen in its core. Its outer layers will expand outwards. It can grow up to 100 times the size it was when it was a main sequence star.



<p>Stage 5 - The outer layers of gas are ejected from the surface of the star. The core of the star collapses and shines brightly, making the surrounding gas glow.</p>	
<p>Stage 6 - The core of the star has collapsed to about the size of the Earth but still has the mass of the Sun. This means it is very dense. This type of star is made of highly compressed carbon and oxygen. Its surface is very hot and it shines bright and white. This kind of star can look quite faint from a distance because it is so small.</p>	
<p>Stage 7 - Nuclear reactions are no longer taking place inside the star. It will radiate its energy away in the form of light and heat and will slowly cool down and fade. It will take many billions of years to cool right down.</p>	

You have just learnt what will happen to the Sun, but the Sun is not very big compared to other stars. Not all stars start with the same mass and it is this that determines what happens to them. The life cycle of a massive star is different from the life cycle of a lower mass star, like the Sun.



## ACTIVITY 3: CARD SORT GAME - HIGH MASS STARS

Repeat the same process but this time for a high mass star.

<p>Stage 1 - All stars are born in clouds of gas and dust.</p>	
<p>Stage 2 - As the dust and gas contracts, it will begin to heat up and start to glow.</p>	
<p>Stage 3 - If the centre of the dust and gas cloud contains enough matter it will become hot enough that nuclear fusion can take place. This is the birth of the star! These stars release energy which stop them from contracting and cause them to shine brightly. The Sun is one of these stars.</p>	
<p>Stage 4 - When stars with a mass more than 10 times that of the Sun begin to run out of hydrogen, they expand. However, because of their greater mass, these stars begin to fuse heavier elements, which generates even more energy and further expansion. These stars shine red because their vastly expanded surface ends up being cooler.</p>	



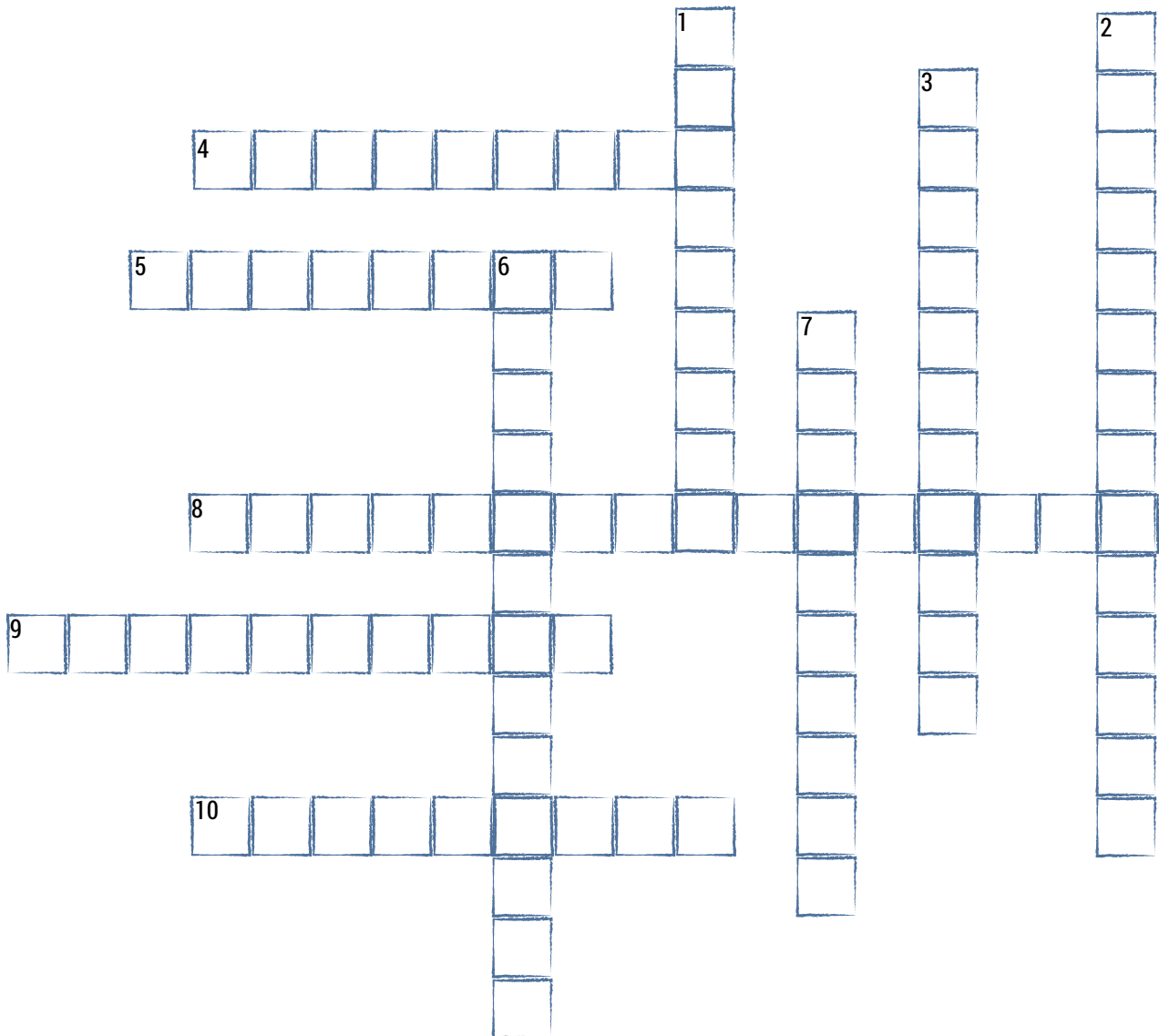
Stage 5 - When all the elements that can be fused run out in the core, it collapses in less than a second, causing an explosion and a shock wave that blows the outer layers of the star out into space. This explosion shines very bright (brighter than the whole galaxy) for a short amount of time. This only happens to stars that are greater than 10 times the mass of the Sun.

Stage 6a - During the explosion, the core of the star is crushed. If the core is small, it will form a small dense star about 10 km across. The remains of these stars can spin rapidly on their axis and when their flashes of electromagnetic radiation are detected they are called pulsars.

Stage 6b - If the core of the star is not small, it will collapse to create a very small and very, very dense area of space with a gravitational pull so strong that even light cannot escape.



## ACTIVITY 4: CROSSWORD



### Across

4. An explosion caused by the collapse of a red supergiant. (8)

5. The dying stage of a star. They become larger and change colour due to the decrease in temperature. (3,5)

8. The Sun is one of these. It is in the steady period of its life, burning hydrogen to helium. (4,8,4)

9. This is what a low or medium mass star will become later in its life. Typically they have the same mass as our Sun, but are around the same size as the Earth. (5,5)

10. A clump of gas and dust that is still gathering mass from the surrounding cloud of gas. (9)

### Down

1. Core of a red supergiant that has collapsed. It is so dense that even light can't escape. (5,4)

2. Dust and gas in space which goes on to form stars. (9,5)

3. Core of a red supergiant that has collapsed. They can spin on their axis really fast. (7,4)

6. The joining together of hydrogen and helium atoms to release large amounts of energy. (7,6)

7. Dead star that is no longer hot nor bright. (5,5)



# SESSION 3: ENGINEERING TELESCOPES

In this session you are going to find out about the world's best telescopes. Clever engineering ideas have allowed astronomers to build telescopes in exciting ways that let them push their discoveries wider and deeper into space!

'What is the biggest telescope?' is a common question that has lots of different answers! That is because there are lots of different types of telescopes that astronomers use to study different things about space.

## ACTIVITY 1: TELESCOPE GAME

Your STEM Club Leader will read out the rules of the game. As you are playing, try and answer these questions:

Which telescope has the widest diameter? \_\_\_\_\_

Which telescopes are in space?

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Which type of telescope collects (or observes) the longest wavelength?"

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The Lovell Telescope is the largest telescope (widest diameter) in the UK. It is a radio telescope which means it collects radio light waves. Radio waves can penetrate the Earth's atmosphere and so radio telescopes can be built anywhere in the world and can work night and day, even when cloudy.



The Liverpool Telescope is the world's largest fully robotic telescope. It was built in Merseyside but is now located on La Palma, one of the Canary Islands. It is an optical telescope (it sees the same light that we can see with our eyes) and has a 2 m mirror for focusing the light it collects. It operates at nighttime and works best on dark cloudless nights.





## ACTIVITY 2: MARSHMALLOW STRUCTURES

The Liverpool Telescope has an intricate structure to hold its collecting mirror and imaging devices. It must be strong to carry the weight of the mirror and be able to move quickly to view different objects in the sky.

In this activity you will build a structure from only uncooked spaghetti and marshmallows. The aim of the task is to be able to hold a 500 g weight (e.g. a can of pop or similar). Your leader will provide you with the materials you need to get building.

The only rules you have is that your structure must:

- ☆ Be at least 15 cm tall
- ☆ Hold a weight for at least 10 seconds
- ☆ Only be made of marshmallow and spaghetti

*Draw your design here:*



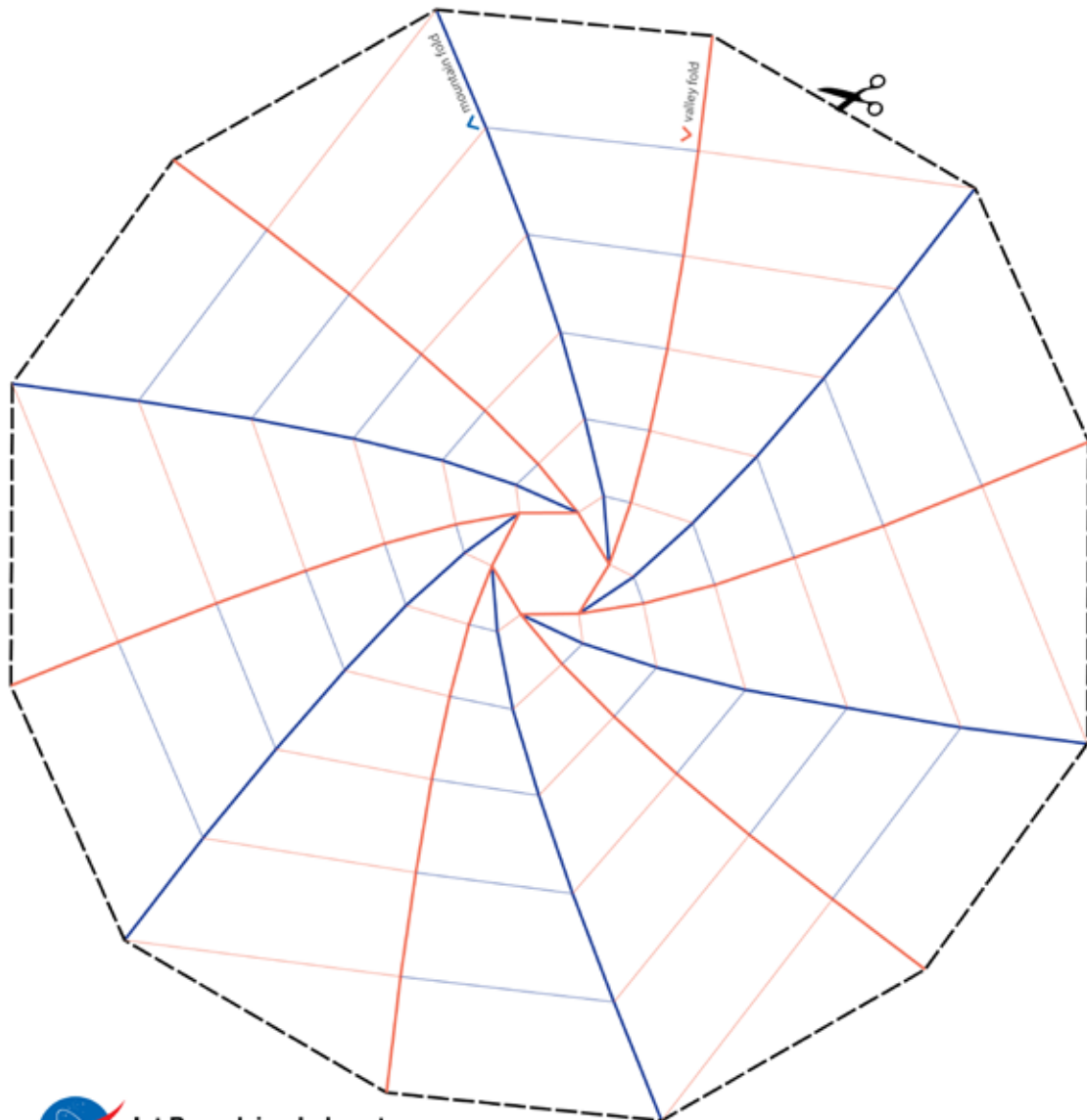
## ACTIVITY 3: ORIGAMI TELESCOPES

Some wavelengths of light cannot penetrate the Earth's atmosphere. If astronomers want to study that part of the electromagnetic spectrum they put those telescopes into space. Another reason for space telescopes is to get above the clouds and weather that can affect a telescope's performance.

Telescopes that go into space face engineering challenges. They need to be lightweight, small enough to fit into a spacecraft, and block the Sun's light and other unwanted light. When designing space telescopes, astronomers sometimes ask for help from origami experts.

In this activity, you will make a sunshield using the origami folding method. Your leader will give you a copy of the template below, cut it out and follow the fold lines.

- ☆ Blue lines are mountain folds that point up, as viewed from the printed side of the paper.
- ☆ Orange lines (which make up the central hexagon) are valley folds that point down.



# SESSION 4: PLANNING OBSERVATIONS

The night sky is full of fascinating objects from stars and planets to galaxies and comets, but finding your way around can be tricky. The key to successful observing is planning. In this session you will learn how to use software to plan an evening of planet hunting.



For this Session you will be using Stellarium on a computer. Stellarium is astronomy software that lets you simulate the night sky in order to plan your observing. It will show you what the cloud-free sky will look like from anywhere on Earth at any time.

Your STEM Club Leader will give you instructions on how to use Stellarium separately. Keep this booklet to make notes about your observations and complete the table below.

For your first observing session you will not be using a telescope. When you are exploring Stellarium you are interested in brighter objects that you will be able to see with your eyes. Good objects to start with are the Moon and the planets.

Planets orbit around the Sun just like the Earth. This makes their position in the sky difficult to predict. Different planets are visible at different times. Sometimes lots of planets can be seen at the same time. Sometimes you might not see any. Or you might see one at the start of the night, and another at the end. This is why planning your observing session is very important – so you know what, when and where!

**For your chosen evening, see when each of the objects listed below will be visible and fill in the rest of the table.**

Date of your Observing Evening: \_\_\_\_\_ Sunset time? \_\_\_\_\_

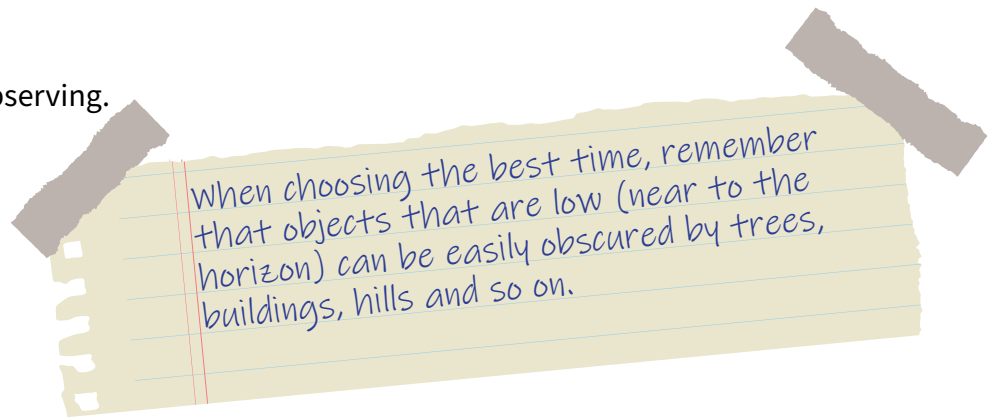
Location of your Observing Evening: \_\_\_\_\_

What time will you start? \_\_\_\_\_ What time will you end? \_\_\_\_\_



Object name	Is it visible at the start?	Is it high or low in the sky?	Is it visible at the end?	Is it high or low in the sky?	When is the best time to observe it?	What direction should you look?
Moon						
Mercury						
Venus						
Mars						
Jupiter						
Saturn						

Good luck with your observing.  
Clear Skies!



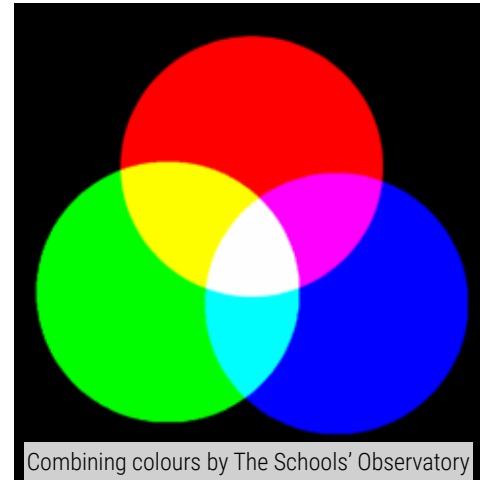
# SESSION 5: COSMIC CLUES

In this session you will be investigating stars using light and colour.

## Why are things different colours?

Light is the only source of colour. When light hits an object, some of the visible spectrum is 'soaked up' or **absorbed** and only some of the light is 'bounced off' or reflected. The light that is **reflected** is the light that we see. For example, a red object absorbs almost the full spectrum of light and reflects only the **wavelength** of light that our eyes see as red.

Visible white light is made of three primary colours: red, green and blue. Our eyes see the different wavelengths as different colours. Some colours are made by combining different wavelengths in the spectrum. For example: red + green light = yellow light.



## How does the Liverpool Telescope (LT) record colour?

The LT measures the intensity (brightness) of the light it collects; it doesn't directly measure the colour of the light. But it does have different filters that only let through light of a specific range of wavelengths (or colour).

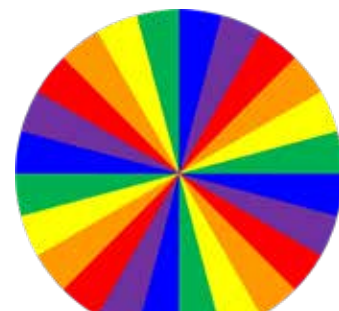
Users of our telescope (like you!) can add colour to their images. They can use software to assign blue colour to images taken through the blue filter, red colour to images taken through the red filter and so on. You will have a chance to do this in Session 6!

## ACTIVITY 1: MAKE A COLOUR WHEEL

You will rapidly spin a wheel containing different colours to try and trick your eyes into mixing the colours.

### INSTRUCTIONS

1. Cut a circle out of paper or card.
2. Divide the circle into equal segments using a protractor and ruler.
3. Colour the segments with coloured pens or pencils to match the circle on the right (alternatively your leader can print you a copy of the circle).
4. When you have coloured the circle, stick a piece of Blu Tak on the back in the middle. Stick the end of a pencil or pen in the Blu Tak (alternatively you can punch a hole in the centre of the card and stick the pen through the hole).
5. Hold the pen or pencil between your hands and rub them together to make the disc spin.



## IMPORTANT

***Make sure you split your circle into equal parts and use the same order of colours shown here.***



## DURING THE EXPERIMENT

Look at the spinning circle.

- ☆ What did you see?
- ☆ What happens to the colours when you spin it at different speeds?
- ☆ Why do you think this happens?

Try and spin the colour wheel as fast as possible and get a friend to do the observing.



Can you think of an occasion in nature when white light is split up into a spectrum of colours?

## ACTIVITY 2: MAKE A MESSAGE DISAPPEAR!

You are going to experiment by looking at different coloured objects through colour filters (pieces of coloured cellophane). You will then try to hide a secret message.

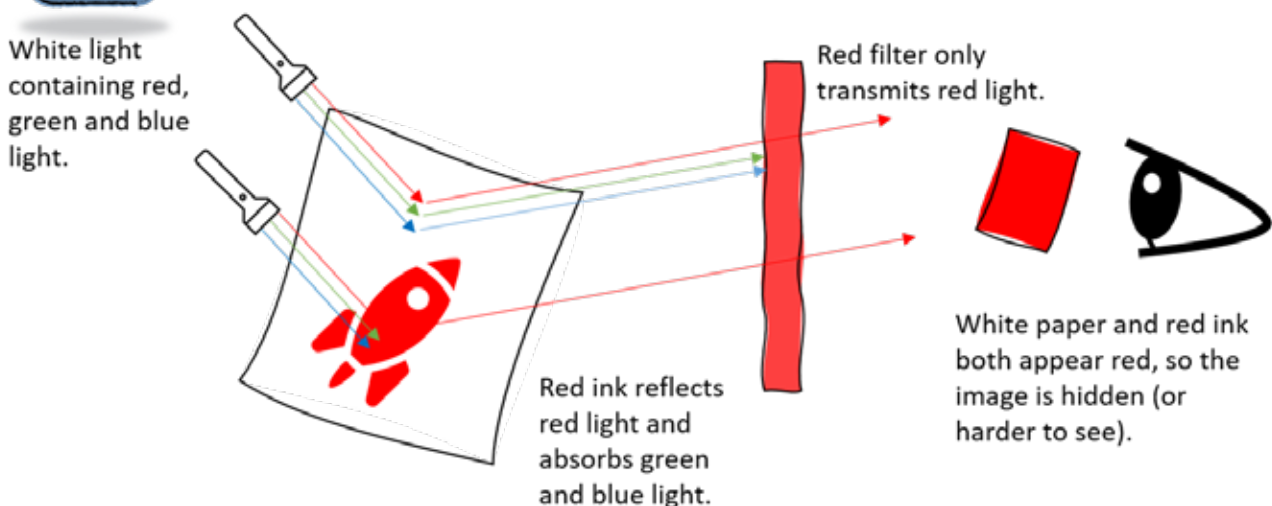
1. Look through a colour filter at objects in the room or out of the window. What do you notice?
2. Write a message here. Use green, blue, and red ink. Board markers work well.

3. Look at the message through one of the colour filters.
4. What happens to each colour when you look through the filter?

5. Why don't you hide a secret message for a friend to find!



Why do you think astronomers need colour images?



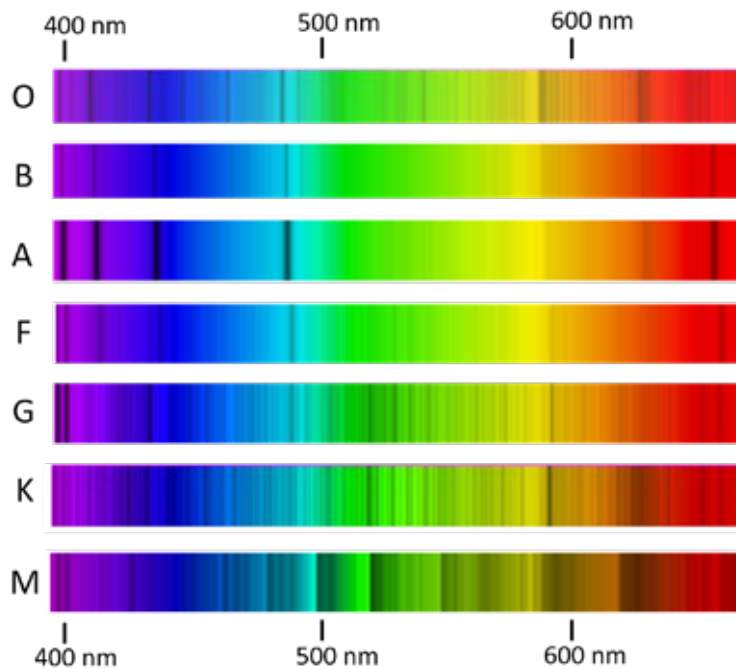
## ACTIVITY 3: STELLAR FORENSICS

Measuring colours is only one way of analysing starlight. Another way is to use a spectroscope to spread out the light into a spectrum. This kind of science is called **spectroscopy**.

A star's outer layers act like a filter to **absorb** certain wavelengths. We see dark lines where wavelengths of light have been absorbed. The spectra are like a barcode or a fingerprint that give scientists extra information about stars. The pattern of absorption spectra is changed by the star's surface **temperature**. This means that scientists can use spectroscopy to work out how hot or cold stars are.

Did you know? Astronomers can also use spectroscopy to work out what **elements** a star contains. The element helium was discovered by studying the spectral lines of the Sun before helium was found on Earth! **Be a detective and try to identify some stars from their spectra.**

Most stars are classified by surface temperature into groups. The groups have the letters O, B, A, F, G, K, and M. Group M stars are the coolest at about 2,500°C. Group O stars can be over 30,000°C!



Taken from Spectroscopic Atlas for Amateur Astronomers (v 3.0) by R. Walker

Reference spectra by R. Walker

Remember this classification using the mnemonic: **One Bold And Fearsome Goat Kicked Me!** Why not make up your own?

My own mnemonic for remembering spectral types:

O _____	G _____
B _____	K _____
A _____	M _____
F _____	



## INSTRUCTIONS

1. Have a careful look at the reference spectra on the previous page. Notice that the dark absorption lines are different for each one.
2. Match up each of the four sequences of stars' spectra with the reference spectra.
3. Put the corresponding letters in the boxes underneath each sequence.
4. Check with your leader to find out if you've cracked the code correctly!

The scale at the top of the spectra tells you the wavelength of the light in nanometres. Use it to help you match up the dark absorption lines in the spectra. One nanometre is one millionth of a millimetre ( $1 \times 10^{-9}$  m).

**Sequence 1:**

?

?

?

Code word:

**Sequence 2:**

?

?

?

Code word:

**Sequence 3:**

?

?

?

?

Code word:

**Sequence 4:**

?

?

?

?

Code word:





# SESSION 6: 3-COLOUR IMAGES

In this session, you will create a colour image of M51 using an observation taken by the Liverpool Telescope. M51 is also known as Messier 51, NGC5194 or the 'Whirlpool Galaxy'. It is a spiral galaxy interacting with a dwarf galaxy.

The Liverpool Telescope takes pictures using different 'filters'. Use our software to combine three filtered images of M51 (a red image, a blue image, and a green image) to make a colour picture.

## ACTIVITY 1: LOAD THE IMAGES

1. Launch the software. Your STEM Club Leader will tell you how to find this.
2. If your STEM Club Leader hasn't already given you the data files, go to our website: [www.schoolsobservatory.org/discover/activities/3\\_colour\\_imaging](http://www.schoolsobservatory.org/discover/activities/3_colour_imaging)  
Download three of the data files, e.g. 'M51\_red.fits', 'M51\_green.fits' and 'M51\_blue.fits'.
3. In our software click on 'File', then 'Open Image', find the location of the saved files from step 2 and click on the 'red' data file, then click 'Open'.
4. Move to a second window within the software.
5. Click on 'File', then 'Open Image', and click on 'green', data file, then click 'Open'.
6. Move to a third window in the software.  
Click on 'File', then 'Open Image', and click on 'blue', data file, then click 'Open'.  
You should now have three images loaded into image stores 1, 2 and 3. It does not matter what they look like, as you will be working on that later.  
Now open a fourth window.
7. Click on 'Colour' in the main menu, then click '3-Colour Image'.  
Then, to get everything setup and ready, click on the 'Make new image' button at the top of the tool. This will make a first-guess version of the 3-colour image and display it in the main image panel. Don't worry if this looks very dark - it will often just show black with perhaps a couple of small 'dots', but this is quite normal at this stage.



## ACTIVITY 2: ALIGN THE IMAGES

The software has done its best to line up the red, blue and green images on top of each other. But it might not have done it perfectly. You may need to correct this.

To align the image, you will use the panel on the right that contains the '3-Colour Image' tools. You will use the 'Zoom Preview' window, the 'Working Colour' buttons and the 'Alignment' buttons.

1. Click on the circle next to the word 'Red' in the 'Working Colour' panel. You are now working on the red image.
2. Try moving your mouse pointer over one of the bright 'dots' in your main image window then "click" with the left mouse button. The 'Zoom Preview' window will change to show the small piece of the image under your pointer.
3. Try and get your 'dot' in the centre of the 'Zoom Preview' window - you may find it easier if you hold down the left-button on your mouse and move the mouse pointer slowly over the image.
4. You should see that the red, green and blue 'dots' are slightly separate and not on top of each other. Use the Alignment buttons to nudge the red image up, down, left and right until it is under the blue one. This will make the 'dot' look more purple.
5. Next, move the green image so it is on top of the others. To do this, click the circle next to the word 'Green' in the 'Working Colour' panel. You should see the background colour of the tool change to green.
6. Use the 'Alignment buttons' to nudge the green image so it is on top of the red and blue images. Your 'dot' should end up as whiter, smaller point. It's actually a star!
7. Click on the 'Make a new image' button in the top-right panel to save your progress and see your new aligned image in the main window.

## ACTIVITY 3: CREATE THE 3-COLOUR IMAGE

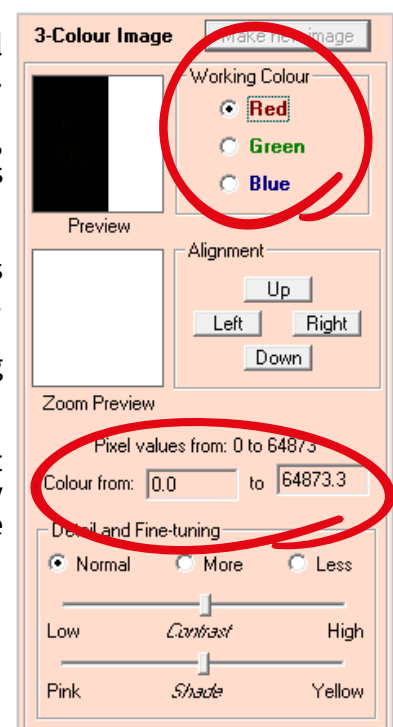
1. Reselect red as your working colour. You now need to select 'Pixel values' to bring out the stars and colourful regions of the image.

About half-way down the panel on the right side of the window, you will find a line that says 'Colour from: X to Y' (your numbers will be different depending on which files you have loaded).

Reduce 'Y' (the larger number) by a factor of 10, e.g. if it was '20000' reduce it to '2000', then click 'Make new image' at the top.

2. Repeat step 3 for the 'Green' and 'Blue' sections in the 'Working Colour' area of the panel.

It is worth playing around a bit with these values to bring out exactly what you want. Don't forget that you can use the Display menu tools to Zoom in and out on the main picture, and the 'Zoom Preview' to explore in detail.

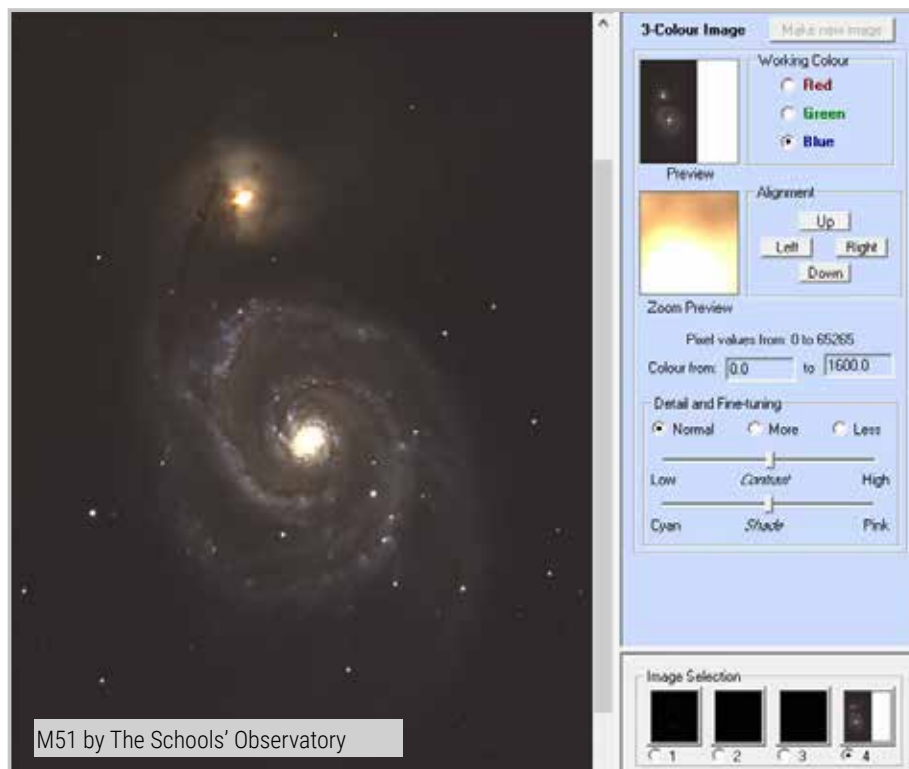


The files you download to use in this activity are sample files we have named to make it easy to follow.

When you download files from our website they will not be named using red, green or blue in their filenames. Instead the red images will have '000' in the filename, the green will have '001' and the blue will have '002', e.g. 10308F**000**.fits, 10308F**001**.fits and 10308F**002**.fits.

You still load them in the same order; red or 000 into 'Image Selection #1', green or 001 into 'Image Selection #2' and blue or 002 into 'Image Selection #3'.

3. When you have an image that you like, you can save it to your computer. Click 'File', then click 'Save picture'. Choose a location on your computer and give your file a suitable 'File name', then click 'Save'. Well done, you have created a 3-colour image of a spiral interacting galaxy known as M51 from an observation with the Liverpool Telescope. Why don't you try making more images in the Extension activity.



4. Using The Schools' Observatory, you can create 3-colour images of many objects. You can do this in 2 ways:

- ☆ Use data from our Archive that is full of observations made by the Liverpool Telescope: [www.schoolobservatory.org/obs/arch](http://www.schoolobservatory.org/obs/arch)
- ☆ Request your own 3-colour observation of your favourite astronomical object using Go Observing: [www.schoolobservatory.org/obs/go](http://www.schoolobservatory.org/obs/go)

Some of our favourites are the Ring Nebula, Sombrero Galaxy, and Stefan's Quintet.

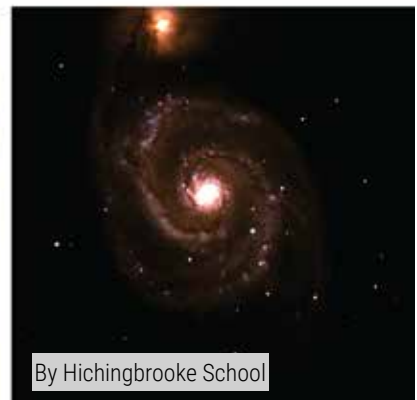


# JUST FOR FUN!

We love to see the images you have created from your observations! Share your images with us.

Ask your STEM Club Leader to share your images with us by:

★ Tagging @SchoolsObs on [Twitter](#) or [Instagram](#)



*By sharing your images with us, you consent for The Schools' Observatory to use your image on our website and social media accounts and/or for publicity.*



# WORD SEARCH

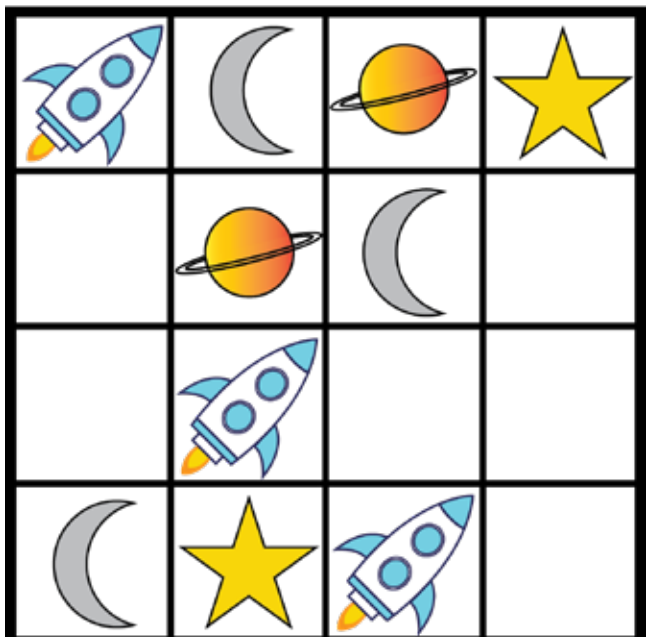
Can you find all the space words in the puzzle below?

W U S U F L U A U Y A Q B C W  
 A I T T M W T U U O S I Z F A  
 V O Z C A U A R P N N P D C V  
 E B M I C R O W A V E U A F E  
 U S V F M P J D G Z F Y V C L  
 D E C A L C U L A T E O Y T E  
 I R S N F C H O C O L A T E N  
 S V L T L R V G W P O G A M G  
 T I V I S Z E W A P L A N E T  
 A N Z N G V E Q S L M Q B A H  
 N G X O G H Q D U P A X S S Q  
 C O W D V K T Q S E E X M U K  
 E X U E W L Q S H K N E Y R Y  
 B K L Q Y J E S G Q Y C D E J  
 T E L E S C O P E U X E Y H W

ANTINODE  
 CALCULATE  
 CHOCOLATE  
 DISTANCE  
 FREQUENCY  
 GALAXY  
 LIGHT  
 MEASURE  
 MICROWAVE  
 OBSERVING  
 PLANET  
 SKY  
 SPACE  
 SPEED  
 STAR  
 TELESCOPE  
 WAVE  
 WAVELENGTH

# ASTRO-DOKU

Draw the pictures in the right squares to complete this astro-doku puzzle. Each picture can only appear in a column and row once.



Answers - page 30



## ABOUT THE SCHOOLS' OBSERVATORY

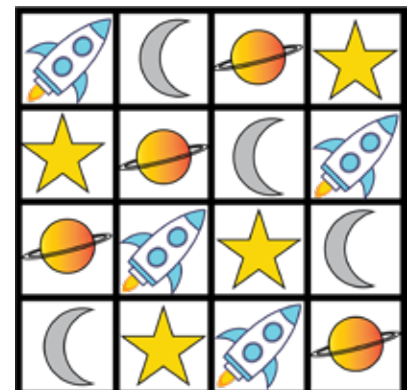
The Schools' Observatory (TSO) is proud to be part of Liverpool John Moores University (LJMU). We are part of LJMU's Astrophysics Research Institute (ARI). LJMU has a robotic telescope, called the Liverpool Telescope, which is located at the top of a very high mountain on La Palma in the Canary Islands. LJMU is one of the few UK Universities that owns and operates a professional telescope.

We were created to help young people across the UK and Ireland use the Liverpool Telescope. You can read all about our team here: [www.schoolsobservatory.org/about/team](http://www.schoolsobservatory.org/about/team)

Congratulations! You have now finished the Silver STEM Club booklet! We hope you have enjoyed yourself and learnt a few things along the way.

If you want to know about other topics that are not already on our website, ask your Stem Club Leader to email us and let us know! [SchoolsObs@ljmu.ac.uk](mailto:SchoolsObs@ljmu.ac.uk)

## WORD SEARCH ANSWERS



**[PLACE YOUR CERTIFICATE HERE]**



## THE SCHOOLS' OBSERVATORY

If you enjoyed the Silver award ask your STEM Club Leader about our Gold award, six amazing sessions taking you to the next level in your space adventure.

### 6 GOLD SESSIONS:

*DESIGN A TELESCOPE  
COMPARE GALAXIES  
THROW A STAR PARTY!  
AND MORE...*

### *PROUD TO BE PART OF*



[WWW.SCHOOLSOBSERVATORY.ORG](http://WWW.SCHOOLSOBSERVATORY.ORG)

Triangulum galaxy by The Schools' Observatory

**STEM**  
Club

**SECONDARY EDITION**

