OBSERVING REQUEST
University of Arizona Observatories

5291

Year: 2015 **Term:** Jan–Jul **Proposal type:** short-term

Evolutionary Analysis of Nearby Debris Disks

P.I.: Jennifer Patience (Arizona State University; *jennifer.patience@asu.edu*;)

CoI(s): T. Cotten (University of Georgia), I. Song (University of Georgia), J. Bulger (ASU), K. Ward-Duong* (ASU), A. Rajan* (ASU), P. Rojo (Universidad de Chile)

Abstract of Scientific Justification

Debris disks are intimately linked to the formation and evolution of planetary systems and play a key role in the detection of planetary systems. The past thirty years of infrared astronomy has led to a large number of published debris disk discoveries, however, much of these efforts resulted in published candidate pools without further confirmation. By searching $\sim$200 reviewed articles, we gathered a list 910 claimed IR excess stars in the literature. Using a state-of-the-art photosphere fitting method that includes the AllWISE survey, we selected an additional 1030 Tycho-2 candidate infrared excess stars showing excess in at least one AllWISE passband. Through exhaustive vetting of these candidates, we created a list of 1700 high fidelity IR excess stars. We divided these stars into several groups according to distance, dust luminosity and evolutionary stage for further characterization. The target sample presented in this proposal includes nearby ($<$ 200 pc), faint ($m_V > 9$ mag) stars demonstrating infrared excess requiring the sensitivity of a large, world-class instrument to obtain high resolution optical spectroscopy for age diagnostics and the study of planetary evolution theories. We intend to gather metallicity information using measurements of many FeI and FeII lines as well as age information using Li 6708Å absorption, Hα emission, and accretion signatures to gain insight into the relationship between the star and its disk properties. In combination with facilities at CTIO and La Silla Observatory, this project seeks a comprehensive analysis of debris disks stars not yet completed on the large scale and the data obtained will provide evidence for or against relationships between the host star, the debris disk, and ultimately planetary formation.

Summary of observing runs requested for this project

Run	Telescope	Cage	Instrument	PI	AO	Nights	Moon	Scheduling Optimal	Scheduling Acceptable	Sharing Poss.	Sharing Adv.
1	MMT	f/5	Hectochelle			2	grey	Jan–Jun	Jan–Jun	yes	yes

Scheduling constraints and unusable dates *(up to 4 lines)*: There are no scheduling constraints for this proposal and any available time can be used to observe this target sample in full or in part.

no text past this line

A * appended to the proposal type indicates a continuation proposal; a * appended to the name of a proposer indicates the proposer is a (graduate) student; a proposer whose name is underlined is certified on the proposed telescope/instrument combination; if a * appears within the PI or AO box in the observations summary table, the instrument is a PI instrument and/or Adaptive Optics are requested – signatures are required on the next page.

Target list (attach list if longer than 26 objects)

#	Object	RA	Dec	mag / color / type / redshift / comment / etc.
1	HIP 1866	00:23:38.02	-03:45:49.15	V=10.89
2	Please see attached list for the full 92 targets requested			

Approval for Instrument Use from PI: ____________________

*(have instrument PI signature appear on, or attach PI e-mail to, **all** copies)*

Graduate students *(provide the following information for **each** student named as PI or CoI on the cover page. Have the advisor's signature(s) appear on **all** submitted copies)*

Student's Name	Advisor's Name	Advisor's Signature	2nd-yr	Thesis
Tara Cotten	I. Song	see attached note	no	yes
K. Ward-Duong	J. Patience	Jennifer Patience	no	no
A. Rajan	J. Patience	Jennifer Patience	no	no

Scientific Justification

The discovery of the first debris disk star, Vega (Aumann et al. 1984), demonstrated the capabilities of using infrared photometry as a tracer of debris in stellar systems. Since this finding, nearly 1000 journal articles have been published that discuss various aspects of debris disks from dust detections to direct imaging of planets. Debris disks have been shown to contain both small grains and larger, planetesimal sized objects similar to the Kuiper Belt of our Solar System (Wyatt 2008). Additionally, the dust seen in debris disks such as Vega requires the continual replenishment from larger bodies (Backman & Paresce 1993). Therefore, debris disks serve as the best targets for a study of the evolution of planetary systems, since they provide various environments across a multitude of ages (Zuckerman & Song 2004a).

Through examination of the connection between debris and planetesimals, Matthews et al. (2014) summarizes interesting trends between a disk and other physical parameters including multiplicity, metallicity, and stellar rotation. In particular, Maldonado et al. (2012) and Marshall et al. (2014) searched for a trend between debris disks and planets given their direct connection. Maldonado et al. reported that the presence of a planet dictated the metallicity, in agreement with Fischer & Valenti (2005) who pointed to a positive correlation between higher metallicity stars and planet host stars. Marshall et al. (2014) whose sample consisted of known exoplanet host stars, was limited by a small sample and unable to make any strong predictions. Rodriguez & Zuckerman (2012) approached the topic of multiplicity to better understand the nature of dust around multiple systems and with a sample of 28 sources they found a hint of multiple stars having more rapid disk dispersal rate. Further, Mizusawa et al. (2012) and references therein describe connections between the debris disks and the rotation of the host star. They found that rapid rotators have the highest percentage of excess but point out the necessity for better ages and metallicity measurements for many of their stars. These interesting results are limited by their small samples, thus, heralding the need for a larger sample in order for confirmation or refutation regarding the theories of star-disk-planet interactions.

Our creation of a large, comprehensive census of debris disks, began with the selection of over 200 publications which identify over 1200 infrared excess candidate stars. These studies used either pointed observations from telescopes such as *Spitzer* (Bryden et al. 2006; Chen et al. 2006) or all-sky surveys such as IRAS or WISE (Rhee et al. 2007; Patel et al. 2014) and many further restricted their samples based on spectral type (Smith & Wyatt 2010; Avenhaus et al. 2012), reliable distance using trigonometric parallax from the Hipparcos catalog (Wu et al. 2013), or cluster membership in order to invoke a reliable age estimate (Carpenter et al. 2009; Zuckerman et al. 2011) to name a few. To ensure the largest sample and include the most recent all-sky survey, AllWISE, we also cross-correlated the 2 million objects in the Tycho-2 catalog with the $\sim$ 750 million objects in the AllWISE catalog using a similar technique of Schneider et al. (2013). Through meticulous examinations of SEDs and AllWISE images we produced the most reliable, comprehensive list of 1700 infrared (IR, hereafter) excess stars to date (see experimental design a detailed procedure for selecting new IR excess stars). We created priority assignments based on fractional dust luminosity (defined as $\tau \equiv L_{IR}/L_*$), distance, evolutionary status and brightness such that this multi-facility project emphasizes the capability of each proposed instrument. Restricting the sample of 1700 stars to be within 200 pc and without previous archival optical spectra available yielded a sample of 808 stars. Following the incentive of obtaining age information for these targets, the proposed sample was restricted to F type or later stars and a brightness cut of V$>$ 9 mag was applied since MMT can observe the faintest objects: 225 stars remained. Finally, we propose to obtain spectra for 92 northern hemisphere IR excess stars which are observable from MMT. Figure 1 offers a detailed picture of our high fidelity IR excess stars.

Constraining the age of a star is known to be the most challenging piece of information to attain and yet it is the most necessary for an evolutionary analysis. We will use the age-dating schema of Zuckerman & Song (2004b; displayed in their Figures 3 and 5) by measuring the equivalent width (EW) of age indicators such as Li 6708Å and Hα (6563Å). Zuckerman & Song (2004b) compared the measured lines to a range of cluster ages for solar type stars to generate the best estimate of individual stellar ages. In addition, we propose to measure the EWs of key iron lines to produce a metallicity measurement for each star. We will also use line measurements of the FWHM from the observed spectra and arc lamp to compare the broadening due to rotation of the star and the intrinsic broadening of the instrument. In this way, we will deduce a rotational velocity measurement. Since this is a multi-facility project, the measurements performed on the stars not proposed here should be similar because we are seeking comparable high resolution optical spectroscopy.

Many studies performed similar searches for IR excess to our Tycho-2 and AllWISE cross-correlation although any follow-up stellar information has yet to be assembled. Specifically, Patel et al. (2014) produced a sample of 220 stars with infrared excess in WISE within 75 pc of the Earth and Wu et al. (2013) found 141 nearby *Hipparcos* stars with WISE excess at 22μm, but were unable to advance understanding of the star-disk evolution with only dust information. Chen et al. (2014) marginally investigated the evolution of dust around a collection of stars limited by the requirement for available infrared spectroscopy from *Spitzer* IRS. With the release of the AllWISE all-sky mid-infrared mission and the advent of new infrared missions still a few years in the future, this study is a last chance to fully characterize an important sample of IR excess stars. The goal of characterizing this large debris disk population by obtaining stellar and age information would triple the number of well-studied disks and enable more realistic interpretations of the correlations discussed above as well as provide a better picture of the temporal evolution of dust. In particular, we will consider a dustiness-metallicity correlation similar to the planet-metallicity correlation (Fischer & Valenti 2005) as well as confirm or contradict the possible relationship between stellar rotation and dustiness. In full, this project will comprise 1700 infrared excess stars of all spectral types, ages, metallicities, and dustiness in order to complete the census of nearby debris disk stars.

We have already begun the optical spectroscopy follow-up of a number of northern hemisphere targets displaying high fractional dust luminosity using the Lick Hamilton spectrograph. We divided the southern targets into bright or faint groups: the brightest targets will be pursued by the CHIRON instrument on the SMARTS 1.5m telescope and the PUCHEROS instrument on the 0.5m telescope at La Silla Observatory while the others require a larger telescope (e.g. du Pont 2.5m telescope). This proposal for the MMT Hectochelle optical spectra focuses on the faintest infrared excess stars from our census. Aquiring age, metallicity and rotational information for the proposed sample of stars will build upon previous studies and enhance candidate exoplanet searches and star-disk relationships. The spectroscopic information obtained in this proposal will be included in the dissertation of Tara Cotten which will offer a complete census of nearby debris disks with the intent of constraining the criteria for a bone-fide debris disk star and offering future exoplanet survey targets.

References

Aumann, H. H. et al., 1984, AJ , 278, 23.
Avenhaus, H. et al., 2012, A&A , 548, 105.
Backman & Paresce, 1993, *Protostars and Planets III*, 1253.
Bryden, G. et al., 2006, ApJ , 636, 1098.
Carpenter, J. M. et al, 2009, ApJ , 705, 1646.
Chen, C. H. et al., 2006, ApJS , 166, 351.
Chen, C. H. et al., 2014, ApJS , 211, 25.
Fischer, D. A & Valenti, J., 2005, ApJ , 622, 1102.
Kennedy, G. M. et al., 2013, MNRAS , 433, 2334.
Kenyon, S.J. & Bromley, B.C,. 2004, ApJ , 602, L133.
Maldonado, J. et al., 2012, A&A , 541, 40.
Marshall J. P. et al., 2014, A&A , 565, 15.
Matthews, B. C. et al., 2014, arXiv:1401.0743.
Mizusawa, T. et al., 2012, AJ , 144, 135.
Patel, Rahul I. et al., 2014, ApJS , 212, 10.
Rhee, J. H. et al., 2007, ApJ , 660, 1556.
Rodriguez, D. R. et al., 2012, ApJ , 745, 147.
Schneider, A. et al., 2013, ApJ , 777, 78.
Smith, R. et al., 2010, A&A , 515 95.
Sousa, S. G. et al., 2007, A&A , 469, 783.
Wu, C.-J. et al., 2013, ApJS , 208, 29.
Wyatt, Mark C., 2008, ARA&A , 46, 339.
Zuckerman, B. & Song, I., 2004a, ApJ , 603, 738.
Zuckerman, B. & Song, I., 2004b, ARA&A , 42, 685.
Zuckerman, B. et al., 2011, ApJ , 732, 61.

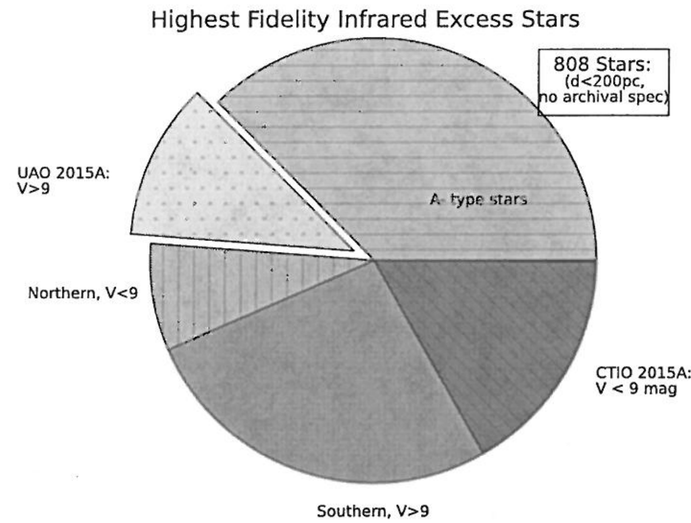

Figure 1: Pie chart demonstrating the full census of nearby, high fidelity infrared excess stars: 808 nearby stars without archival high resolution optical spectroscopy. The dotted pie slice contains stars that were selected based on brightness (visual magnitude > 9) and then further by northern declination for MMT Hectochelle during 2015A. The slice with diagonal lines contains bright stars recently proposed through NOAO for the SMARTS 1.5m observations. The remaining sections are the observations that will be performed using various instruments according to their brightness criteria described in the scientific justification section. The portion of the chart that is striped horizontally contains only A-type stars which will not benefit from optical spectra but are still relevant to our census and characterization.

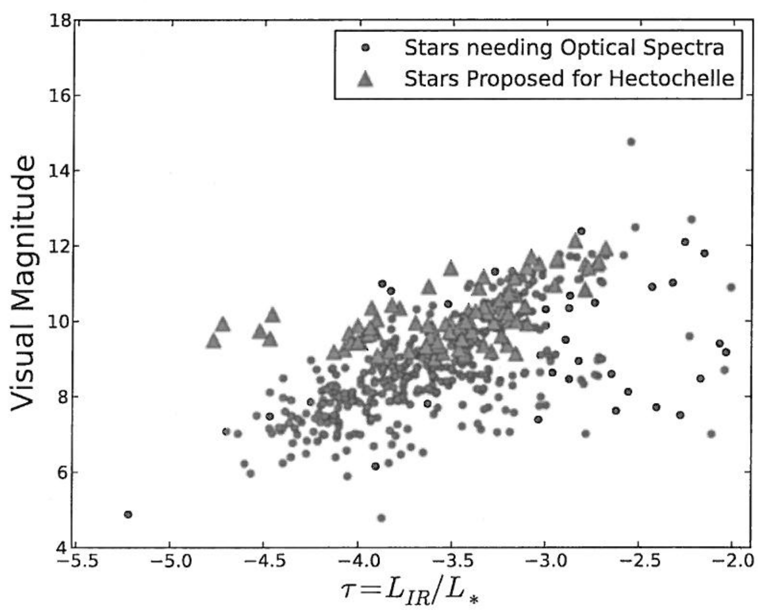

Figure 2: Demonstration of the range of fractional dust luminosities and optical brightness of the sample provided in this proposal. Targets included in this proposal have been selected with V> 9 mag and display a range of fractional dust luminosities. The remainder of stars with V>9 mag not included in this proposal lie in the southern hemisphere.

Experimental Design & Technical Description *Describe your overall observational program. How will these observations contribute toward the accomplishment of the goals outlined in the science justification? If you've requested long-term status, justify why this is necessary for successful completion of the science. **(up to one page)***

We propose to obtain high resolution optical spectrometry using Hectochelle for a distinct sample of high fidelity infrared excess stars lacking stellar information. Initially, we collected $\sim$ 1200 stars published as infrared excess stars from almost 200 journal articles. Since each study used a different excess criteria we then confirmed infrared excess using our automated SED fitting tool and screened each star using the four AllWISE images. This secondary check of claimed infrared excess yielded a sample of 910 stars. To generate a complete survey of stars with infrared excess, we cross-correlated a nearby Tycho-2 sample using proper motion as a proxy for distance ($\mu \gtrsim$ 25 mas yr^{-1}) with the entire AllWISE catalog ($\sim$ 747 million objects). This sample was subject to having reliable AllWISE measurements in all four passbands and main sequence colors. Using the fully automated SED fitting tool, we selected 1030 stars with infrared excess at either the 12μm or 22μm passband and examined the AllWISE images to exclude all false positive detections such as a nearby contaminating source or spurious AllWISE photometry. The combination of these two searches produced a list of 1700 high fidelity infrared excess sources, excluding the number of duplicate stars expected from combining our two searches and also excluding stars demonstrating excess indicative of an early stage of star formation (i.e. T-Tauri). The remaining target selection cuts relevant for this proposal ensure a nearby (d$<$ 200 pc), faint (V > 9 mag), sample of F through M type stars without available optical spectra which would benefit from observations using the MMT Hectochelle instrument: this produced 225 objects. We narrowed the target list to 92 stars based on the observable northern hemisphere range available during the 2015A semester and targets not previously proposed to other instruments. We request 2 nights to commence the observations of these stars.

Using the Hectochelle instrument, we plan to obtain optical spectra at a resolution of R$\sim$ 30,000. To effectively obtain stellar parameters, we need to measure EWs with an uncertainty as small as $\pm$ 10 mÅ. Due to the size of the telescope, we have limited the sample by selecting those stars with V >9 mag which would require extremely long exposure times on a smaller telescope. An estimate of on source time for a typical object (V=12 mag) in the target sample would be up to an hour under the condition of achieving a S/N > 50. In addition to the expected overhead times which include slew, calibration exposures, and readout time, we predict the faintest object can be observed in just over an hour. In total, we request 6 nights to complete the MMT Hectochelle observations taking into account the possibility for bad weather.

Age diagnostics performed on each infrared excess star in our high fidelity sample will produce the largest scale study of the temporal evolution of disks. The sample proposed here completes the sample of the faintest northern hemisphere infrared excess stars which lack accurate stellar properties necessary for a full characterization. By obtaining the EW of Li 6708Å and Hα we propose to obtain age information regarding these debris disk systems and better constrain the evolution of circumstellar material surrounding these stars. We will use the filter centered on 6707Å for these detections. Given the strength of the spectral features, we will measure EWs using IRAF and the program ARES (Sousa et al. 2007) such that a metallicity and various abundances can be interpreted from key iron line measurements. We expect to use the metallicity measurements of this large sample to further confirm or reject the correlation between high metallicity stars and dusty debris disks. Finally, $v \sin i$ will be measured through analysis of the spectral lines using IRAF to measure the broadening produced by the rotational velocity compared to instrumental broadening measured through the calibration (ThAr) lamp and to search for doublets produced by multiplicity.

In addition to the spectra obtained in this proposal, we will complete the characterization of these debris disk stars by simultaneously obtaining spectra through collaborative efforts using the du Pont telescope, CTIO SMARTS 1.5m telescope, and the La Silla Observatory 50cm telescope. A simultaneous and complimentary proposal has also been submitted during this semester to observe bright infrared excess stars using the CHIRON instrument on the SMARTS 1.5m telescope through NOAO. The debris disks presented in this proposal will finalize observations for the remaining northern hemisphere sample, thus contributing significantly to the goal of accumulating a comprehensive picture of debris disks.

Summary of Time Requested and Awarded *The TAC needs to understand the scope of this project — (1) tell us how many UAO nights you've already had for this project, how many you request this time, and (a good guess of) how many you need to complete the project; (2) if a substantial amount of observing for this project comes from non-UAO telescopes, tell us about that observing, and how the UAO part fits in; (3) if you are collaborating with people who have telescopes, especially if you are part of a large collaboration, tell us who is leading the project, and how UAO time and your participation fit in.* ***(up to one page)***

1 - UAO Telescope Time
This project has not sought UAO time prior to this proposal. We estimate 6 nights total of observing to acquire high resolution optical spectrometry of 92 high fidelity infrared excess stars should be sufficient. The proposed number of observation nights includes a 30% bad weather estimate. In the current proposal, we request 2 nights to initiate the project.

2 - non-UAO Telescope Time
A related proposal to NOAO was recently submitted to obtain optical spectroscopy using CHIRON on CTIO SMARTS 1.5m telescope. The objects proposed were southern hemisphere targets with visual magnitudes brighter than 9. A total of 134 stars were included which is 27% of our final sample still lacking follow-up optical spectroscopy. Currently, our collaborators through the University of California system are pursuing roughly 63 additional bright northern hemisphere infrared excess stars (12% of our final sample lacking optical spectra). In addition, through Chilean collaboration, we intend to obtain spectra for the remaining southern hemisphere targets (43% of our final sample which lacks optical spectra) using the du Pont 2.5m telescope in parallel with the La Silla Observatory 50cm telescope. Targets will be partitioned based on brightness and availability of time on each instrument in order to ensure proper use of these instruments to their full capabilities. In addition to these observations, a total of 690 stars with archival optical spectroscopic data using instruments such as FEROS, UVES, HARPS, ELODIE, SOPHIE, and Hamilton will be examined in order to measure the stellar parameters discussed above. The UAO observations obtained in this proposal (the remaining $\sim$18% of the sample needing optical spectroscopy) will complete the northern hemisphere census of nearby debris disk stars.

3 - Collaborations This project is being led by Tara Cotten, graduate student of I. Song, as part of her dissertation project. J. Patience and her students K. Ward-Duong, A. Rajan, and J.Bulger are collaborators in this study to aid in the characterization of a large group of infrared excess stars. P. Rojo, M. Jones, and L. Vanzi are in collaboration through the use of the PUCHEROS instrument at the La Silla Observatory. The recent use of this instrument has proved capable of acquiring echelle optical spectroscopy for the brightest objects on this small telescope. This collaborative effort will also aid in the use of the du Pont telescope for our southern hemisphere fainter objects. Finally, C. Melis and B. Zuckerman have been participating in this project and observing northern hemisphere stars when available. The amalgamation of these observations as well as archival data will be summarized in a paper written by T. Cotten and collaborators following the completion of these observations. Students working under the supervision of Patience and Song have a number of joint publications, and the proposed study would lead to more collaborative papers for the students.

Previous Use of Steward Facilities *List **all** allocations of telescope time for the present project and allocations for other projects on facilities available through UAO during the past 2 years, together with the current status of the data (cite publications where appropriate). Mark those allocations related to the present proposal (i.e, precede text with* `\related` *command). **(up to one page)***

Companion Search - Allocations and Papers:
Magellan: 2013B - FourStar search for companions to GPI targets - *PI: Patience (2 nights)* - not useful
MMT: 2013A-UAO-S2 - ARIES A-star companion follow-up - *PI: De Rosa (4 half-nights)* - 50% useful, **2013B-UAO-S2 - ARIES A-star companion follow-up** - *PI: De Rosa (1 night)* - 75% useful, **2013C-UAO-S10 - ARIES A-star companion follow-up** - *PI: De Rosa (2 nights)* - 75% useful
• **Patience et al. 2014**, *The TBOSS (Taurus Boundary of Stellar/Substellar) Survey of Disk Properties*, 2014 IAUS, 299, 224 - Sample for follow-up projects, including LBT proposal
• **Bulger et al. 2014**, *The Taurus Boundary of Stellar/Substellar (TBOSS) Survey I: far-IR disk emission measured with Herschel*, A&A accepted - Sample for follow-up projects, including LBT proposal
• **Ward-Duong et al. 2014**, *A Direct Imaging Study to Search for and to Characterize Planetary Mass Companions*, 2014 IAUS, 299, 74 - Includes MMT data
• **Ward-Duong et al. 2014**, *The M-dwarfs in Multiples (MinMs) survey - I. Stellar multiplicity among low-mass stars within 15 pc*, MNRAS, submitted - Includes MMT data
• **Skemer et al. 2014** *LEECH: A 100 Night Exoplanet Imaging Survey at the LBT*, 2014 IAUS, 299, 70

Companion Characterization - Allocations and Papers:
LBT: 2013A - Thermal-IR measurements of substellar companions: - *PI: Patience (1 night)* - 50% useful
MMT: 2013C-UAO-S11 - ARIES Substellar spectroscopic characterization - *PI: Ward-Duong (2 nights)* - 0% useful, **2014A-UAO-S1 - ARIES Substellar spectroscopic characterization** - *PI: De Rosa (4 nights)* - 25% useful
• **De Rosa et al. 2014**, *Debris Disks and Multiplicity within the 75pc Volume-limited A-Star (VAST) Survey* 2014 IAUS, 299, 334 - Includes MMT data
• **De Rosa et al. 2014**, *The VAST survey - IV. A wide brown dwarf companion to the A3V star ζ Delphini*, MNRAS, accepted - Characterization most similar to MMT proposal, includes MMT data
• **De Rosa et al. 2014**, *The VAST survey - V. Confirmation observations of low-mass companions to nearby A-type stars*, MNRAS - Analysis of MMT data complete, paper in progress
• **Maire et al. 2014**, *The LEECH Exoplanet Imaging Survey. Further constraints on the planet architecture HR 8799 system*, A&A, in prep

---

Brown dwarf Atmosphere Monitoring - Allocations and Papers:
MMT: 2012A-UAO-S3 - SWIRC Brown dwarf variability monitoring - *PI: Patience (2 nights)* - 75% useful, **2013A-UAO-S99 - SWIRC Brown dwarf variability monitoring** - *PI: Rajan (2 nights)* - 0% useful.
• **Rajan et al. 2014**, *Searching for Photometric Variability across the L, T & Y Dwarf Sequence*, 2014 IAUS, 299, 301 - Includes MMT data
• **Wilson, Rajan, and Patience 2014**, *The Brown-dwarf Atmosphere Monitoring (BAM) Project I: Multi-epoch monitoring of extremely cool brown dwarfs*, A&A, 566, 111 - The paper established the code and observing practices for all current and future BAM projects, including the MMT proposal
• **Rajan et al. 2014**, *The Brown-dwarf Atmosphere Monitoring (BAM) Project II: Multi-epoch monitoring of extremely cool brown dwarfs*, MNRAS, submitted - Includes MMT data
• **Burgasser et al. 2014**, *Splinter Session on Cool Cloudy Atmospheres: Theory and Observations*, Cool Stars 18, submitted - Includes MMT data

From: Inseok Song <song@uga.edu>
Subject: Support for student on MMT proposal
Date: 30 September 2014 18:38:44 MST
To: Jenny Patience <ast111asu@gmail.com>
Cc: tara@physast.uga.edu> <tara@physast.uga.edu

Dear Jenny,

This email message is to attest my support for my student Tara for her MMT time application. The MMT proposal with the title, "Evolutionary Analysis of Nearby Debris Disks", is germanely related to Tara's dissertation project. She is making a good progress for a timely completion of this multi-facility census of debris disks.

Best,

Inseok

Table 1: Target List

#	Object	RA	Dec	mag
1	HD 236394	00:23:23.81	+58:14:01.22	V=9.00
2	HIP 1866	00:23:38.02	-03:45:49.15	V=10.89
3	BD+67 34	00:25:12.14	+68:48:26.65	V= 9.20
4	TYC4015-206-1	00:33:57.70	+61:26:33.76	V= 9.93
5	HD 232234	00:37:54.76	+55:18:01.35	V= 9.20
6	HD 236551	00:50:59.57	+59:41:35.92	V= 9.83
7	BD+62 204	01:07:35.50	+63:21:11.40	V= 9.73
8	TYC4038-493-1	01:24:35.32	+65:18:30.83	V= 9.92
9	HD 13172	02:12:00.20	+69:30:04.54	V= 9.16
10	TYC2838-2350-1	02:17:17.95	+41:55:00.32	V= 11.52
11	BD+45 598	02:21:13.13	+46:00:06.72	V= 9.09
12	HIP 11157	02:23:32.32	+19:37:55.49	V= 9.04
13	AG Tri	02:27:29.33	+30:58:23.84	V= 10.22
14	TYC4313-986-1	03:10:52.60	+68:02:15.99	V= 9.80
15	V459 Per	03:21:58.64	+49:12:53.30	V= 9.21
16	BD+50 784	03:33:58.95	+50:52:55.81	V= 9.95
17	BD+26 592	03:39:53.73	+26:43:00.68	V= 10.35
18	HIP 17125	03:40:03.10	+27:44:25.37	V= 9.62
19	HIP 17245	03:41:36.18	+25:37:09.08	V= 10.17
20	HIP 17316	03:42:24.01	+21:28:24.15	V= 9.83
21	HIP 17317	03:42:24.04	+22:25:15.68	V= 10.43
22	HD 23061	03:42:55.13	+24:29:34.58	V= 9.53
23	2MASS J03445639+2425574	03:44:56.41	+24:25:56.89	V= 10.38
24	TYC 1256-516-1	03:45:01.68	+19:33:33.26	V= 9.44
25	BD+21 516	03:45:09.89	+21:42:16.09	V= 10.04
26	HD 23513	03:46:40.01	+23:06:36.70	V= 9.43
27	HD 23935	03:49:52.93	+25:38:50.40	V= 9.65
28	HD 23975	03:50:17.69	+25:22:45.99	V= 9.67
29	HD 24086	03:51:06.35	+25:35:40.46	V= 9.18
30	HD 24302	03:52:53.49	+24:42:56.17	V= 9.50
31	HD 24463	03:54:21.60	+24:04:31.97	V= 9.7
32	HIP 18544	03:58:01.71	+20:40:36.00	V= 9.43
33	HD 232871	04:01:36.58	+50:43:40.18	V= 9.61
34	HIP 18955	04:03:44.18	+22:56:38.96	V= 9.74
35	HD 26133	04:07:50.53	-07:56:25.30	V= 9.08
36	HD 28356	04:28:32.73	+06:05:52.11	V= 9.07
37	BD+46 894	04:32:32.48	+47:11:26.62	V= 9.96
38	2MASS J04343128+1722201	04:34:31.30	+17:22:19.91	V= 15.79
39	HIP 21983	04:43:31.81	+11:10:00.40	V= 10.346
40	HD 280124	04:46:38.61	+35:47:13.13	V= 10.69
41	CCDM J05053+2740AB	05:05:15.40	+27:39:36.45	V= 10.39
42	HD 242807	05:20:38.54	+07:58:49.07	V= 9.72
43	HIP 27429	05:48:29.74	+52:32:37.86	V= 9.25
44	TYC137-627-1	06:29:57.84	+03:06:06.54	V= 9.57

Table 2: Target List Continued

#	Object	RA	Dec	mag
45	TYC2940-236-1	06:36:54.32	+44:26:55.92	V= 11.43
46	HD 237660	08:01:25.51	+56:18:30.87	V= 9.73
47	TYC4873-1606-1	08:59:34.18	-05:34:05.37	V= 10.48
48	HIP 44295	09:01:17.37	+15:15:53.34	V= 9.726
49	BD+39 2350	10:27:57.42	+39:00:07.47	V= 9.36
50	BD-02 3215	10:46:18.33	-03:01:05.84	V= 10.96
51	HIP 59893	12:17:02.77	-04:15:04.08	V= 10.18
52	TYC3460-2402-1	13:18:04.38	+46:43:08.18	V= 10.72
53	BD+19 2735	13:58:13.52	+19:17:11.59	V= 9.36
54	HIP 68755	14:04:22.97	-03:28:04.66	V= 10.45
55	HIP 72387	14:48:01.37	+38:27:57.09	V= 9.87
56	TYC2558-467-1	14:53:05.99	+33:58:52.77	V= 10.27
57	TYC2558-422-1	14:53:15.94	+33:55:31.75	V= 11.14
58	TYC2572-551-1	15:55:16.64	+30:46:28.42	V= 12.13
59	TYC4425-1270-1	16:09:46.88	+73:55:41.87	V= 10.88
60	TYC3878-1813-1	16:27:28.93	+53:55:52.53	V= 11.18
61	HIP 80781	16:29:39.89	+62:05:12.94	V= 10.92
62	HD 149941	16:37:35.40	+07:17:03.40	V= 9.22
63	TYC1530-202-1	16:59:07.93	+20:01:46.14	V= 9.99
64	HD 155906	17:14:26.41	-00:42:28.95	V= 9.67
65	BD+85 286	17:25:07.45	+85:06:55.90	V= 9.58
66	TYC5099-369-1	18:26:14.46	-01:32:50.84	V= 10.99
67	TYC3531-1441-1	18:36:37.54	+48:26:10.19	V= 11.70
68	HD 338031	19:14:14.51	+24:45:57.86	V= 10.23
69	BD+62 1699	19:14:19.85	+62:29:56.34	V= 10.00
70	HD 231133	19:19:02.25	+16:16:24.81	V= 9.33
71	HD 338425	19:26:53.30	+24:31:50.04	V= 10.21
72	HD 189024	19:58:11.26	-04:21:19.79	V= 9.11
73	HD 356704	20:05:56.29	+12:41:07.82	V= 9.46
74	HD 228230	20:11:58.93	+34:06:10.93	V= 9.14
75	TYC3574-2022-1	20:38:11.62	+46:49:04.53	V= 9.86
76	TYC4246-319-1	20:43:50.96	+60:28:01.37	V= 9.89
77	TYC3959-578-1	20:50:50.11	+57:28:20.16	V= 10.39
78	TYC2184-820-1	21:00:31.65	+28:29:21.32	V= 11.50
79	TYC1112-317-1	21:06:23.95	+12:51:45.52	V= 10.95
80	BD+62 1895	21:07:16.81	+62:53:56.09	V= 9.09
81	BD+57 2298	21:12:21.66	+57:49:08.11	V= 10.40
82	TYC4462-2701-1	21:43:33.77	+68:38:09.73	V= 9.99
83	HD 235655	21:54:39.51	+52:02:35.19	V= 9.21
84	ADS 15617 AB	22:06:01.10	-02:03:44.25	V= 9.73
85	TYC3208-881-1	22:24:14.97	+42:28:08.16	V= 10.27
86	TYC3990-439-1	22:25:09.07	+57:42:41.08	V= 11.41
87	BD+67 1451	22:34:20.70	+68:30:14.20	V= 9.13
88	TYC3226-1310-1	22:43:17.42	+44:41:11.23	V= 11.41
89	HD 215294	22:44:14.02	309:01:23.97	V= 9.04
90	HIP 115819	23:27:48.70	+04:51:25.88	V= 10.30
91	HD 222301	23:38:33.12	+76:49:01.86	V= 9.26
92	HIP 117779	23:53:08.53	+29:01:05.27	V= 9.93