Lesson Plan

NeuroHeadway

Neuroscience Into Education

Lesson Eight

Planets outside the solar system

Teachers' Notes

Slide 1 – Title Slide

Slide 2 – Introduction

- **Exoplanet** is the term we give to planets outside our solar system.
- This is just a planet around another star.
- Think of all the stars you can see in the sky – an interesting question is, how many of them have planets and are they like our own Solar System that we have learned about.
- Our galaxy, The Milky Way, is home to about 100 billion stars.
- Recent work has estimated that at least 10% of all stars have 1 or more planets around them. I could even be as high as 70%. The true fraction is currently unknown mainly because we are still discovering more and more as technology improves.
- Even for 10%, that means there are (at the very least) 10 billion planets in our galaxy alone.
- Astronomers have made convincing discoveries of a few thousand.
- In this lesson, we're going to discover more about these mysterious planets, and what makes them potential habitats for life elsewhere in the universe.

Slide 3 – How do we detect exoplanets?

- We don't actually directly see most exoplanets in most cases – although we will come back to some examples where we can
- Because we can't see them directly, many of the images in this lesson are artists impressions. But they are well researched ones an illustrate the concepts well.
- The two most common methods of exoplanet detection involve detecting the effects of a exoplanet on the star that it orbits around
- The first is illustrated here – a planet passes in front of its host star and casts a shadow. This is called a transit. Here is an example of Venus passing in front of the Sun in 2014. We could see this from earth, but here is an image
- Venus is the black circle in the upper left of the Sun's disk
- And here is a link to a nice video of the transit from NASA https://solarsystem.nasa.gov/resources/389/venus-transit-across-the-sun-2014/

Slide 4 – How do we detect exoplanets? (Continued)

- We look for a star's light to dip. It dips periodically and repeatedly, as the planet continues to orbit around the star

- Transits are a rare occurrence, since the orbit of the planet must be aligned with our direction.
- Here is a nice illustration by NASA : https://www.youtube.com/watch?v=8v4SRfmoTuU
- Because they are rare, we need to look at a large chunk of the sky containing about 15,000 stars, to detect about **1 star with a transit.**
- They are effectively shadows created by the exoplanet passing in front of their star.
- These transits appear as dips in data, representing how much light the planet blocks out as it moves in front of its star.
- From these dips, not only can we determine the presence of a planet, but also its size, its composition, and whether or not it has an atmosphere like our own.

Slide 5 – Proxima Centauri

- The second is called the "doppler wobble" technique – were we watch a star wobble because the exoplanet is tugging it due to gravity as it orbits around the star. The first exoplanet was discovered with this technique in 1995.
- In this case, the planet's orbit does not need to line up exactly with our telescope's line of sight.
- Every planet has its own gravitational field which will have a (small) effect on the rotation of its parent star. This gravitational pull causes the star to 'wobble', and we can measure how much and how fast the star is wobbling to determine if there are any planets orbiting it.
- We measure the wobble by measuring the planet's speed. It appears to change periodically. This is called the **Radial Velocity** method.
- Remember back to the Lesson 5 on Stars and the closest star to us – Proxima Centauri. Just recently in 2016, astronomers discovered that Proxima has a planet !
- It is quite a small planet, probably between 1 to 10 times the mass of the earth.

Slide 6 – Hot Jupiter's

- **Hot Jupiters** are a class of exoplanet, physically similar to Jupiter (gas giants), that orbit their parent star very closely and quickly. A full orbit around the star can be as little as 10 days – which means a "year" on a hot Jupiter could be just 10 Earth days.
- Due to their size and proximity to their star, they are the easiest type of exoplanet to detect
- Using the **radial velocity** method, as described in the last slide. Their strong gravitational field has quite a noticeable effect on their star's 'wobble'.
- Because they are close, they are also easier to detect through transits. And of course, Jupiter like planets are big so they cast a larger shadow than (for example) earth-like planets.

Slide 7 – Activity

Worksheets: The weird and wonderful Hot Jupiters

There are two worksheets. One with a mathematical activity (Lesson8 Activity 1b.docx) and one with an easier, more descriptive tasks (Lesson8 Activity 1a.docx).
The class can start with the easier one and then try the mathematical one afterwards if there is time. Or keep the mathematical task for the G&T students and give them it afterwards.

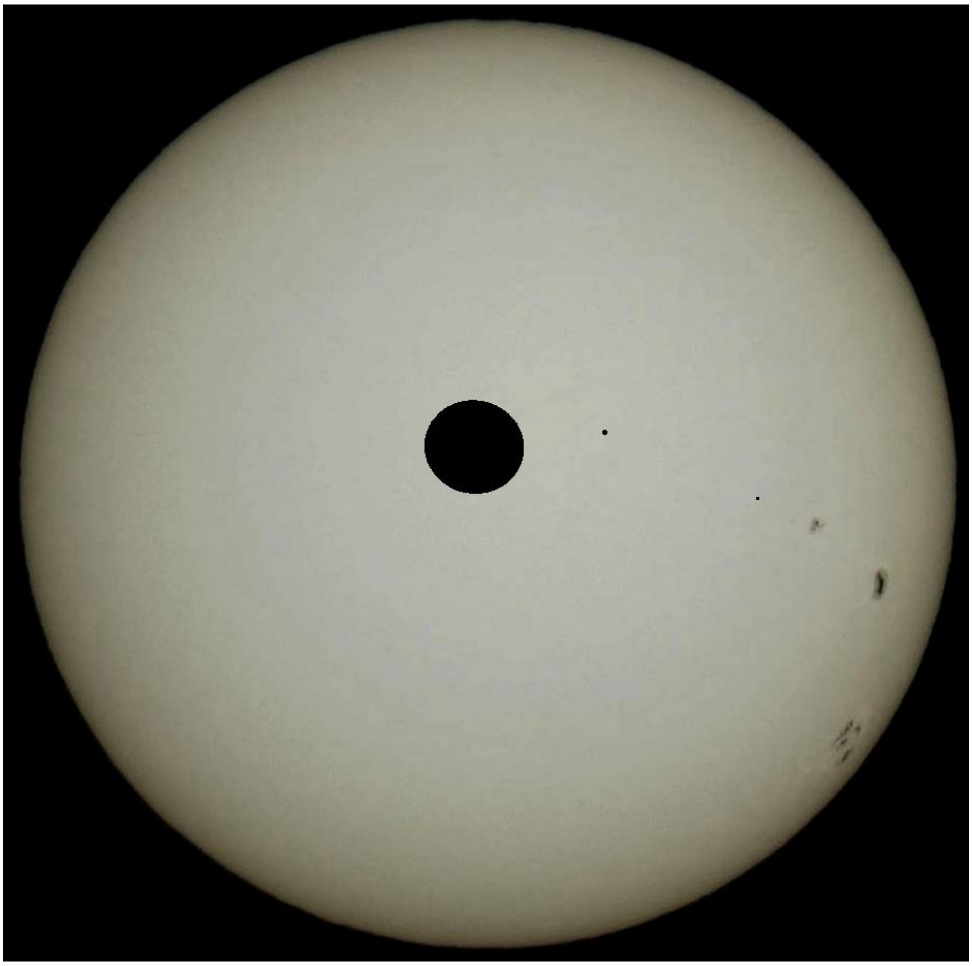
Slide 8 – Rogue Planets

- These are planets without a central star. Most of them are gas giants, floating freely around space with no purpose or direction.
- They are formed when a solar system is very young. Sometimes a large planet collides with a smaller one, kicking it out of its system. Usually a rogue planet is simply a proto star that never gained enough mass to start burning. For this reason they are usually gas giants, and sometimes called 'failed stars'.
- It is believed that many young stars will fail and become rogue planets. There could be more of these than actual planets!
- Here is one example of a very faint red object discovered by a telescope in Hawaii in 2013. The distance to the star has been measured and it is quite close – only 80 light years. You can see it is very red, which means it is very cool. These are hard to find because they are so dim. The mass is about 6 times that of Jupiter, so it is definitely a giant planet and not a star.

Teachers Evaluation and Handouts

The weird and wonderful Hot Jupiter's

Here is a simulated picture of how Jupiter would look from earth if it passed in front of the Sun. This is not a real image, but simulates exactly how Jupiter would appear. Imagine that this is this is an exoplanet passing in front of its host star.



1. **If you look closely you can see two small dots to the right of Jupiter. What do you think these are?**

2. **What do you think are the dark patches near the right hand side of the Sun?**

3. **This is a simulated image of a how an exoplanet system would look to us. Of course we do not see it like this, we just see the total light from the star. On the diagram, draw where the hot Jupiter would be if we observed it about 1 hour later.**

4. **If it was an earth like exoplanet that passed in front of the star, what would be the difference to the dimming of the light? Would the star fade**

    a. **By more?**

    b. **By less?**

5. **Knowing that the radius of the earth is about ten times smaller than Jupiter, draw an earth like exoplanet on the diagram.**

6. **Hot Jupiter's are quite common in our Galaxy. Do you think that hot Jupiter's are possible places were life could exist?**