Ryan J. Oelkers
Curriculum Vitae

Mitchell Institute for Fundamental Physics & Astronomy
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Research Interests
data mining of large astronomical data sets ◆ the mass-radius relation for young stars ◆ binary star and exoplanet detection and classification ◆ star and planet formation ◆ transient detection techniques ◆ variable star detection and classification ◆ small aperture telescope surveys

Education
PhD, Physics **Expected May 2016**
Texas A&M University ◆ Department of Physics & Astronomy ◆ College Station, TX
Advisor: Lucas M. Macri

MS, Physics **May 2015**
Texas A&M University ◆ Department of Physics & Astronomy ◆ College Station, TX
Advisors: Lucas M. Macri & Lifan Wang

MS, Engineering Sciences and Applied Mathematics **June 2010**
Northwestern University ◆ Engineering Science and Applied Mathematics Dept. ◆ Evanston, IL

BS, Pure and Applied Mathematics **May 2009**
Stevens Institute of Technology ◆ Mathematics Department ◆ Hoboken, NJ
Advisor: Frank T. Fisher

Conferences and Presentations
Poster ◆ BashFest ◆ Austin, TX ◆ Oct. 18 – 20, 2015
Talk ◆ Mitchell Meeting on Variable Stars and Transients ◆ Magnolia, TX ◆ Jun. 18, 2015
Poster ◆ IAU 314 Symposia on Young Stars and Planets ◆ Atlanta, GA ◆ May 11-15, 2015
Talk ◆ Workshop on Variable Stars and Transients ◆ Delhi, India ◆ Jan. 15, 2015
Talk ◆ 2014 APS Meeting ◆ College Station, TX ◆ October 19, 2014
Talk ◆ IATE Astronomy Colloquia ◆ Cordoba, Argentina ◆ May 13, 2014
Talk ◆ Workshop on Variability of Astronomical Sources ◆ Pune, India ◆ Jan. 23, 2014
Poster ◆ AAS Meeting #223 ◆ Washington, D.C. ◆ January 5-9, 2012
Talk ◆ Brazos Valley Astronomy Club ◆ College Station, TX ◆ October 18, 2013
Talk ◆ TOROS Workshop ◆ Salta, Argentina ◆ June 28, 2013
Talk ◆ 3rd Mitchell Workshop on Cosmology and SNe ◆ Magnolia, TX ◆ Apr. 10, 2013
Poster ◆ AAS Meeting #221 ◆ Long Beach, CA ◆ January 6-10, 2013
Talk ◆ Brazos Valley Astronomy Club ◆ College Station, TX ◆ Oct. 19, 2012
Talk ◆ NFSC Young Scientist Forum ◆ Beijing, China ◆ Aug. 2, 2012
Poster ◆ AAS Meeting #219 ◆ Austin, TX ◆ Jan. 8-12, 2012
Talk ◆ Texas A&M University Astronomy Symposium ◆ College Station, TX ◆ 2011-2015

Fellowships and Awards

East Asian Pacific Summer Institute Fellowship ◆ $5000 ◆ National Science Foundation ◆ 2012
Edwin A. Stevens Scholarship - $32,000 over 4 years ◆ Stevens Inst. of Technology ◆ 2005-09

Press Releases

"Seeing Double" ◆ The Battalion ◆ College Station, Texas ◆ October 18, 2011

International Experience

India ◆ attended Indo-US Science and Technology meetings to facilitate collaboration ◆ January 2014 & 2015
Argentina ◆ installed a remote telescope in collaboration with the University of Córdoba ◆ 2013 & 2014
China ◆ worked at Nanjing University to create a difference image analysis pipeline ◆ Summer 2012

Mentoring Experience

Katelyn Stringer ◆ Undergrad Middle Tennessee State ◆ AggieCam Calibration ◆ Summer 2014
Colin Wisdom ◆ Undergrad Texas A&M ◆ Transients with AggieCam ◆ Spring 2015
Tarini Konchady ◆ Undergrad Johns Hopkins ◆ Transients with AggieCam ◆ Summer 2015

Teaching Experience

Texas A&M University

Physics and Astronomy Department

- Grader for ASTR 101 (September 2014 – December 2014)
- Instructor for ASTR 102 (May 2011 – May 2013)
- Teaching Assistant for ASTR 111 (September 2010 - May 2011)
- Guest instructor for ASTR 111, 314, 401

Center for the Integration of Teaching, Research and Learning

- Certified Practitioner (May 2015 - Present)

Institute for Experimental and Theoretical Astrophysics, University of Córdoba

- "Ryan Lectures": A series of lectures on photometry (June – October 2014)

Stevens Institute of Technology

Mathematics Department

- Test Reviewer for MA 115, MA 116 and MA 227 (May 2008- May 2009)

Scientific Outreach

Texas A&M University

- Harvey Mitchell Elementary School ◆ Guest Astronomer ◆ Spring 2015
- Davila Middle School Family Space Night ◆ Guest Astronomer ◆ Spring 2013 & 2015
- Texas A&M Star Parties ◆ Volunteer ◆ 2012 - Present
- Science Olympiad ◆ Astronomy event coordinator ◆ 2011 - Present
- Texas A&M University Observatory Open Houses ◆ Volunteer ◆ 2010 - 2011
- Texas A&M Physics Festival ◆ Volunteer ◆ 2010 - Present

Ryan J. Oelkers
Publication List

Refereed Publications

First Authorship

1-A Wide Field Search for Transiting Hot Jupiters and Pre-Main Sequence Binaries in Young Stellar Associations, **Oelkers, R., J**, Macri, L., M., Marshall, J. L., DePoy, D. L., Lambas, D.G., Colazo, C. Guzzo, P., Konchady, T., Quinones, C., Stringer, K., Tapia, L., Wisdom, C., 2016, in prep

2-A Search for Transients from Antarctica using Difference Image Analysis of the 2009 and 2010 CSTAR Observations, **Oelkers, R., J**, Macri, L., M., Wang, L., Ashley, M. C. B., Cui, X., Feng, L.L., Gong, X., Lawrence, J. S., Qiang, L., Luong-Van, D., Pennypacker, C. R., Yuan X., York, D. G., Zhou, X., Zhu, Z., 2015, to be submitted to AJ November 2015

3-Difference Image Analysis of Defocused Observations with CSTAR, **Oelkers, R., J**, Macri, L., M., Wang, L., Ashley, M. C. B., Cui, X., Feng, L.L., Gong, X., Lawrence, J. S., Qiang, L., Luong-Van, D., Pennypacker, C. R., Yuan X., York, D. G., Zhou, X., Zhu, Z. AJ, 2015, 149, 50O

Co-Authorship

4-Analytical solution for dilute strain concentration tensor for coated inclusions and applications for polymer nanocomposites: Part 2. Cylindrical Inclusions F.T. Fisher, Z. Wang, **R. Oelkers**, and K.C. Lee, 2015, Mechanics of Materials, to be submitted

5-Analytical solution for dilute strain concentration tensor for coated inclusions and applications for polymer nanocomposites: Part 1. Spherical Inclusions, F.T. Fisher, Z. Wang, **R. Oelkers**, and K.C. Lee, 2015, Mechanics of Materials, submitted

6-KELT-6b: A P~7.9 d Hot Saturn Transiting a Metal-Poor Star with a Long-Period Companion, Collins, K. A…. +36 others including **Oelkers, R. J.,** AJ, 2014, 147, 39C

Non-Refereed Publications

First Authorship

7-A Wide Angle Search for Hot Jupiters and Pre-Main Sequence Binaries in Young Stellar Associations, **Oelkers, R., J**, Macri, L., M., Marshall, J. L., DePoy, D. L., Colazo, C. Guzzo, P., Lambas, D.G., Quinones, C., Stringer, K., Tapia, L., Wisdom, C., Proceedings of IAU Symposium No. 314, (Cambridge University Press), 2015, J.H. Kastner, B. Stelzer, S.A. Metchev, eds.

Ryan J. Oelkers
Past and Current Research

My research has primarily focused on the precision analysis of large photometric data sets ($> 10^6$ images) from small-aperture telescopes (< 20 cm). I have learned to differentiate between systematic effects and true astrophysical variations and to decouple eclipse-like events from stellar variability. I have applied this knowledge to an instrument deployed at the Bosque Alegre Astrophysical Station to identify planetary and stellar eclipses in young stellar associations. I have advanced knowledge of photometric reduction using aperture photometry and difference-image-analysis. I also have experience reducing echelle spectra from HRS on the Hobby Eberly Telescope and SES on the 2.1m from McDonald Observatory. Below, I provide a brief summary of my past and current research.

Past: Searching for Signs of Variable and Transient Behavior with CSTAR

The Chinese Small Telescope ARray (CSTAR) was designed to test the feasibility and quality of an observatory stationed at Dome A on the Antarctic Plateau between 2008-2010. The CSTAR telescope exploited the superb observing conditions from Dome A (< 0.4 mag extinction for 70% of dark time) to provide high cadence, multi-color (*gri* & *clear*) time-series photometry during each six month observing season. Initial reductions of the 2008 and 2010 CSTAR data sets using aperture photometry showed remarkable clarity and precision (Wang et al. 2011 & 2013). Routine servicing after the 2008 winter season left the detectors defocused during the 2009 operation, greatly exaggerating blending and crowding effects, and rendered reduction with aperture photometry impractical. I developed a novel version of difference-image-analysis, using a Dirac-δ function kernel, combined with a slew of trend removal techniques to compensate for these effects. This data pipeline was the main result of my *East Asian and Pacific Summer Institutes Fellowship* during the summer of 2012. I worked with many Chinese collaborators at the University of Nanjing to develop the code and tailor it for the CSTAR system. I successfully reduced $\sim 8\times10^5$ images taken during the 2009 season and detected variability in > 100 objects including RR-Lyraes, δ Scutis, eclipsing binaries and transiting exoplanet candidates (Oelkers et al. 2015a). A light curve for a recovered Cepheid II variable in an eclipsing binary system is shown in Figure 1 of the science proposal.

Following this reduction, I launched an investigation into stellar flare rates during the 2009 and 2010 observing seasons. It was necessary to reduce an additional $\sim 2 \times 10^5$ images with my data pipeline to achieve this goal. I found the detector was plagued with ghosting and aliasing effects which mimicked flare-like events. I developed a rigorous algorithm to compare the candidate flare's timing, length and amplitude with those of known ghosting events to avoid contamination. I determined a flaring rate of $3.5 \pm .2 \times 10^{-6}$ flares/hr for the entire CSTAR field, $2.3 \pm .5 \times 10^{-6}$ flares/hr for Late K dwarfs and $2 \pm 1 \times 10^{-6}$ flares/hr for M dwarfs in our sample. I also concluded that small-aperture telescopes, like CSTAR, are not well suited for blind transient searches due to their large pixel scales (< 15"/pix) and bright limiting magnitudes ($V \approx 15$) (Oelkers et al. 2015b). My work with the CSTAR telescope was beneficial to the astronomical community in three ways. First, it produced multi-color light curves for $> 10,000$ sources with a ~ 20 s cadence on a 250 d baseline. Second, I identified a large number of systematic effects and their sources which have been removed due to my rigorous data reduction efforts. Finally, the data pipeline is robust enough to detect true astrophysical variation in crowded and poorly constrained data sets. My pipeline is applicable not only to analyzing noisy data sets, but also to differentiating between variability and low signal-to-noise eclipse measurements as described below.

Current: A Wide Angle Survey for 'Hot Jupiters' and Pre-Main Sequence Binaries

Precise and accurate measurements of stellar masses and radii at diverse ages, obtained through observations of double-lined spectroscopic eclipsing binary systems, provide the most rigorous tests of stellar evolution models (Torres et al. 2010, Baraffe et al. 2015). The vast majority of the systems that have been accurately characterized are composed of objects on the main-sequence or post-main sequence evolutionary tracks. In contrast, only a dozen pre-main sequence binaries (PMBs) have been discovered and studied in depth (Morales-Calderon et al. 2012). A dramatic increase in the total number of systems at early times is required to alleviate the conflict between theory and observation.

Motivated by these contentions, I conducted a photometric survey of three young (< 50 Myr) and nearby (< 150 pc) stellar associations as part of my PhD thesis. The imaging equipment consisted of an Apogee Alta F16M camera, a Mamiya photographic 300mm lens and a Hoya UV/IR cut filter to restrict the wavelength range to $0.4 - 0.7$ μm. The associations studied were Upper Scorpius, η Chamaeleontis and IC 2391, chosen to span a significant range in age ($2 - 50$ Myr) and yield light curves of sufficient quality for a large range of spectral types (F-early M). I obtained a total of $\sim$200 hours of observations during 2013-14. I analyzed the data using the above mentioned photometric techniques to compensate for the inherent variability found in pre-main sequence objects which can mask and mimic these eclipse signals. I identified over 300 PMB candidates and 7 transiting Hot Jupiter candidates. The 1.5 m telescope at Bosque Alegre, 0.8 m telescope at McDonald Observatory, 0.5 m telescope at the Texas A&M Observatory and the company of 1 m telescopes from LCOGT have provided higher precision photometric follow up for over 40 systems. I ruled out transiting Hot Jupiter candidates with P < 3 d in Upper Scorpius and placed a lower limit of 10 Myr for Hot Jupiter migration timescales (Oelkers et al. in prep). I obtained exploratory spectroscopy for 7 systems using SES on the 2.1 m telescope at the McDonald Observatory and plan to use CHIRON on the SMARTS 1.5 m at CTIO for further spectroscopic follow up. A PMB candidate at each stage of the classification process is shown in Figure 2 of the science proposal. This work will improve the mass-radius relation at early times and help to constrain the theoretical limits on planet and star formation, a main goal of the Cosmic Origins program. This work provides the foundation for my Hubble Fellowship science proposal.

References

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Morales-Calderón, M. et al., 2012, ApJ, 753, 149
Oelkers, R. J., et al. 2015a, AJ, 149, 50
Oelkers, R. J., et al. 2015b, to be submitted
Oelkers, R. J., et al. 2016, in prep
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Ryan J. Oelkers

A Synoptic Survey of Young Stellar Associations for Pre-Main Sequence Eclipsing Binaries

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Introduction and Motivation: A wide range of astrophysical studies require an unqualified understanding of the fundamental properties of stars. Diverse topics such as planet, star & galaxy formation, the initial stellar mass function, the distance scale and supernovae are just some examples of areas that would benefit from increasingly more realistic stellar evolution models to fully realize the scientific potential of observations. Precise and accurate measurements of stellar masses and radii at diverse ages, obtained via double-lined eclipsing binary systems, provide the most rigorous tests of these models (Torres et al. 2010, Baraffe et al. 2015). Presently, the vast majority of the systems that have been properly characterized contain main-sequence or evolved objects. In contrast, only a dozen pre-main-sequence eclipsing binaries (PMBs) have been discovered and studied in depth (Morales-Calderon et al. 2012).

Studies of these few PMBs have shown significant differences with predictions, calling into question some of the assumptions adopted by the models. For example, the transformation of observed properties such as temperature and luminosity into mass and age has been shown to be discrepant by $50 - 100\%$ for stars below $1M_{\odot}$; an inconsistency which can only be relaxed by the use of empirical relations (Stassun et al. 2014). On a related topic, a good understanding of circumstellar disk formation, accretion and dissipation is critical to establish the timescales for planet formation and migration. Yet, the failure to discover authentic Hot Jupiters around pre-main sequence stars is in sharp contrast with the expectations from migration models (Yu et al. 2015). On a broader scale, the determination of star formation rates is very sensitive to the assumed initial mass function – a parameter that is heavily dependent on the adopted evolutionary tracks of pre-main sequence stars and currently fails to explain the observed distribution of stellar masses (Kennicutt & Evans 2012). Hence, a significant increase in the number of well-characterized young systems spanning the widest possible range of masses and ages is the best approach to test and eventually improve evolutionary models. **As a Hubble Fellow, I will conduct a synoptic survey of young stellar associations that will at least triple the number of well-characterized pre-main sequence eclipsing binary systems and constrain the mass-radius relation at early times.**

Observations and Host Institution: The proposed survey will target 6 northern and 6 southern young stellar associations (YSAs) spanning a wide range in age ($2 - 400$ Myr; see Table 1 for details) to significantly increase the sample of pre-main sequence stars (PMS) in eclipsing systems. Each YSA will be observed on a nightly basis (weather permitting) over 2 months to maximize the sensitivity to binaries of different periods. Assuming a 60% observing efficiency and a random distribution of periods & eclipse depths for astrophysically viable binaries, this cadence will recover $> 85\%$ ($> 95\%$) of systems with P≤ 60 (≤ 20) d. Presently, most confirmed members in these YSAs are early-type (O/B/A) stars ($N \sim$200 in total). Adopting a Chabrier (2003) initial mass function, a binary fraction of $2/3$ (Lada 2006), an eclipse probability of Prb $\approx \sin\theta$ and the aforementioned recovery fractions, I estimate the survey will discover a total of $24 - 480$ PMBs.

Thus, the proposed survey will at least triple the amount of well-characterized PMBs even under the most conservative scenario.

Two observatories are excellent candidates to carry out this survey because of their pre-existing survey infrastructure and on-site follow up capabilities: McDonald Observatory (MD, lat=$30.67°$N) and Bosque Alegre Astrophysical Station (EABA, lat=$-31.72°$S). My proposed host institution, the University of Texas at Austin (UT), will allow me access to the MD 0.8 m telescope. The telescope is capable of remote observation, can provide multi-color (*UBVRI*) photometry and has a large FoV (~ 0.6 sq. deg.). Additionally the telescope has a subscription rate much lower than other telescopes (13% in the 3rd trimester of 2015). The observatory only requires safety training to use the telescope on unsubscribed nights, in lieu of telescope allocation committee approval, and I successfully completed this training in the spring of 2015. The combination of these factors will allow the survey program to dominate each observing cycle. MD also possesses a company of telescopes which can provide spectroscopic follow-up for each of my candidates. Specifically, the IGRINS instrument on the 2.7 m is an infrared spectrograph designed to target PMS stars and has been shown to provide radial velocity precision down to 30 m/s, well within the acceptable range to detect binary star reflect motion (Park et al. 2014). Additionally, the High Resolution Spectrograph and the proposed Habitable Zone Planet Finder can provide higher precision, higher resolution spectroscopic follow up when the Hobby Eberly Telescope is recommissioned during 2016. The on-site detection and follow up capabilities of MD make UT an excellent choice as a host institution.

The southern survey will be conducted from EABA through an ongoing collaboration with the University of Córdoba. The survey equipment consists of a 16 Mpix Apogee CCD, a 54-mm aperture Mamiya lens and a broad filter (400-700 nm) with a field of view of 50 square degrees sampled at 6"/pix. I participated in the development of this equipment and used it for my PhD Thesis, in which I surveyed 3 YSAs for Hot Jupiters and PMBs. **This initial survey yielded >300 PMB candidates based on <200 hrs of data (Oelkers et al., in prep).** The survey equipment is maintained by the EABA observatory staff and will be remotely operated from UT. Additionally, I have been granted 3-4 nights of observing time per month on the 1.54 m at EABA for higher precision multi-color (*UBVRI*) photometric follow up. The installation of a low-medium resolution spectrograph in the spring of 2016 will give the observatory spectroscopic capabilities and allow for seamless transition between detection and follow-up operations (Nagasawa et al. 2014).

Data Processing and Candidate Selection: The data will be processed using the existing pipeline developed as part of my PhD Thesis. Initial steps include debiasing, flat-fielding, residual background subtraction and bicubic image alignment. Photometry is obtained via difference imaging with a Dirac-δ function kernel, followed by the application of a Trend Filtering Algorithm (Kovács et al. 2005) to correct for small and localized residual variations not well represented by the kernel. The pipeline has been shown to produce high-precision photometry close to the scintillation and photon-noise limits (Oelkers et al. 2015a,b), and can run quickly on desktop-class CPUs even for significantly larger data sets ($\sim 10^6$ images with $10,000+$ sources).

The inherent variability in PMS stars, both periodic and aperiodic, compounds the difficulty of detecting eclipse signatures which may last $< 10\%$ of the period phase. I will employ a variety of variability "whitening" techniques prior to eclipse searches to increase detection capabilities. Aperiodic variability, while difficult to predict, can be removed with an outlier resistant B-spline with special care taken to de-weight sudden eclipse-like signatures in a light curve (Vanderburg &

Johnson 2014, Wang et al. 2015). Removing the first 10(9) (sub-)harmonics prior to searching for eclipses has also been shown to help identify milli-mag eclipse signatures hidden in periodic variability, as shown in Figure 1 (Wang et al. 2013, Oelkers et al. 2015a,b). Each whitened light curve will be searched with the Lomb-Scargle algorithm (Lomb 1975, Scargle 1982) and the Box Least Squares algorithm (Kovács et al. 2002) to identify binary signals. All objects with statistically significant periods ($< 1\%$ of the false alarm probability) that lie outside of aliased frequencies will be selected for further assessment. Each candidate light curve will be phased and visually inspected to confirm the nature of the eclipse. These techniques will also be sensitive to the detection of transiting planets which will be identified for further follow-up. While passing all these criteria does not ensure *bona-fide* binary eclipses, each step helps to reduce the amount of false positives from the sample. I believe my experience with extracting signals from poorly characterized and noisy data sets places me in a unique position to accomplish this task. Figure 2 shows an example PMB candidate discovered during my PhD Thesis during all steps of the classification process.

Membership Confirmation and Spectroscopic Follow Up: Any PMB candidate passing all of the above significance tests will then be subjected to membership confidence testing prior to being queued for photometric and spectroscopic follow-up observations. The 2MASS catalogue (Skrutskie et al. 2006) can provide information about possible infrared excesses which are indicative of PMS stars. Furthermore, the UCAC4 proper motion catalogue (Zacharias et al. 2013), can be used to confirm membership of any candidates. Photometric follow up will obtain independent, higher precision eclipse and quadrature observations to verify the eclipse nature of the system and refine the orbital period. I will use each observatory's on-site spectroscopic capabilities to obtain six epochs of medium-high resolution spectroscopy to derive radial velocities of the host star to an accuracy of < 1 km/s. By observing the candidates at their predicted orbital quadratures, I will be able to simultaneously search for the spectral signatures of double-line spectroscopic binaries and maximal RV shifts in the spectra of single-line spectroscopic binaries using template cross-correlation techniques. The resulting photometric and spectroscopic information will then be combined and analyzed by a binary fitting program such as JKTEBOP (Southworth et al. 2013) to solve for the binary system parameters and update the mass-radius relation at early times.

Impact on Future Space Missions: This synoptic time-series survey has the potential to provide crucial precursory information for a variety of complementary future space missions. The Transiting Exoplanet Survey Satellite (TESS) is expected to provide a robust detection of transiting planets for 500,000 bright stars with 30 min cadence (Ricker et al. 2014). My survey will provide advance knowledge of candidates, both binary and planetary, that require longer baselines and higher precision measurements for accurate classification. This a priori knowledge helps to avoid the difficulties associated with searching through large data sets to find only the most interesting candidates. Additionally, a major science goal of the James Webb Space Telescope (JWST) is the understanding of star and planet formation (Gardner et al 2006). My proposed survey will provide the JWST a catalogue of PMS objects, regardless of their binary nature, which can be studied at greater photometric and spectral resolution to investigate the nature and structure of possible proto-planetary disks. Through these efforts, my survey will produce complimentary science for the NASA Cosmic Origins program which, in part, aims to explain how stars form and evolve.

As a Hubble Fellow, I will provide urgently needed additional constraints for stellar evolutionary models by surveying young stellar associations and directly measuring the masses and radii of stars in pre-main sequence eclipsing binary systems.

Table 1. Proposed Young Stellar Associations

Name	R.A. [hrs]	Dec.[°]	Survey Months
Cam OB1-G144	03:39	+55	Dec. - Jan.
Orion OB1b	05:30	-01	Feb. - Mar.
Melotte 111	12:22	+25	Apr - May.
NGC 6910	20:23	+40	Jun. - Jul.
IC 5146	21:53	+47	Aug. - Sep.
IC 348	03:44	+32	Oct. - Nov.
Canis Majoris	07:05	-11	Dec. - Jan.
IC 2391*	08:40	-53	Feb. - Mar.
Lower Centaurus	12:30	-57	Apr. - May
Upper Scorpius*	16:30	-24	Jun. - Jul.
η Chamaeleontis*	08:45	-79	Aug. - Sep.
Tucana-Hologorum	02:00	-60	Oct. - Nov.

Note. — *: Initial survey data already available (Oelkers et al., in prep.)

References

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Torres, G. et al. 2010, ARA&A, 18, 67
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Wang, L. et al. 2013, AJ, 146, 139
Wang, D. et al. 2015, arXiv, 1508.01853
Yu, L. et al. 2015, ApJ, 812, 48
Zacharias, N. et al. 2013, AJ, 145, 44

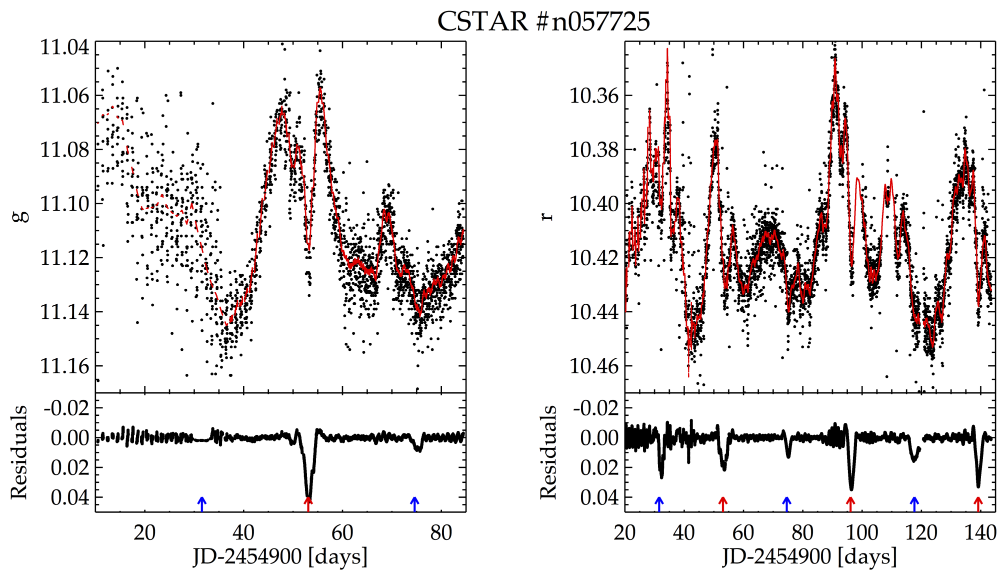

Figure 1 Light curves of CSTAR #n057725 from Oelkers et al. (2015). This star is likely a Population II Cepheid in an eclipsing binary system showing complex variability. The bottom panels highlight the eclipse events that take place every 43.2 d which were detected with the whitening process described in the text. Red arrows mark the expected time of primary eclipse and blue arrows mark the expected time of secondary eclipse.

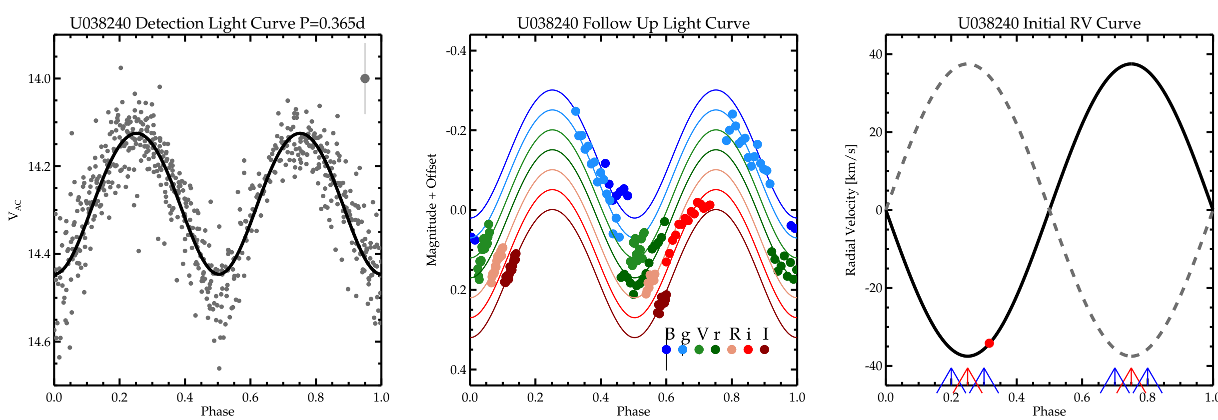

Figure 2 Pilot survey PMB candidate U020683 discovered as part of my PhD Thesis shown at each stage of the classification process: detection [*top*]; multi-color follow up [*middle*]; initial RV measurements [*bottom*]. The solid lines denote the best fit JKTEBOP models (Southworth 2013). The expected RV variation is extrapolated from the eccentricity of the system and the best fit orbital parameters from JKTEBOP. The blue arrows denote the acceptable range of observations in phase and the red arrows denote the exact quadrature.