

STARS RESOURCES

Teacher notes

Variable stars over time

ACTIVITY

Discover variable stars and measure their relative luminosity.

Students will:

- understand that some stars vary in how much light they emit over time.
- measure the relative luminosity of objects.

This activity is aimed at students in middle secondary school.

CURRICULUM LINKS

YEAR 8 SCIENCE – PHYSICAL SCIENCES V.9

Science Understanding

classify different types of energy as kinetic or potential and investigate energy transfer and transformations in simple systems AC9S8U05

- investigating relationships between kinetic and potential energy in a simple system such as a roller-coaster or Newton's cradle
- classifying types of energy as either kinetic energy such as movement, heat and electricity or potential energy such as chemical, elastic and gravitational
- critiquing and using representations such as flow diagrams to illustrate changes between different forms of energy in a system

Science Inquiry

develop investigable questions, reasoned predictions and hypotheses to explore scientific models, identify patterns and test relationships AC9S8I01

- discussing what is meant by a causal relationship and examining how causation is different from correlation
- developing investigable questions to test causal relationships
- predicting what will happen when conditions change in a given scenario or phenomenon

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CURRICULUM LINKS cont'd

select and use equipment to generate and record data with precision, using digital tools as appropriate AC9S8I03

- selecting and using equipment with required precision
- recording data with precision appropriate to the instrument such as rounding up or down with finer graduations or estimating an intermediate value with coarser graduations
- using digital tools such as digital microscopes, simulations and video-recording devices when appropriate to observe, measure and record qualitative and quantitative data
- using appropriate positive and negative signs for standard units, number of decimal points and exponential notation where relevant when recording data

select and construct appropriate representations, including tables, graphs, models and mathematical relationships, to organise and process data and information AC9S8I04

- using simple formulas in spreadsheets to organise and process collected data
- constructing energy flow diagrams to represent energy changes in a system such as a rollercoaster or rocket launch
- collating data from a number of sources such as different groups in the class who performed the same investigation to create a summary

analyse methods, conclusions and claims for assumptions, possible sources of error, conflicting evidence and unanswered questions AC9S8I06

- identifying assumptions then examining if extra variable controls are required and how these might affect the data and conclusion
- identifying sources of error in methods such as inconsistent variable control and inaccuracies in procedures or measurements, and explaining how the method could be improved
- comparing results with other groups or secondary sources to examine consistency and describing where there may be conflicting results or conclusions

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BACKGROUND INFORMATION

Variable stars change in size regularly. This is to do with instabilities between the pressure from fusion inside the star pushing outwards and gravity pulling everything towards the centre. We can't see the size change with the visible eye. Instead, we see the brightness of the star changing over time.

Why does a star pulsate and vary?

A star is a massive object that produces tremendous pressure within itself, caused by radiation and gas. This pressure forces the star's outer layers outwards. However, gravity also affects the star and pulls it inward. When the pressure pushing outwards and the gravity pulling inward balance each other, the star is stable.

If the outward pressure becomes stronger than the pull of gravity, the star's outer layers will expand, reducing the gravitational pull and causing the pressure to decrease even faster. Eventually, a temporary equilibrium is reached, but the layers moving outward still have momentum, causing the equilibrium to be short-lived. The pull of gravity eventually overtakes the outward movement, causing the layers to fall back inwards.

As the layers fall inward, the gravitational pull increases, while the pressure also rises. This process causes pressure to push outwards again, which eventually leads to the sequence starting over again.

Betelgeuse is an example of a variable star. It is a spectral M1-2 type star, and a semi-regular variable star. Technically speaking, it's a subtype SRc.

Further reading:

'Variable star', Wikipedia, https://en.wikipedia.org/wiki/Variable_star (6 March 2023)

Astronomical Society of South Australia, 'Observing Variable Stars', <https://www.assa.org.au/resources/variable-stars/observing-variable-stars/>

Read about variables: 'Pulsating Variable Stars', CSIRO/ATNF website, https://www.atnf.csiro.au/outreach/education/senior/astrophysics/variable_pulsating.html

Animation: 'Animation of a variable star', HubbleWebbESA, YouTube (47 seconds), <https://youtu.be/sXJBrRmHPj8>

Betelgeuse: 'Hubble sees red supergiant star Betelgeuse slowly recovering after blowing its top', Hubblesite, <https://hubblesite.org/contents/news-releases/2022/news-2022-037> (11 August 2022).

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BACKGROUND cont'd

Life of Betelgeuse: 'Red Supergiant Star Betelgeuse Was A Different Color Just 2,000 Years Ago', ScienceAlert, <https://www.sciencealert.com/red-supergiant-star-betelgeuse-was-a-different-color-just-2000-years-ago> (6 September 2022).

'How to see the Variable Stars with a Telescope', Telescope Nerd website, <https://www.telescopenerd.com/how-to-see/variable-stars.html> (27 January 2023)

PLANNING AHEAD

- The study of variable stars requires multiple nights of observing. It is recommended you choose a particular constellation which contains variables, and return to that recognisable constellation each time. One obvious constellation is Orion the Hunter, where Betelgeuse is the giant red variable. In fact, its variability is visible with the naked eye.
- Prepare to observe twice a week for a month and record that data electronically. Avoid nights of full Moon or hazy atmospheres. Clear, dark skies are needed for this sort of observing.
- When measuring variable stars, unless you have advanced equipment and access to specialised software, you will not be able to measure absolute brightness of your star. Instead, you will compare your chosen star's brightness to another neighbouring star.
- Read the Astrophotography Teacher Notes regarding planning for the best observing conditions and setting up the equipment.
- After photos are taken, students will need to manipulate the photo files using software. Check ahead of time with your IT department to see which software you are able to or allowed to use. Quite often school-provided laptops require administrative permissions to install non-standard software.

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OBSERVATION NIGHTS (student-led)

1. Set up the telescope, smartphone camera adapter with smartphone attached.
2. Find your target star, ensuring you include another star in the photo – the same star in every photo. The assumption is that the reference star will look the same in all photos (i.e., same colour, and same apparent size), and that Betelgeuse will grow or shrink in the photo as it becomes brighter or dimmer. A brighter object will smear its light across more pixels, which is why it will look bigger.
3. Take a 5-10 second exposure photo of the stars.

POST-OBSERVATION

Using the photos, make relative measurements of the brightness of your variable star over time compared to the reference star.

This can be done in a number of ways, depending on how easy it is to access software. Below is a list of simplest to most specialised methods.

1. Print each of the photos onto A4 paper. Have students look at the size of the 'blob' that is the variable star in each image. Using their own interpretation of the image, and perhaps a small ruler with a millimetre scale on it, have students tabulate their results and consider how they might graph the brightness over time. Suggest relative scoring scales such as a Likert scale of 'much brighter', 'a little brighter', 'much more dim', 'a little dimmer'.
2. For a simple software option, try using one of these programs: <https://listoffreeware.com/free-image-histogram-software-windows/> Essentially, software for manipulation of images that has the ability to display a histogram.

The histogram will graph the intensities of the colours within the image. It is a straight-forward tool for comparing how bright or dim the variable star is over a number of different observations. Analysis of the histograms will show that one or two peaks grow and shrink significantly in each photo. Those peaks will represent the changes in the output of the variable star.

The histogram will supply numerical values on the y-axis that can be extracted manually and tabulated or graphed against date.

3. If you have the ability to download Java-run software, you can use VStar for analysis of your data. Download the software here: <https://www.aavso.org/vstar>

Watch this 5-minute video on how to use the software: <https://www.aavso.org/sites/default/files/vstar/VStarVideoTutorial.mp4>

(All websites accessed April 2023)

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