The Search for Extra Solar Planets by the Transit Technique.

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Introduction: Since as early as 1952, astronomers have theorised the existence of detectable planets orbiting other stars outside our solar systems [1]. Since that time, many techniques have developed to find these planets, but two stand out as the most reliable and widely used.

Background: The main method used to locate these planets is the Doppler, or radial velocity, technique. A star with an orbiting planet will exhibit a characteristic "wobble", or a red and blue shift, due to the gravity of the planet. This has become an incredibly reliable and standard technique for detecting planets.

However, in recent years, a new technique has emerged as a new standard for planet hunting. The transit technique, also known as photometry, analyses the change in magnitude of a star as an object orbiting in the plane parallel to line of sight "transits", or passes in between the star and the earth. By analysing photos of the star during a transit, the magnitude can be extracted and analysed in the form of a light curve. One advantage of the transit technique is the ability to use smaller telescope setups to achieve accurate and precise measurements.

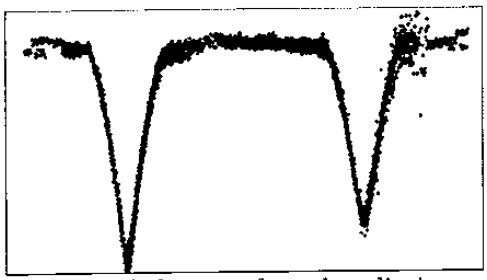
David Charbonneau and his colleagues at California Institute of Technology used this technique to confirm the existence of a planet orbiting around the star HD 209458 which was originally found by the Doppler technique [2]. Using the two techniques, they were able to estimate mass and radius of the large, gaseous planet with relatively small error. Their equipment consisted of a 286 mm focal length telescope with 99mm aperture with a CCD device, not large by professional astronomy standards.

Methodology: Dr. Claud Lacy has observed variable stars with a small, motorized 10-inch telescope on top of Kimpel Hall since late 2000, developing and honing techniques that will allow the discovery of extra solar planets here at the university in the future. The process features many steps:

1. Scheduling an observation: *Ursa*, the web-based telescope, allows any registered user to schedule an observation of any star they choose for a limited amount of time. Normally, a star and time are chosen based on variable characteristics and predicted transit times. http://ursa.uark.edu/
2. Retrieving Pictures of the Star: after the night's observations are made, all separate still photos are compiled. Single photos can be observed using a commercial program,"SBIG CCD-Ops".
3. Analysing the Photos: Using "Measure", a program written by Dr. Lacy, the magnitude of the star in question is analysed in every frame and then plotted to produce a light curve showing the dimming and brightening of a star in transit.
4. Phase Plots: Using "New Minima", another program written by Dr. Lacy, a concatenation of many nights' observations can be viewed

at once by date or, more conveniently, by phase, showing the general characteristic of the light curve.

Most of the stars observed now with the telescope are variable, changing magnitude of light periodically, and binary stars which, like a transiting planet, feature an object passing in front causing a dip in magnitude.



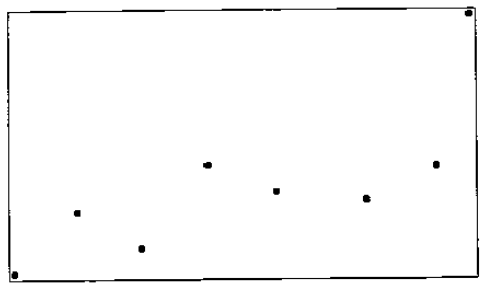
Sample light curve from the eclipsing binary, CV Boo.

Objectives: To go further and detect planets with this system, the technique must be refined and perfected to reduce sources of error, such as "noise" and bad pixels in the digital photos. To see just how well this method works at present, we attempted to produce a light curve for a transit of HD 209458.

Another useful tool being developed to analyse the data is a "Light Curve Viewer" program. Like most of the other programs used in this project, it was developed by Dr. Lacy in Macintosh FutureBasic. In the final stages of production now, it will allow easy reference to the magnitude, phase, and date of an observation as well as quick detection of bad data points.

Observations and Data: The star HD 209458 was late in getting to an observable position above the horizon; our first trial observation occurred 7-22-02 UT. The results of the first observation showed the small portion of the end of the eclipse that we could get while the transit was observable.

A second observation is scheduled for 7-29-02 UT; however, it will not be done in time to include on this abstract. But work will continue on observing this star and its planet as we search for others.



The end portion of HD 209458's transit event.

The program is still not complete, but writing and testing will also continue beyond this project.

Conclusions: The transit technique has proven to be an accurate and reliable method for finding extra solar planets, just as precise as the Doppler technique and more accessible for someone without the use of a gigantic telescope setup.

While the university has yet to actually detect the whole transit of the planet around HD 209458, the continual improvement of techniques and hardware will probably allow for future detections of these transiting planets.

Summary: While the technique is not yet perfect and a planet has not yet been detected, the transit technique at the University of Arkansas holds considerable promise for the near future. Maybe one day, an amateur astronomer with a lucky star might be able to use this technique and the

university web-based equipment to find a planet of his own.

References: [1] Struve, Otto, Proposal for a project of high-precision stellar radial velocity work. The Observatory, 1952; [2] Charbonneau, David, Detection of Planetary Transits Across a Sun-like Star, Astrophysical Journal, 1999