Group B Report- Exoplanets

One of the things that the Liverpool telescope is used for is to find transiting exoplanets. An exoplanet is any type of planet orbiting a different star to our own. A transiting exoplanet is an exoplanet which is orientated in such a way that when it moves across the face of its parent star the change in light level can be detected from earth. [1]

When an exoplanet passes in front of its parent star it will very slightly decrease the amount of light coming from the star, if the planet is lined up with earth correctly we can detect the drop in brightness. We can draw a light curve (light level against time) this curve can tell if there is an exoplanet and if more information about the star is known we can work out the radius and orbital period of the exoplanet. [2]

There are many other methods of detecting exoplanets including: looking at the star's radial velocity, gravitational microlensing and astrometry. You can detect exoplanets by examining the radial velocity of the star. If there is a planet in a system the star will orbit a centre of mass, this orbit can be detected by examining the red/blue shift of the star's spectral lines. When the star is moving away from earth in its orbit its spectral lines will be red shifted and if it is moving towards you its spectral lines will be blue shifted.[3]

Gravitational microlensing occurs when the gravitational field of a star acts as a lens and magnifies the light of a distant star. If lensing star has a planet orbiting it then the lensing effect will noticeably change over time. If the lensing effect changes over time then we can say that a planet orbits the star. [4]

Astrometry involves tracking the movement of a star over a long period of time. If a planet is orbiting the star then the star will not be stationary but will have a orbit around a centre of mass meaning the star will move. If the star does move more than expected then it is likely it has an exoplanet orbiting it. [5]

The Liverpool telescope is situated on the Canary island of La Palma (see figure 1) this is due to the dark nights and the fact it can sit above the clouds. The telescope itself is a 2m reflector telescope that is fully autonomous, due to the fact the telescope is fully autonomous it can react quickly which means it is ideal for observing things such as exoplanets and supernova. The Liverpool telescope has an instrument know as RISE- Rapid Imager for the Search for Exoplanets (see figure 2). This is a fast readout designed with the sole purpose of timing how long it takes an exoplanet to transit across the face of a star. The data that we used was obtained from the RISE instrument attached to the Liverpool

Figure 1

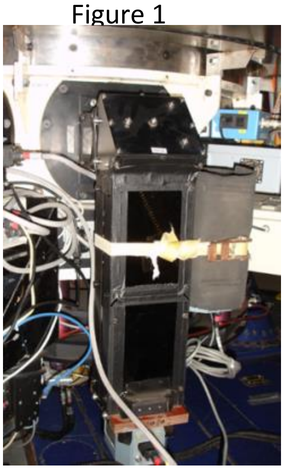
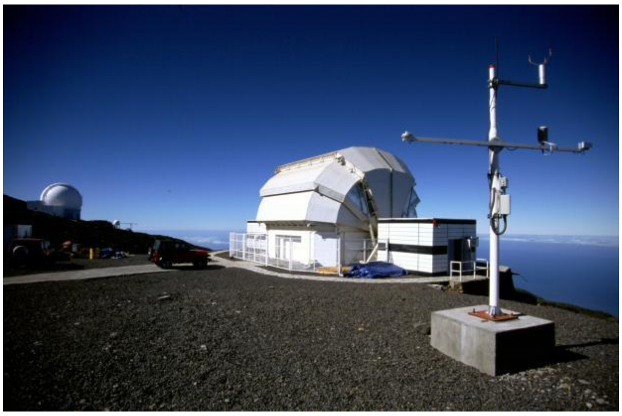


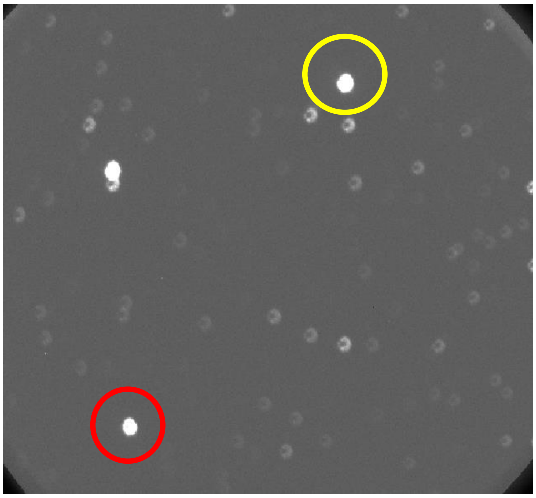
Figure 2



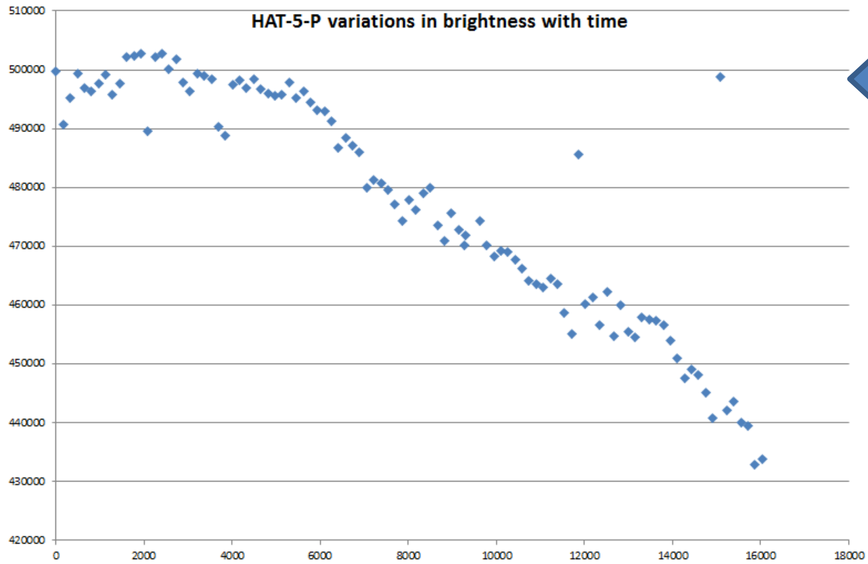
telescope.[6]

HAT-P-5 is a G type star located approximately 1,100ly away from earth which has a radius of about 1.167 solar radii. For our task we were tasked with finding out whether the star system contained an exoplanet. The data we were given was in the form of 101 images collected by the Liverpool Telescope between the hours of 22:58 and 03:28. The images showed 3 bright stars as well as many other dimmer stars (see figure 3). In order to find the exoplanet we needed to produce a graph of brigtness against time.

Figure 3 the red circle shows the target star and the yellow circle shows the control star

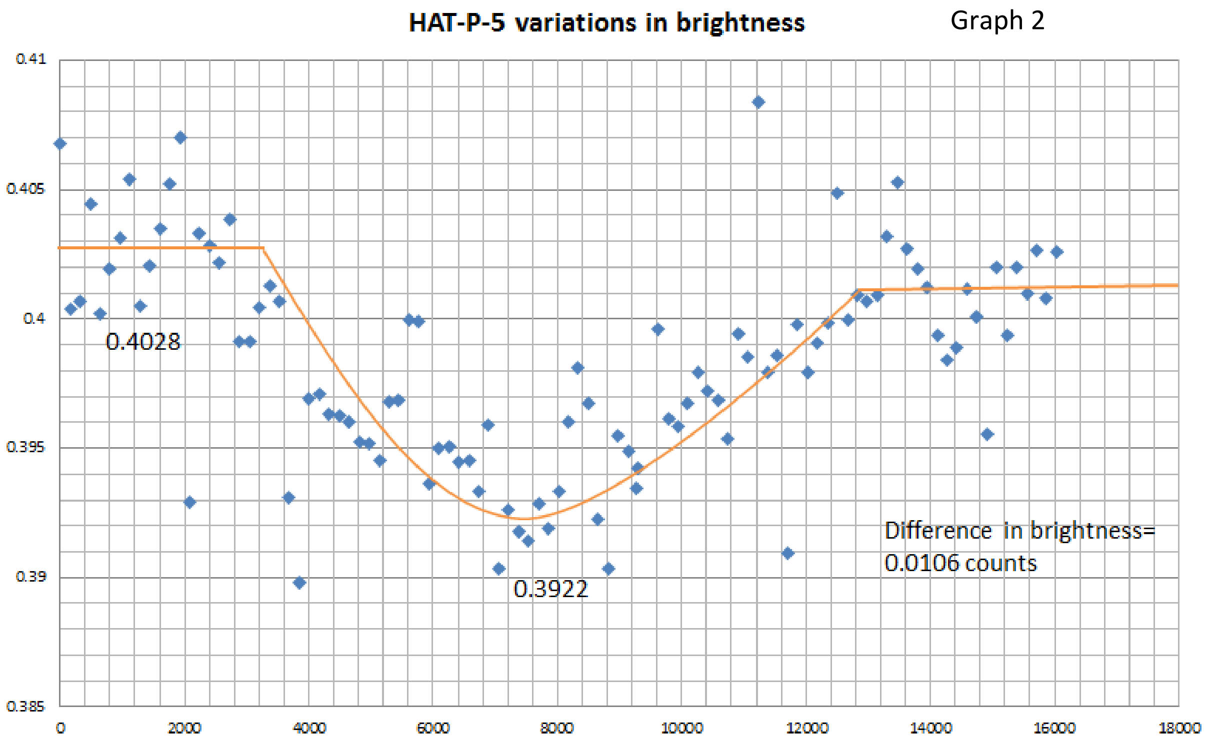


To get the data so that we could produce the graph we had to use the LTimage software and measure the brightness of the star. We had to measure the brightness of the star thought to contain the exoplanet and another control star this is because as the earth rotates the amount of atmosphere between the earth and the star will change.To counter the changing ammount of atmosphere we divided the target star brightness by the control star brightness. If we had not divided the target star brightness by the control star brightness we would have ended up with a graph for the target star that would not show a dip in brightness level (see graph 1).



Graph 1- as you can see the level of brightness drops throughout the night meaning it is difficult to see any noticeable brightness drop caused by an exoplanet. The graph for the control star also follows a broadly similar shape which means that if we divide the target star by the control star we can see the characteristic brightness drop caused by an exoplanet

Once we had found the brightness of both stars in all 101 images we worked out the time in seconds between each image. We decided to put brightness on the Y-axis and time on the X-axis and produced what is known as a light curve (see graph 2). In astrophysics brightness is measured in counts.



As you can see there is a definite dip in the brightness levels of the star meaning that an exoplanet orbits the star. Other studies also show that the HAT-P-5 contains a gas giant orbiting close to the star meaning it is what is known as a hot Jupiter the planet has the International Astronomical Union designation of HAT-P-5b. [7]

The radius of the star was already known which meant that it was possible to work out the radius of the exoplanet.

The radius of an exoplanet = $\sqrt{\frac{chage\ in\ brightness\ \text{(counts)}}{\text{brightness before transit (counts)}}} \times radius\ of\ the\ star$

Once the radius of the star had been converted into metres we worked out the radius to be approximately 1.88 Jupiter radii or1.31432680x10^8m. The original study concluded that the exoplanet had a radius of 1.26 Jupiter radii. [7]

In conclusion our light curve shows definite signs of an exoplanet which is also backed up by a scientific journal, the radius we found for the exoplanet was close to the value stated in the journal. We can defiantly say that it is a planet transiting and not a star as the level of brightness drop is only very slight. The study used the radial velocity method to find the exoplanet and if more accurate graphical software had been used I believe that our value for it radius would be closer to the true value.

[1] What is a Transiting Exoplanet?. 2015. What is a Transiting Exoplanet?. [ONLINE] Available at: http://exoplanets.co/extrasolar-planets/what-is-a-transiting-exoplanet.html. [Accessed 02 July 2015].

[2] Transit Photometry | The Planetary Society. 2015. Transit Photometry | The Planetary Society. [ONLINE] Available at: http://www.planetary.org/explore/space-topics/exoplanets/transit-photometry.html. [Accessed 02 July 2015].

[3] Radial Velocity | The Planetary Society. 2015. Radial Velocity | The Planetary Society. [ONLINE] Available at: http://www.planetary.org/explore/space-topics/exoplanets/radial-velocity.html?. [Accessed 02 July 2015].

[4] Microlensing | The Planetary Society. 2015. Microlensing | The Planetary Society. [ONLINE] Available at: http://www.planetary.org/explore/space-topics/exoplanets/microlensing.html. [Accessed 02 July 2015].

[5] Astrometry | The Planetary Society. 2015. Astrometry | The Planetary Society. [ONLINE] Available at: http://www.planetary.org/explore/space-topics/exoplanets/astrometry.html. [Accessed 02 July 2015].

[6] The Liverpool Telescope : Telescope + Instruments : Instruments : RISE. 2015. The Liverpool Telescope : Telescope + Instruments : Instruments : RISE. [ONLINE] Available at: http://telescope.livjm.ac.uk/TelInst/Inst/RISE/. [Accessed 02 July 2015].

[7] Bakos, G., Shporer, A., Pál, A., Torres, G., Kovács, G., Latham, D., Mazeh, T., Ofir, A., Noyes, R., Sasselov, D., Bouchy, F., Pont, F., Queloz, D., Udry, S., Esquerdo, G., Sipőcz, B., Kovács, G., Stefanik, R., Lázár, J., Papp, I. and Sári, P. (2007). HAT-P-5b: A Jupiter-like Hot Jupiter Transiting a Bright Star. *ApJL*, [online] 671(2), pp.L173-L176. Available at: http://iopscience.iop.org/1538-4357/671/2/L173/fulltext/ [Accessed 2 Jul. 2015].