CCD Astrometry of the Host Star System HD 75289 with Exoplanet

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Abstract: Student teams from the Early College Program in Oahu and the Montessori School of the Maui Work and Service Program made remote CCD measurements of a southern neglected double stars system HD 75289 using the Las Cumbres Observatory (LCO) global telescope network. The differential magnitude between primary and secondary was 6.7 requiring the use of z' and Y filters for observation. While the primary is an F9, the exoplanet hosting secondary is reported to be an M2. Astrometric solutions of the pair indicate a separation of 21.33 arcsec and a position angle of 76.99 degrees.

Introduction

Gravitationally bound stellar objects obey Kepler's Laws of Motion. Knowledge of the period of the orbiting bodies allows astronomers to determine masses of stars, which is one of the fundamental physical properties of stars. In double stars observations, astronomers identify and describe the motion of the system by their relative separation and position angle. The distance between primary and secondary stars is designated by the Greek alphabet ρ (rho) measured in arc seconds. The relative position of the secondary star as it goes around the primary star, is measured in degrees, with celestial North as being in zero position. This angle is designated by the Greek letter Theta (θ). Depending on the orbital period of the secondary star, many observations on these parameters spanning many decades or centuries will provide the exact orbit of the star system. Modern advancement in observational astronomy and mathematical modeling of orbits has enabled scientists to determine theoretical orbits in a shorter time interval.

A group of nine Early College Program students from Waipahu High school located on the island of Oahu (Figure 1), Hawaii and another group of students from the island of Maui (Figure 2), participated in the study of a neglected double star system in the southern hemisphere. The Early College Program supports students to enroll in college level courses while continuing their four years of high school classes. As a part of their early college program and as Associate Degree students, Waipahu high school students enrolled in the ASTR 298, a Research Seminar course in Astronomy. In this class students learned scientific research methods, data acquisition, analysis, and learned to write a scientific paper ready to be published in a scientific journal.

Three students from Maui, also participated as part of the Montessori School of Maui Work and Service Program. They select from a variety of Work and Research projects, including astronomy, volunteering at

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Figure 1: Hoku Kamahele team from Waipahu High School: (left to right) Donald C. Napala, Jocelynn Bolosan, Shanti C. Mohanan, Evan Sugayama, Vea Aubre y Bumatay, Pink Mariz G. Felipe, Charize Balignasay, Skecynyth H. Perlas, Vanessa Rhea C. Sao, and teacher Mark Silliman.

Figure 2: Students of Montessori- Lea Stuart, Yasmina Vafaie, and Sierra Ryden

the National Park Service, etc. This astronomical research project spanned an academic semester, meeting once per month.

For this research project, the authors decided to collect data using the Las Cumbres Observatory global telescope network (LCO). The aim of the LCO education and the outreach program is to excite, inspire, and encourage learners of all ages to peruse science investigations and develop their critical thinking skills (LOCGT, 2013). Numerous prospective binary star systems were considered for our Leeward Community College Astronomy Research Seminar Project; however, the team decided to make CCD astrometric measurements of a neglected double star system that had not been observed since 2004. What made this star system particularly interesting was the presence of an exoplanet orbiting the primary star. This target was especially challenging for its large difference in delta magnitude; with the primary star magnitude being 6.58, while the secondary is a faint red dwarf star at 12.58. In the Washington Double Star Catalog, this star system is found under the coordinates with Right Ascension 08:47:40.35 and Declination -41:44:24.9. This system is also known as MUG 6. MUG 6 had just three previous observations, which gave researchers three data points from which to make further extrapolations. Recently, Mugrauer et al. (2004) were able to gather data on the same system and reported the presence of a new low-mass star companion with a spectral classification G0V, and discovered that it had an exoplanet orbiting it.

The Common Proper Motion (CPM) of the two stars (small divergence in the direction and speed of the two stars' proper motions across the celestial sphere) suggested that they could be a long period binary. This made them of special interest.

This system is referenced in the Hipparcos Catalog as having had previous scientific observations (Mugrauer, 2004) in H band using adaptive optics (AO). It wasn't entirely clear that we would be able to observe the faint red secondary with regular CCD astrometry (i.e. not near infrared astrometry in the H band with adaptive optics.) When we started out, we did not know if we could see the secondary at all with a regular camera. Thus, this was a major research question.

Our research project had three specific objectives. They were to: 1) investigate through trial observations whether it is possible to image this large delta magnitude double star system without using a near infrared camera and adaptive optics, 2) measure the relative position angle and separation neglected double stars, and 3) compare position angle and separation of past observations with current observations.

Instrumentation and Procedure

The first observing attempt was made using the LCO 0.4 meter network. Images were requested with the following filters with integration times given in parenthesis: B (6 seconds), V (4 seconds), zs (1 second), and ip (1 second). Note that zs is Sloan Z filter and ip is the PanSTARRS I filter. The images requested were fulfilled by the 0m4a telescope on the LCO node at Siding Springs, Australia. The secondary was not detected in any of the images. It is possible that a longer integration time on these telescopes might have resulted in a detection, however we decided that a better way to proceed would be to use a larger aperture telescope.

Observations were requested on the LCO 1.0-meter network with the following filters with corresponding

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Figure 3: Las Cumbres Observatory Sutherland, in South Africa.

integration times provided in parenthesis: B (6 seconds), V (4 seconds), R (2 seconds), I (2 seconds), zs (4 seconds), and Y (8 seconds). The observations were taken with the "domb" telescope, (labeled 1mo-13) at the Sutherland node of the LCO network. In the shorter wavelength filters (B, V, R) the cores of the primary star were saturated; however, even with this overexposure the secondary was not visible. Some16 images in the zp band and 15 images in the Y band were obtained which contained no saturation. The secondary was visible in the individual images of both bands. The useable images were stacked to form two composite images, one made of the 16 images in the zp band, and the other made of the 15 images in the Y band.

Data Analysis and Results

Astrometric solution of HD 75289 was obtained by analyzing the observational data using Astrometrica. The coordinate of the primary is RA 084740.3, DEC -414416. Astrometric solution put the average separation

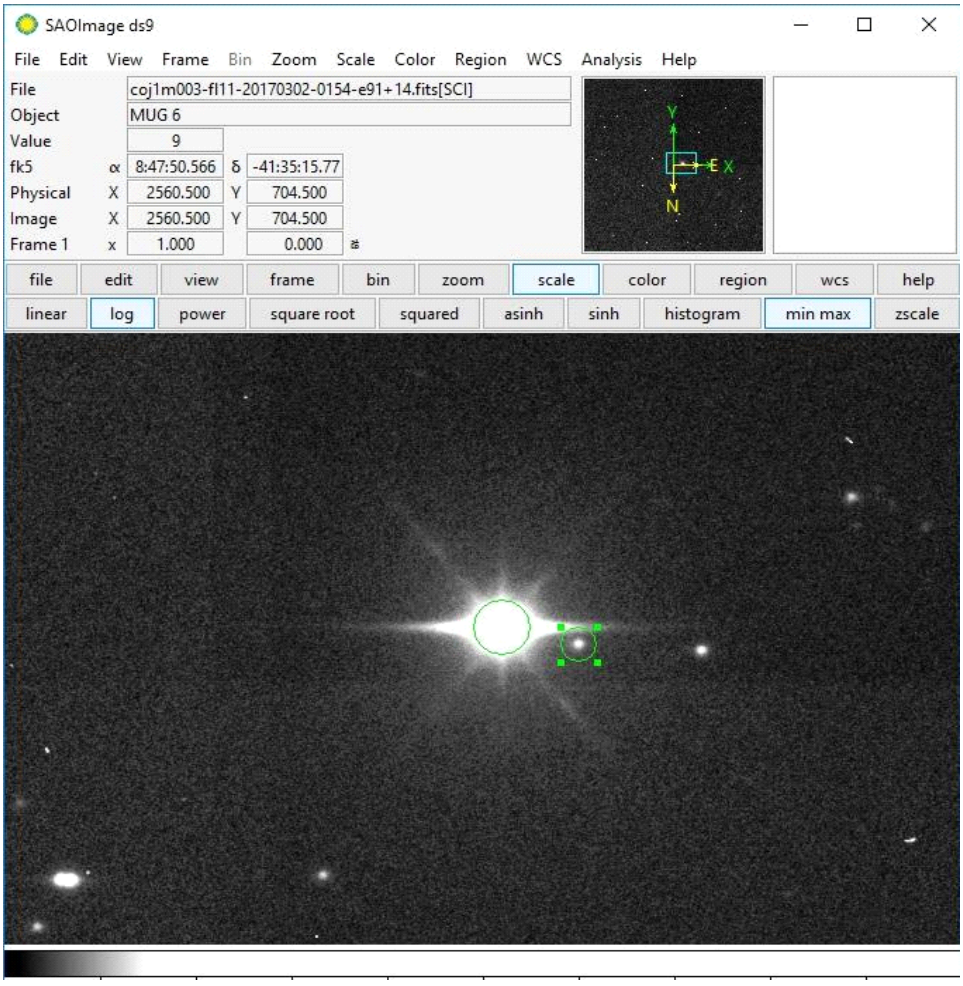

Figure 4: Image plate of MUG6. The bright primary star is located in the middle and the secondary star is located on the green circle at about 3:30 at about 76 degrees (North is straight down).

Table 1. Comparison of present results to previous MUG 6 data (2004)

Star ID	Our Sep	MUG 6 Sep.	Delta Sep.	Our PA	MUG6 PA	Delta PA
MUG 6	21.33	21.5	0.173	76.99	90.0	-13.022

between primary and secondary, rho (ρ), to be 21.327 arcsec, and the average position angle, theta (θ), to be 76.978 degrees. The present results are compared to the previous observational results by MUG6 in Table 1.

Discussion

The red secondary star was not detectable with the 0.4 m telescope and R filter but was detectable with the 1m telescope with the z' and Y filters. Comparing present observational data to previous results, it was found that separation of primary and secondary values is 0.173 arc seconds which agrees with the previous observation. However, our Position Angle (PA) does not agree with two previous results. Difference in average position angles computed from present to previous data shows a delta PA of -13.022 degrees while the difference in average angles computed of the same from 2004 to 2000 is +10 degrees. There are two possible explanations for the nature of the present data. It could be that the secondary star has its orbital plane in line of sight and secondary star has speed through perihelion, or it is possible that our astrometric solutions are not in line with previous results.

Conclusions

It was possible for the team to: 1) photograph the large delta magnitude double star system with a regular CCD camera, 2) obtain astrometric solution of the neglected pair, and 3) to compare our observations with previous observations.

Acknowledgements

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