# *The expansion of the universe* **Teacher background notes**

**In this investigation, Edwin Hubble’s observations will be examined as evidence for the Big Bang theory. In 1929, Hubble discovered that the light from distant galaxies was red shifted and that the further a galaxy is from Earth, the faster it is moving away. This was evidence for the expansion of the universe following the Big Bang.**

## [Australian Curriculum: Science links](http://assist.asta.edu.au/resource/2986/expansion-universe-cle)

## Learning intentions

Students will be able to:

* explain that red shift applies to objects that are moving away from the Earth
* identify that the amount of red shift relates to the speed of recession
* analyse the validity of claims made in secondary sources
* make accurate measurements
* construct appropriate representations that allow them to interpret and analyse the data
* identify patterns and relationships in data.

## Suggested time for this CLE

The time needed to complete *The expansion of the universe* CLE will depend on the depth of the prior knowledge of students, the time to perform the various investigations and to follow up with any extension activities. Allow 2–3 hours.

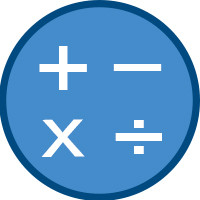
## Prior conceptual knowledge

Science / Year 10 / Science Understanding / Earth and space sciences

Content description

*The universe contains features including galaxies, stars and solar systems and the Big Bang theory can be used to explain the origin of the universe*[*(ACSSU188)*](http://www.australiancurriculum.edu.au/science/curriculum/f-10?layout=1#cdcode=ACSSU188&level=5)

## New concepts to be introduced

*Any maths concepts are highlighted in the teaching and learning plan by this symbol *

The concept of a wave appearing to be different as it moves towards or away from an observer is known as the Doppler Effect. In fact, it works for a moving observer as well. Radar works on this principle. As an aircraft intercepts radar waves, the waves bounce off the moving aircraft and return to the ground station. How much the waves change or shift from their original form indicates how fast the aircraft is moving. Police radar determines a speeding driver’s speed in the same way. Applying this concept to light appearing to be a different colour than it really is due to an object’s speed is a challenging one for students. Nevertheless, a useful comparison is how sounds can appear to change in pitch as an object approaches and then travels away from an observer. (This is explained well in the Stephen Hawking video in the Introduction in the Teaching and Learning Plan). An approaching object bunches the waves up in front of it giving them an apparently shorter wavelength. Since blue light has a shorter wavelength than red light, this is known as ‘blue shift’. A receding object will spread out the waves travelling back from it giving them an apparently longer wavelength. Since red light has a longer wavelength than blue light this is known as ‘red shift’.

In 1929, Edwin Hubble discovered that the light from distant galaxies was red shifted and that the further a galaxy is from Earth, the larger is its red shift. He then found a simple linear relationship between the recessional speed of a galaxy and its distance from Earth. The two variables are directly proportional to each other. This became known as Hubble’s Law.

v = H × d

recessional speed = Hubble’s constant × distance from Earth

The constant of proportionality H is given the name ‘the Hubble constant’ and is also the gradient of the graph. Since time equals distance over speed, the time it has taken the various galaxies to reach their current positions is the same as the inverse of the Hubble constant. Hence 1/H or H-1 gives the approximate age of the Universe. This has been measured with more and more accuracy over the years as technology has improved.

Graphing and calculating gradients can be challenging for students. However, the graph in this case (though is in the form of *y* = m *x*) should be quite simple for students to analyse. The student investigation sheet will help them with this process.

## Possible misconceptions

|  |  |
| --- | --- |
| **STUDENTS MAY THINK…** | **INSTEAD OF THINKING…** |
| The person driving the car (in the video) also hears a change in pitch from the car | The person driving the car always hears the same pitch from the car as they are stationary relative to the car |
| The universe is infinite and ageless—it has always existed as it does now | Evidence shows the universe began somehow and is continually changing |
| There is no link between the age of the universe and the expansion of the universe | The age of the universe is closely linked to the expansion of the universe |
| The light coming from distant galaxies is all the same | The light coming from distant galaxies can be analysed with scientific instruments and differences can be detected |
| The expansion of the universe cannot be visualised or modelled | The expansion of the universe can be visualised and modelled using simple materials |
| The Big Bang was an explosion | The Big Bang was an expansion of space itself |
| Space is just emptiness | Space is a real, stretchable, flexible thing |
| Galaxies are moving away from us *through* space | Galaxies are moving away from us *with* space |
| You can see the galaxies moving by just looking at them, even through a powerful telescope | You have to analyse the light coming from the galaxies in order to detect their movement |
| The Big Bang theory is just an idea | The Big Bang theory is the result of several important observations and real evidence |
| The origin of the universe is a well-known fact | The origin of the universe remains one of the greatest questions in science |

## Links to further information

‘The beginning of everything – The Big Bang’**,** YouTube (5.55 min) <https://youtu.be/wNDGgL73ihY>

‘Picture of the Big Bang (a.k.a Oldest Light in the Universe)’, YouTube (4.00 min) <https://youtu.be/_mZQ-5-KYHw>

‘Hubble’s Expanding Universe Red Shifts The Big Bang’, YouTube (4.15 min) <https://youtu.be/hVApTLE7Csc>

‘Brian P. Schmidt’, ANU Research School of Astronomy and Physics website <http://www.mso.anu.edu.au/~brian/index.html>