TEACHER NOTES – ASTRONOMY IN THE NEWS #16
DETECTING EARTH AS AN 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: Eavesdropping planets?

Since the predominant method for finding exoplanets is using the transit method, it is a reasonable assumption that astronomers on other planets may use that method to find Earth. As such, it is possible to make a prediction on the number of places that could detect Earth in that way.

The Gaia satellite is measuring the position, distance, and three-dimensional motions of millions of stars within the Milky Way. By using the positions and distances, along with extrapolating the motions of these stars, a sample of 2,034 stars were found to be able to view the Earth’s transit for at least 10 hours a day within the last 5,000 years or in the next 5,000 years. Of these, nearly 70% are currently in position to do so (1,402 stars).

Along with the transit method, exoplanets could also detect radio waves emitted from Earth. We have transmitted radio waves for approximately 100 years, therefore stars within 100 light years (or 30 parsecs) could detect this electromagnetic signature. Within this radius, there are 75 stars. Any intelligent lifeforms on these planets could detect our signal!

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

https://www.theguardian.com/science/2021/jun/23/scientists-identify-29-planets-where-aliens-could-observe-earth

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

https://arxiv.org/abs/2107.07936

IMAGES:

1. (Left) Colour-magnitude diagram of the stars from the Gaia Catalog of Nearby Stars. The x-axis represents the colour, which is the difference in brightness in two different wavelengths, whilst the y-axis is the magnitude, or brightness, of the stars. The red markers are the stars within the transit zone, and can observe Earth, whilst the solid grey points are potential stars which are slightly more ambiguous (i.e. could be astronomical objects of a different nature).
2. (Right) Artist's impression of the Milky Way, with an overlaid marker showing how far the Earth's radio waves have travelled in the time since the first transmission. This is indicated by the yellow circle, which is also shown in the zoomed-in inset.

Slide 4 – Activity: Detecting Earth transiting

As mentioned above, the radius of a planet can be determined from the level of dimming that occurs to the star's light curve. The level of dimming that occurs is related to the relative ratio of the planet and star radii as it is just a "shadow" on the surface of the star.

The activity this week is to determine what fraction of the Sun's light would be blocked out by a transiting Earth for an observer on another planet to detect. The radii of the Earth and the Sun are given on the slide, and the fraction of light is just the ratio of the two areas (πr^2), or:

$$\frac{R_{EARTH}^2}{R_{SUN}^2}$$

Part of the activity is to work out this relationship and using these numbers gives a fraction of 0.00008 or 0.008%. The follow-up question is whether observers on other planets would be more likely to detect this or our radio waves, and with such a small fraction, it is likely to be the electromagnetic radiation.

GCSE Specifications:

Specification	Knowledge Point
Pearson Edexcel Astronomy	7.6, 11.9, 12.4, 13.8