Exo-planets

Teacher's Notes

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Introduction

An exoplanet, or an extrasolar planet, is a planet which orbits any star other than our Sun – so one which is not within our Solar System. As far back as the 16th century, the existence of exoplanets has been assumed, but it is only within the last 25 years that astronomers have actually detected these planets.

The first confirmed detection of an exoplanet was in 1995, however, a published discovery, in 1988, of a planet orbiting another star has since been confirmed.

To date (Jan 2010), 429 exoplanets have been detected in our galaxy. Most of these planets are giant planets, thought to be similar to Jupiter, in our own Solar System. Astronomers estimate that at least 10% of Sun-like stars will have planets. Of the planet systems which have been found, 45 of them are multi-planet systems (i.e. the star has more than 1 planet orbiting it).

Naturally, one of the things which astronomers are keen to find are exoplanets which could harbour life. As such, the search for Earth-sized extrasolar planets which orbit their star in the 'habitable zone' is one of the major aims. The habitable zone of a planet system is where there could be liquid water, i.e. not too close to the parent star so that any liquid water would evaporate and not too far away where it would freeze.

Detection Methods

Finding these exoplanets does not come without its challenges, however, with developments in technology, it is becoming easier, hence more and more extrasolar planets are being discovered. There are various methods used currently, including:

Radial Velocity or Doppler Method

This method has by far been the most productive method of detecting exoplanets to date. The method makes use of the fact that a star with a planet in orbit around it, will move in its own small orbit, due to the gravity of the orbiting planet. Astronomers can measure the variations in the speed of the star moving towards and away from the Earth.

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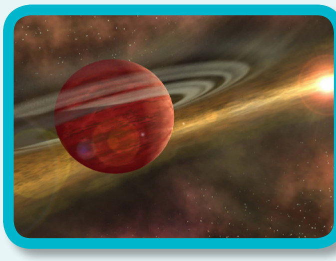
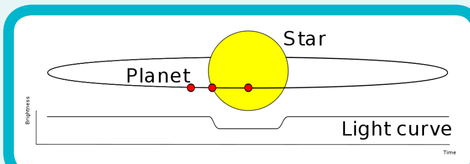
Classroom demo:
Demonstrate this effect to your class with a bit of ceilidh dancing! Ask 2 pupils to come to the front of the class (preferably the largest and smallest pupils in the class). Ask them to link hands between them and for them to spin round, as if ceilidh dancing (make sure they have reasonable space around them!). Ask the larger pupil to try to stay rotating on one spot whilst the other pupil goes around. The rest of the class should be able to see that the larger pupil (the star) 'wobbles' slightly.



This method is very good for finding exoplanets which are very massive, and quite close to their parent star. Finding planets orbiting their star at a greater distance requires many years of observation. One drawback to this method is that from the measurements, astronomers are only able to estimate the planet's minimum mass.

Transit Method

When a planet goes in front of, or transits, its parent star, the observed brightness of that star dims slightly. By measuring the brightness over a period of time, astronomers can determine whether there could be a planet, or planets, orbiting that star. This method can also help astronomers determine the size of the exoplanet, and when this information is put together with measurements from the radial velocity method, the density of the planet can be determined. The extrasolar planets which astronomers know most about, are those which have been studied using both the transit method and the radial velocity method.



'Transit method'

Classroom demo:
To demonstrate this method to the class, ask 2 pupils to come to the front of the class. Project a bright blank screen onto the wall or your white board. Ask the pupils to stand one either side of the screen and to throw a ball back and forward to each other. Ask the class to imagine the ball is a planet orbiting a star, and ask them what things they could measure from this experiment. You could try this with different sized balls to show how less light will be blocked by smaller planets.

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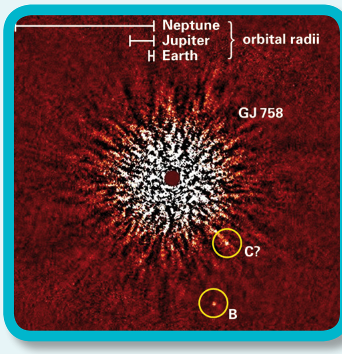
One big advantage to this method is that information about the planet's atmosphere can also be gathered using this technique. If a planet passes in front of its parent star, as it does so, some of the star light will be passing through the planet's upper atmosphere. By measuring the change in the spectrum of the starlight, astronomers can detect different elements in the planet's atmosphere.

One disadvantage of this method is that it often results in false detections. As such, any transit method detection requires additional confirmation, normally using the radial velocity method.

Direct Imaging

Because planets themselves are quite poor sources of light compared to their parent star, any light they do emit is usually lost in the glare from the star. As such, it is not very easy to detect exoplanets using direct imaging. Current technology generally only allows astronomers to directly image exoplanets which are very large, hot and far away from their parent star.

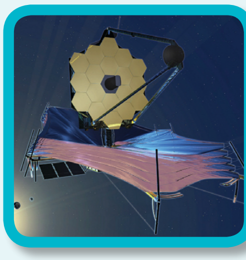


'Direct imaging'

Future Technology

There are various ground and space-based telescopes currently being planned, designed and built which will aid the search and study of extrasolar planets.

One such telescope is the European Extremely Large Telescope (E-ELT). This telescope is currently in its planning stages, and when built will have a mirror with a diameter of 42m – larger than all the current ground-based telescope mirrors put together. With a mirror of this size, the E-ELT will be able to directly image exoplanets and help astronomers find out more about their composition. Scientists and engineers at the Royal Observatory Edinburgh are involved in designing and planning this new telescope.


James Webb Space Telescope

One of the most well-known telescopes is the Hubble Space Telescope (HST). It has been in space now since 1990 and has made many amazing discoveries and given us many beautiful images. The HST will soon be at the end of its life and will be replaced by the James Webb Space Telescope (JWST). This telescope is due to be launched in 2014 and the development of one of the instruments on board has been led by scientists and engineers here at the Royal Observatory Edinburgh. Looking for extrasolar planets is one of the key aims of the JWST, as well as studying how planet systems form around stars.

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Classroom Activities:

In groups of 4-5, pupils are given an information pack which contains:

- Exoplanets Fact Sheet
- Task Sheet
- A planet system information sheet
  (4 different exoplanet systems available + our Solar System)

Pupils are asked to make a model of their planet system.
For this, each group will require:

- Polystyrene board cut to 55cm x 55cm (large polystyrene sheets available from most major DIY stores)
- Black sugar paper to cover the board
- Toothpicks
- Plastacine
- Ruler
- Pen/Pencil

The pupils are asked to think about where the habitable zone is on their model, and hence whether any of the planets in their system could support life.

Extensions:

There are many ways in which this topic can be extended within the science class, and many opportunities for cross-curricular links. Below are some suggestions:

Science

- You could ask the pupils to research their planet system further on the internet. There is lots of information available through sites such as wikipedia. They could find out information such as how each of the planets was discovered, and when; any extra interesting information about the system (e.g. some of the stars are actually binary stars, i.e. 2 stars orbiting each other)
- Biology – requirements for life, evolution, different species (e.g. how different environmental conditions affect the type of life)

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- Chemistry – look at the atmospheres and rock compositions of the planets within our solar system, ask pupils to think about how properties of materials change at different temperatures and pressures
- Physics – links to gravity and mass
- Stargazing – why not organise an evening of stargazing to look for the stars which the pupils are working on

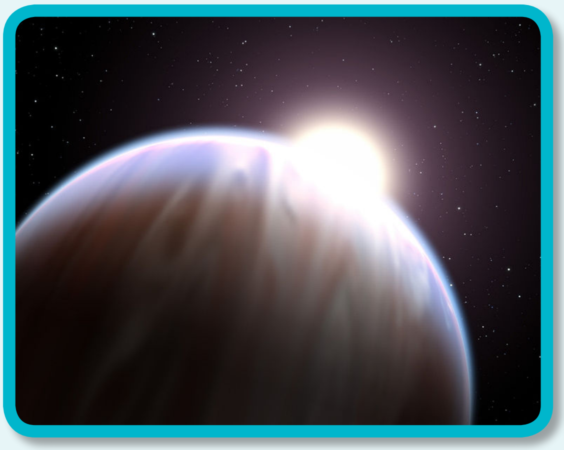
History

- As each of the stars the pupils are looking at are a certain number of light years away from the Earth, pupils could look at what life was like x years ago (e.g. 55 Cancri system is 41 light years away, so the light we see left the star in 1969; HR8799 is 129 light years away, so the light left that star in 1881)

English

- Pupils could write a poem about what life would be like on another planet
- Pupils could write a news report about discovering a new planet, or finding life

Maths



- Calculate the distance each of the stars is away from earth in kilometres or miles
- Calculate the speed at which the planets are orbiting their star

Art

- Pupils could create 3D models of landscapes of exoplanets, or create images of views from the planets
- Pupils could create animations relating to travelling through space to the exoplanets

Drama

- Create a drama piece about discovering new planets or life on exoplanets

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