31 December 2015

Dr. Keivan Stassun
Professor of Physics & Astronomy
Vanderbilt University

Dear Dr. Stassun:

Please find my enclosed application for the postdoctoral fellowship in exoplanets and large surveys at Vanderbilt University. I am a current PhD candidate in the Department of Physics and Astronomy at Texas A&M University with an expected graduation date of May 2016. My research has focused on the reduction of large, photometric data sets from small aperture telescopes to search for variable stars and transient events. I have applied this knowledge to a search for pre-main sequence eclipsing binaries and transiting "Hot Jupiters" in young stellar associations as part of my PhD thesis.

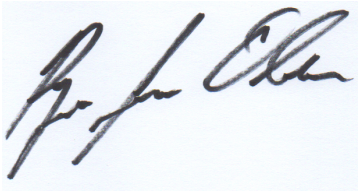
I have developed numerous routines to reduce images, detrend light curves and eliminate sources of contamination in photometry. These techniques have been applied to more than 10^6 astronomical measurements of 10^5+ sources. I led the design, installation and data-pipeline development for a small aperture telescope, nicknamed 'AggieCam,' to survey young stellar associations. My pipelines have been shown to produce high-precision photometry close to the scintillation and photon-noise limits, even in hostile photometric environments. I am very interested in combining the AggieCam and KELT photometry to greatly increase the quality and breadth of data for pre-main sequence stars.

I am also interested in the mentoring opportunities Vanderbilt provides with students in the PhD and REU programs. While at Texas A&M University I have mentored 3 undergraduate students through general research and REU activities. I find these mentoring opportunities to be a catalyst in my development as a successful astronomer.

I believe I will make an excellent candidate for this postdoctoral position because of my experience collecting and reducing large data sets and my attention to detail when differentiating between true astrophysical variation and systematic effects. My strong background in applied mathematics also provides me flexibility as a researcher in science and engineering.

Thank you in advance for your consideration of this application.

Sincerely,



Ryan J. Oelkers
Graduate Student
Physics and Astronomy Department
Texas A&M University

Ryan J. Oelkers
Curriculum Vitae

Email: ryan.oelkers@physics.tamu.edu ◆ **Website:** http://people.physics.tamu.edu/ryan.oelkers/ ◆ **Phone:** (267) 261-9337

Research Interests

data mining of large astronomical data sets ◆ mass-radius relation for stars at young ages ◆ binary star and exoplanet detection and classification ◆ star and planet formation ◆ transient detection techniques ◆ variable star detection and classification ◆ small aperture telescope surveys ◆ signal significance testing

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

Refereed Publications

First Authorship

1. A Wide Field Survey 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, 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. An 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, to be submitted to Mechanics of Materials
5. An 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, submitted to Mechanics of Materials
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, Ryan J.,** AJ, 2014, 147, 39C

Non-Refereed Publications

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.

Conferences and Presentations

Talk ◆ Dissertation Talk, AAS Meeting 227 ◆ Kissimmee, FL ◆ Jan. 6, 2016
Talk ◆ ISM Seminar, University of Texas ◆ Austin, TX ◆ Nov. 20, 2015
Poster ◆ Frank N. Bash Symposium ◆ 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 ◆ Córdoba, 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 Sci. and Tech. meetings to facilitate collaboration ◆ 2014 - 2015
Argentina ◆ installed a remote telescope in collaboration with the Univ. of Córdoba ◆ 2013 -
China ◆ worked at Nanjing University to create a difference image analysis pipeline ◆ 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

References

1. Dr. Lucas M. Macri ◆ PhD Advisor ◆ lmacri@tamu.edu
2. Dr. Darren L. DePoy ◆ depoy@physics.tamu.edu
3. Dr. Nicholas Suntzeff ◆ nsuntzeff@tamu.edu

Ryan J. Oelkers
Research Statement

My research has focused on the precision analysis of large photometric data sets ($> 10^6$ images) from small-aperture telescopes (< 20 cm). I developed a difference-imaging pipeline that has been shown to produce high-precision photometry close to the scintillation and photon-noise limits, even in hostile photometric environments (Oelkers et al. 2015a,b). This pipeline, written in C, can run quickly on desktop-class CPUs even for significantly larger data sets ($\sim 10^6$ images with $10,000+$ sources). This pipeline was successfully applied to data from a small aperture telescope I helped to deploy at the Bosque Alegre Astrophysical Station. Nicknamed 'AggieCam,' the camera identified planetary and stellar eclipses in young stellar associations as part of my PhD thesis. I am eager to continue to search for pre-main sequence eclipsing binaries, transient events and variable stars in the next AggieCam survey and in Vanderbilt's KELT-South data set. Below I provide a brief summary of my past, current and proposed 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. Initial reductions of the 2008 and 2010 CSTAR data sets used aperture photometry (Wang et al. 2011 & 2013) but routine servicing after the 2008 winter season left the detectors defocused during the 2009 operation, greatly exaggerating blending and crowding effects. 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. I worked at the University of Nanjing with many Chinese collaborators to develop the code and tailor it for the CSTAR system as part of my 2012 East Asian and Pacific Summer Institutes Fellowship. I successfully reduced $\sim 10^6$ images with $10,000+$ sources and detected variability in > 100 objects including RR-Lyraes, δ Scutis, eclipsing binaries and transiting exoplanet candidates (Oelkers et al. 2015a). Additionally, I determined a flaring rate of $3.9 \pm .3 \times 10^{-6}$ flares/hr for the CSTAR field (Oelkers et al. 2015b). My pipeline is useful in analyzing crowded data sets and is capable of differentiating between variability and low signal-to-noise eclipse measurements. Figure 1 shows an example of the pipeline recovering binary eclipses in a Type II Cepheid with complex variability.

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

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). At 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.

Motivated by these contentions, I conducted a photometric survey of three young (< 50 Myr) and nearby (< 150 pc) stellar associations (YSA) 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 filter ($0.4-0.7$ μm). The YSAs 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 collaborated with the University of Córdoba in Argentina (UCA) to remotely operate the system from Bosque Alegre Astrophysical Station (EABA) and 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 (PMS) objects which can mask and mimic these eclipse signals. I identified over 300 PMB candidates and 7 transiting Hot Jupiter candidates. A company of telescopes from EABA, McDonald Observatory, Texas A&M University and 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. 2016, *in prep*). I obtained exploratory spectroscopy for 7 systems using SES on the 2.1 m telescope at the McDonald Observatory and with plans for further spectroscopic follow up. The release and publication of this data set is expected in March 2016. Figure 2 shows an example PMB candidate during all steps of the classification process.

Proposed: A Synoptic Southern Search for Pre-Main Sequence Eclipsing Binaries

The large number of PMB candidates identified by the pilot survey showed the survey could be applied on a much larger scale. This new, synoptic survey will target 6 southern YSAs spanning a wide range in age ($2 - 400$Myr) and right ascension to significantly increase the sample of PMS stars in eclipsing systems. These associations are detailed in Table 1. Each YSA will be observed on a nightly basis (weather permitting) during 2 month intervals to maximize the sensitivity to binaries of different periods. Assuming a 60% observing efficiency and a random distribution of periods and eclipse depths for astrophysically viable binaries, this cadence will re-

cover $> 85\%$ ($> 95\%$) of systems with P$\leq$ 60 ($\leq$ 20) days. 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 $12 - 240$ *bona-fide* PMBs. Therefore, even with the most conservative estimates, I could double the number of well-characterized pre-main sequence eclipsing binary systems.

This survey will employ the currently operational pilot instrument through an ongoing collaboration with UCA. The postdoctoral fellowship at Vanderbilt University will provide access to the KELT-South data set to independently confirm both binary and planetary eclipses in overlapping fields. Additionally access to this data set also allows the AggieCam telescope to focus on the YSAs not currently observed by KELT-south, such as η Chamaeleontis. I have been granted 3-4 nights of observing time a month on the 1.54 m at EABA for higher precision, multi-color, 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). This telescope can also be used to follow up KELT-South targets through my continued collaboration with UCA. The resulting photometric and spectroscopic information will then be combined with the 2MASS & WISE catalogs (Skrutskie et al. 2006, Wright et al. 2010) and the UCAC4 proper motion catalogue (Zacharias et al. 2013) to provide insight into possible infrared excesses and help to confirm candidate membership.

A synoptic time series survey has the potential to provide crucial precursory information for the Transiting Exoplanet Survey Satellite (TESS). 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, requiring 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.

As a postdoctoral fellow at Vanderbilt University, 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.

References: Baraffe, I. et al. 2015, A&A, 557A, 42◆Chabrier, G. 2003, PASP, 115, 763◆Kennicutt, R. C., & Evans, N. J. 2012, ARA&A, 50 531◆Lada, C. et al. 2006, 131, 1574◆ Morales-Calderón, M. et al., 2012, ApJ, 753, 149◆Nagasawa, D. Q. et al. 2014, SPIE, 9147E, 2L◆Oelkers, R. J., et al. 2015a, AJ, 149, 50◆Oelkers, R. J., et al. 2015b, submitted to AJ◆Oelkers, R. J., et al. 2016, in prep◆Pepper, J. et al. 2012, PASP, 124, 230◆Ricker, G. R. et al. 2014, SPIE, 9143E, 20◆Skrutskie, M. F. et al. 2006, AJ, 131, 1163◆Southworth, J. 2013, A&A, 557A, 119◆Stassun, K. et al. 2014, NewAR, 60, 1◆Torres, G. et al., 2010, ARA&A, 18, 67◆van Eyken, J. C. et al. 2012, ApJ, 755, 42◆Wang, L. et al. 2011, AJ, 142, 155◆ Wang, L. et al. 2013, AJ, 146, 139◆Yu, L. et al. 2015, ApJ, 812, 48◆Zacharias, N. et al. 2013, AJ, 145, 44

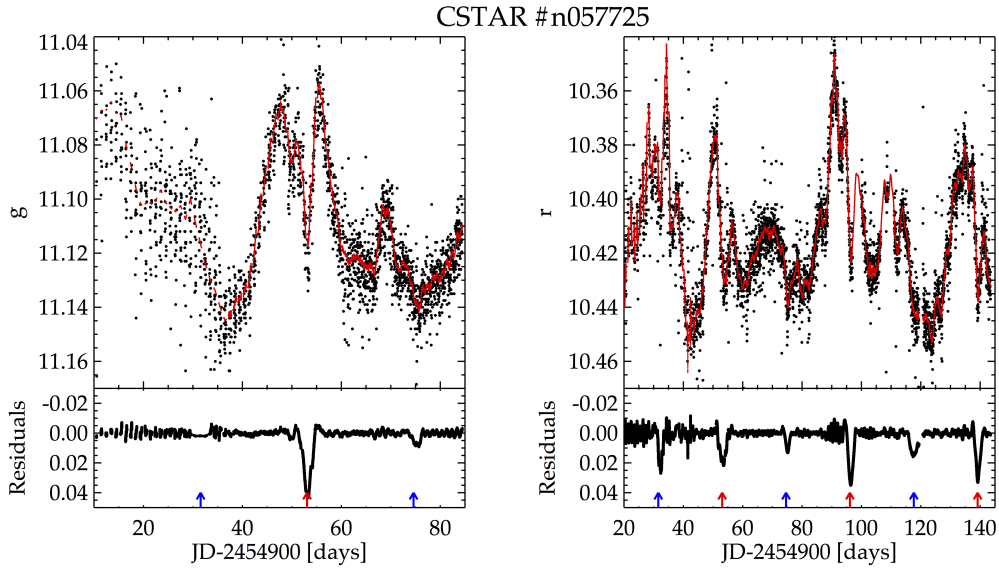


Figure 1: Light curves of CSTAR #n057725 from Oelkers et al. (2015a). This star is likely a Population II Cepheid in an eclipsing binary system showing complex variability. The binary eclipses were recovered using the above mentioned data pipeline. The bottom panels highlight the eclipse events that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

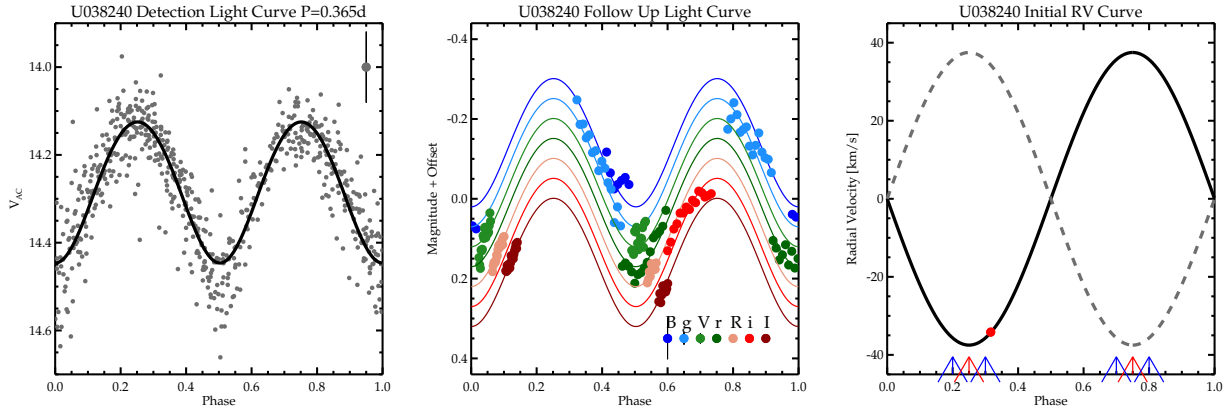


Figure 2: Pilot survey PMB candidate U020683 discovered as part of my PhD Thesis shown at each stage of the classification process: detection [*top*]; multi-color follow up [*middle*]; initial RV measurements [*bottom*]. The solid lines denote the best fit JKTEBOP models (Southworth 2013). The expected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

Table 1. Proposed Young Stellar Associations

Name	R.A. [hrs]	Dec.[°]	Survey Months
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. 2016, in prep.)