15 December 2015

Dr. Richard Smith
Director
Statistical and Applied Mathematical Sciences Institute

Dear Dr. Smith:

Please find my enclosed application for a postdoctoral fellowship in statistical, mathematical and computational methods in astronomy at SAMSI. I am a current Ph.D. 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 to search for variable stars and transient events. I have applied this knowledge to searches for pre-main sequence eclipsing binaries and transiting "Hot Jupiters" in young stellar associations as the cornerstone of my Ph.D. 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 have identified more than $5,000$ variable star candidates and transient events using multiple data sets from small aperture telescopes. My pipelines have been shown to produce high-precision photometry close to the scintillation and photon-noise limits, even in hostile photometric environments.

I received 2 applied mathematics degrees before pursuing my Ph.D. in astrophysics. I helped to derive an analytical solution to the dilute strain concentration tensor as part of my undergraduate research. This work has many applications in nanotechnology, such as predicting the micromechanical properties of polymer coated nanocomposites. This research in applied mathematics and mechanical engineering provided the strong foundation for my graduate research skill set.

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 outside of astronomy.

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

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 ◆ 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
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). I have applied this knowledge to an imager I helped to deploy at the Bosque Alegre Astrophysical Station to identify planetary and stellar eclipses in young stellar associations as part of my PhD thesis. I am interested in using these techniques to continue to search for pre-main sequence eclipsing binaries, transient events and variable stars. I have a strong background in applied mathematics which has provided the foundation for my research skill set. Below, I provide a brief summary of my past, current and proposed research.

Past: An Analytical Solution to the Dilute Strain Concentration Tensor

The past decade has seen a dramatic increase in the use of nanocomposites (nano-sized reinforced phases in a polymer matrix) due to their electrical, thermal and mechanical properties. While this improvement can be attributed to the tremendous amount of surface area per unit volume of the inclusions, the prediction of their micro-mechanical properties can be complicated (Wang, Z. & Fisher 2014). As an undergraduate I worked to solve the dilute strain concentration tensor in both spherical and cylindrical coordinates to provide a basis for the interpretation of auxiliary loading cases (Fisher et al. including Oelkers, R. 2015a,b). This research provided a practical application for my classical mathematical training and sparked my interest in applied rather than pure mathematics. I consider this experience invaluable to my development as a researcher.

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. Additionally, I determined a flaring rate of $3.9 \pm .3 \times 10^{-6}$ flares/hr for the CSTAR field (Oelkers et al. 2015a,b). My pipeline is applicable not only to analyzing crowded 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

A wide range of astrophysical studies require an unqualified understanding of the fundamental properties of stars. 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 (Stassun et al. 2014). An 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 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 plan to use CHIRON on the SMARTS 1.5 m at CTIO for further spectroscopic follow up.

Proposed: A Synoptic Search for Pre-Main Sequence 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 all 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. 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 recover $> 85\%$ ($> 95\%$) of systems with P≤ 60 (≤ 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. Additionally, I have been granted 3-4 nights a month of observing time 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). 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.

This synoptic time-series survey has the potential to provide crucial precursory information for complementary future space missions. The Transiting Exoplanet Survey Satellite 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.

Proposed: Identifying Inherent Activity in Young Stars with K2

PMS stars typically show variability that appears to be arbitrary and unpredictable because of the star's collapse onto the main sequence, increased spot cycle due to magnetic activity, protostellar disk accretion or a combination of all these factors (Stassun et al. 2014). This variability can mask and mimic signals which are important to the understanding of the fundamental properties of stars (such as stellar rotation rates and planetary & stellar eclipses). Current attempts to reduce variation in PMS stars rely on the whitening of light curves against suspected periodic variability (Kraus et al. 2015) or the use of self-described, overly-flexible models which de-weight variation similar to the desired signal (Wang, D. et al. 2015). While these techniques can remove variation, the possibility that *bona-fide* signals will also be removed is greatly increased. The K2 data provides a unique opportunity to relate this variability to its source because of its large sample of PMS stars, long baseline and high cadence. If the amplitude of the variability can be correlated with known astrophysical phenomena (such as sunspots or disk accretion), it can be modeled based on the star's current variability and properly removed, while preserving *all* other signals in the data. This model could then be applied to *all* data of PMS stars regardless of their photometric quality. I believe I am an outstanding candidate to accomplish this task because of my experience reducing a large time-series data set of substantially lower photometric precision than *Kepler*.

References: Baraffe, I. et al. 2015, A&A, 557A, 42◆Chabrier, G. 2003, PASP, 115, 763◆Fisher, F. T., et al. including Oelkers, R. 2015a submitted to Mech. Mater◆Fisher, F. T., et al. including Oelkers, R. 2015b to be submitted◆Kraus, A. et al. 2015, ApJ, 807, 3◆ 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◆Ricker, G. R. et al. 2014, SPIE, 9143E, 20◆Skrutskie, M. F. et al. 2006, AJ, 131, 1163◆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, D. et al. 2015, arXiv, 1508.01853◆Wang, L. et al. 2011, AJ, 142, 155◆ Wang, L. et al. 2013, AJ, 146, 139◆Wang, Z. & Fisher, F. 2014, ASME, IMECE2014-37517◆Zacharias, N. et al. 2013, AJ, 145, 44

Ryan J. Oelkers
Teaching Statement

The physical sciences provide our understanding for how the world evolves around us; yet these subjects are some of the most difficult for students comprehend. This obstacle is not built from the difficulty of the material but rather an archaic interpretation of the methodology necessary to teach the subject. Most physical science classes are taught using a direct lecture format with an emphasis on deriving formulae for students. Unfortunately a student's ability to regurgitate these formulae and insert numbers does not necessarily demonstrate their comprehension of the subject matter. Instead, consistent and clearly defined expectations from the teacher of how the student will learn, an emphasis on scientific reasoning and a commitment from the teacher can greatly influence a student's ability to learn science. Astronomy has an advantage over many other physical science subjects because of the allure of the night sky. A professor of astronomy should use this excitement and intrigue to foster critical thinking without overwhelming students with infinite problem sets. My students main learning goals are: 1) to reason and debate scientific topics and 2) to recognize the importance of the subject even if they do not encounter its direct influences in daily life.

I believe learning develops through excitement and interest from both the student and the teacher. Preparedness and consistency stimulate trust with my students. My notes/slides are always prepared ahead of time and practiced before implementation. The subject is not derived for the students but discussed. We reason through the science together and I use a call and response technique throughout the lecture to keep the students attentive and increase participation. The students will also "break off" into groups to discuss critical thinking questions and then use flash cards to anonymously answer. These cards allow me to gauge the understanding and readiness of the entire class while at the same time allowing the students a sanity check of their own comfort with the material.

I post my notes after each lesson to allow the students to download the material on their own time. I also provide my students with clear explanations of their expectations for the course: how much homework will be assigned, what grades are required to pass and whether attendance is mandatory. I maintain a consistent pace to grade and return assignments. My students will not receive another assignment until the previous one has been returned (for class sizes of 50+ I would request a TA to aid in the grading). The goal of each assignment is to provide an honest representation of the challenges faced by astronomers. Questions are largely conceptual in nature and devoid of formulae and numbers whenever possible. This provides an opportunity for students to think about the subject matter rather than simply look up a formula and plug in a number. An assignment should not only teach a student that the Earth orbits the Sun but how we know it is true.

A challenge to many students is an inability to grasp the importance of the subject outside of the classroom. Astronomy typically caters to students who are seeking to fulfill a science requirement but are not majoring in the subject. When this is compounded with the subject matter literally being light years away, astronomy can have a low impact factor for many students. I require my students to read scientific papers, submit summaries on the main results and explain why the work is important. This helps to combat the argument astronomy is useless because each student has to defend the subject in their own words. This allows non-science students to understand the importance of elective subjects, like astronomy, by showing them the methodology of the course is familiar and relevant to their lives outside of the classroom. These assignments also provide non-science majors with writing and debate skills useful outside of astronomy.

After each semester I provide a survey for my students to complete, allowing them to judge all aspects of my teaching style. The use of clickers and smartphone apps also allow surveys to be conducted on a class by class basis. This feedback is much more helpful in shaping how specific lessons are taught and determining the comfort level of the class with the week's material. I also subject my students to a pre-test on the first and last days of class. This gives the students a tangible piece of evidence of their improved reasoning skills. Any student willing to participate is also contacted in subsequent years to re-take the pre-test in an effort to gauge their retention of the material. My teaching methods are cultivated with each iteration of these surveys as I am still learning what works well for my students.

There is no reason for the physical sciences to be intimidating when consistent and clearly defined expectations are provided, there is an emphasis on scientific reasoning and the teacher shows consistent commitment to the students. The purpose of science is not to solve problem sets but to provide evidence for the most convincing argument. Students should be learning to identify which concepts are necessary to solve the problem and apply this information to come to a reasonable solution. The students do not have to be confident their answer is correct but be able to provide a sound explanation as to why their answer was selected. They will use these skills to fully understand the importance of the subject even if they do not interact with the key scientific concepts in their daily lives. My goal as a teacher is to cultivate an environment where a student can learn to reason and recognize the importance of astronomy. Not every student will become a scientist but I want all of my students to respect and enjoy the subject.