TEACHER NOTES – ASTRONOMY IN THE NEWS #20
AN EXTRAGALACTIC EXOPLANET?

Slide 2 – Background Science: Transiting Exoplanets

There are many methods for detecting exoplanets, such as by using the radial velocity (measuring the wobble of a stellar spectrum due to the existence of a planet orbiting the star) or by direct imaging. However, by far, the most common method to detect an exoplanet is by transit. The transit method involves observing a star and measuring its brightness. As the planet passes in front of the star, the star is dimmed. This method allows you to calculate the radius of the planet. The depth of the dimming is related to the relative radii of the planet and star.

IMAGES:

1. (Left) Bar chart showing the detections of exoplanets per year. There is a further break down of methodology for these detections. This is a visual descriptor of how transits are the most common method. The statistics of this are 4525 exoplanets discovered, with 3447 detected via transiting. The chart and numbers are correct as of September 30th, 2021.
2. (Middle) Cartoon of detecting the transit method. The top is an image showing the orientation of the planet and stars, whilst the lower panel is the light curve of the light reaching Earth. As the planet is not in front of the star, the brightness of the star is at 100%, whereas when the planet is in front of the star, a dimming occurs. This will occur periodically, with the period length the same as the orbit period of the planet.
3. (Right) A real example of a transiting planet, in this case a “hot Jupiter”. These are Jupiter-sized planets which are found on orbits similar to the inner planets in the Solar System. These observations were made with an optical telescope. The plot shows the relative dimming, and it’s only by two percent.

Slide 3: An Extragalactic Exoplanet?

An x-ray source in the Whirpool Galaxy, M51, was identified as a neutron star or black hole in a binary system with another star. The x-ray emission comes material from the star that is accreted onto the neutron star or black hole and as it does, it is heated up to incredibly high temperatures, producing the x-ray emission.

However, when looking at the x-ray light curve (the brightness over time) a dip was found where the brightness was reduced by a significant fraction for 3 hours, even reaching a 100% reduction at the nadir of the emission. This was postulated to be caused by the transiting of a planet. Unlike in the examples on the previous slide, here the object that is transited is very small and very compact, and a large planet (similar to the size of Saturn in this case) would be able to block the entire light coming from a system when it passed in front of it. Instead of blocking optical light, as is traditionally what is measured in the transiting exoplanet method, this time it is the x-ray portion of the electromagnetic spectrum which is obscured. It is the same geometric setup as is illustrated in image 2 of the previous slide.

The planet in question, as mentioned above, is much more similar in size to the object it is orbiting. This planet is thought to be at an orbit radius similar to Uranus in our Solar System at a similar physical size to Saturn which makes confirming this detection difficult since the next transit will be in approximately 70 years. However, the authors did attempt to rule out other possibilities with physical reasons such as differences in accretion rates, variability in the source or eclipse with the other star in the binary all found to display different features in the light curve.

The method proposed here for finding exoplanets is a method that could be used to find more exoplanets within our Galaxy and in other galaxies, especially in those systems which are "invisible" at optical and infrared wavelengths.

This article also links well to the bulletin last week (AITN #19) where a planet was found to be orbiting a white dwarf after the death of a star similar to the size of the Sun. In this case, if it is a planet orbiting a neutron star or black hole, this compact object would have formed via a supernova, therefore the planet must have survived the explosion of its host star.

The articles that this resource is built on can be found here:

https://www.bbc.co.uk/news/science-environment-59044650

www.theguardian.com/science/2021/oct/26/astronomers-spot-first-possible-exoplanet-outside-our-galaxy

A permanent, free version of the research paper can be found here:

https://arxiv.org/abs/2009.08987
IMAGES:

1. (Left) X-ray light curve from the exoplanet candidate showing the dip caused by the proposed eclipse from the planet. The top panel is the observations over a 40,000 second period (~11 hours) whereas the bottom panel is the total observation period of 200,000 seconds (~55.5 hours). The red line is the rolling average every 2,000 seconds.
2. (Top right) Optical image of M51 taken with the Hubble Space Telescope. It shows the grand-design nature of this source, with the spiral arms well defined across the entire system.
3. (Bottom right) A combined optical and x-ray image of M51, with the X-ray emission coming from the Chandra X-ray observatory. The overlaid square indicates the position of the x-ray source in question here.

Slide 4 – Activity: Modelling Transits

This week's activity is a practical experiment to investigate how transits work. The experimental set up is designed to replicate a star and it's orbiting planets. The light/torch/lamp is the star, whilst the 3 circles of cardboard represent the planets. As the torch is shining on the desk, a beam of light should be observed. If a "planet" moves in front of it, a shadow should be produced. The students should different sized planets and see what differences they notice in the shadows, and how this relates to planets transiting distant stars, and why it is easier to observe larger planets than smaller ones.

GCSE Specifications:

Specification	Knowledge Point
Pearson Edexcel Astronomy	6.1, 11.6, 12.4, 13.22, 13.33, 14.6, 14.10
Pearson Edexcel Physics	5.10, 5.11, 7.18, 7.19
Pearson Edexcel Combined Sciences	5.10, 5.11
OCR Physics B	1.1.1, 1.1.7
OCR Combined Sciences B	P1.1.1, P1.1.7
AQA Physics	4.6.2.1, 4.8.1.2
AQA Combined: Trilogy	6.6.2.1

A-Level Physics Specifications:

Specification	Knowledge Point
OCR Physics A	5.5.1(e)
AQA Physics	3.9.3.4