OBSERVING REQUEST
University of Arizona Observatories

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

ACCESS: Probing Exoplanet Atmospheres from the Ground

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David Osip (Carnegie Institution for Science)

Abstract of Scientific Justification

Transmission spectroscopy of transiting planets is a powerful probe of atmospheric composition and structure. Until now most efforts have focused on the ultraviolet, near-infrared, and mid-infrared windows, primarily relying on space-based platforms. Recently, it has been demonstrated that low-resolution spectroscopy of planets even as small as super-Earths is feasible with large ground-based facilities if the systematics are corrected. Motivated by the need for optical spectra of transiting exoplanets we launched an ambitious joint Arizona-CfA-Católica survey, to which Carnegie has also joined. The first observations have been successful and yielded data; we now propose to continue the survey to observe eight very exciting and different transiting planets, sampling masses from sub-Neptune to super-Jupiter scales. We aim to characterize the continuum slope of the transmission spectra and detect atomic and molecular absorption features in order to distinguish between proposed atmospheric models. These observations are part of our ACCESS survey, which is set to become the largest exoplanet spectroscopic survey yet and will construct a comprehensive database of exoplanet optical transmission spectra. This unique database will allow us to: 1) test models of hot Jupiters with and without stratospheres; 2) constrain mean molecular masses of clear atmospheres, and 3) examine trends associated with the presence of upper atmospheric hazes.
This is a coordinated multi-institutional proposal; complementary proposals led by CoIs López-Morales, Jordán, and Osip have been submitted for the Harvard/SAO, Chilean, and Carnegie TACs.

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	MAG1	f/11	IMACS f/2			3	bright	Jan–Jul	Jan–Jul	yes	yes

Scheduling constraints and unusable dates *(up to 4 lines)*: Our observations need to take place in nights when transits occur. At the end of the proposal we provide a list of transit dates, times, and priorities, which have also been communicated to the TAC chair.

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	CoRoT-11b	06:48:19	+05:56:16	V=12.9 mag, P=2.99 d
2	GJ 3470b	07:59:06	+15:23:30	V=12.3 mag, P=3.33 d
3	HAT-P-26b	14:12:37	+04:03:36	V=11.7 mag, P=4.23 d
4	WASP-16b	14:18:44	-20:16:32	V=11.3 mag, P=3.12 d
5	WASP-17b	15:59:51	-28:03:42	V=11.6 mag, P=3.74 d
6	WASP-39b	14:29:18	-03:26:40	V=12.1 mag, P=4.06 d
7	WASP-43b	10:19:38	-09:48:23	V=12.4 mag, P=0.81 d
8	WASP-103b	16:37:16	-07:11:00	V=12.0 mag, P=0.93 d

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
Benjamin Rackham	Dániel Apai		no	yes

Scientific Justification

Transmission spectra of extrasolar transiting planets have proven to be powerful probes of their atmospheres, propelling exoplanet studies to an exciting new era (e.g. Charbonneau+02, Bean+11, Fraine+14). The observed transit radius of a planet at a given wavelength ($R_p(\lambda)$) depends on the combination of the atmospheric scale height ($h = \frac{k_B T}{m_H \times \mu_m g}$) and the wavelength-dependent mean molecular absorption cross section ($\sigma_M(\lambda)$), where k_B is the Boltzmann constant, T is the temperature, m_H and μ_m are the mass of a hydrogen atom and the mean molecular weight, and g is the surface gravity. Measurements of the transit depth ($\Delta f(\lambda) = \frac{R_p(\lambda)^2}{R_s^2}$) at *multiple* wavelengths thus directly probe the molecular opacities and the atmospheric scale height, constraining both the physical and chemical structures of exoplanet atmospheres.

Due to their stability, space telescopes provide ideal platforms for transmission spectroscopy in the ultraviolet (UV), near-infrared (NIR), and mid-infrared (MIR). Spitzer/IRAC observations of hot Jupiters detected evidence for H_2O, CO, and CH_4 and argued for non-equilibrium chemistry (e.g. Knutson+11). HST near-infrared transmission spectroscopy has been successful in probing molecular features in hot Jupiters (Deming+13; Knutson+14a), hot Neptunes (Fraine+14), and super-Earths (Berta+12, Kreidberg+14, Knutson+14b). For example, Berta et al. (2012) and later Kreidberg et al. (2014) used HST/WFC3 to obtain a transmission spectrum of the transiting super-Earth GJ 1214b, probing wavelengths from 1.1 to 1.7 μm, and found a flat spectrum indicative of a high altitude cloud/haze layer. Using data from both HST/WFC3 and Spitzer/IRAC, Fraine et al. recently (2014) detected water absorption in the transmission spectrum of the hot Neptune HAT-P-11b, indicative of a clear, hydrogen-dominated atmosphere. Although space-based platforms continue to produce exciting UV, optical, and near-infrared spectra, these instruments can only reach a small set of transiting planets and are often limited to planets around bright host stars.

The optical wavelength range provides access to prominent atomic lines (e.g. NaI, Hα, KI) and molecular bands, allowing the characterization of the composition and physical structure of atmospheres. At the same time the general continuum slope provides constraints on the presence and size of haze particles (e.g. Jordán+13, Pont+13) and/or thermal inversions (e.g. Fortney+08, Huitson+13). Additionally, ground-based optical platforms enable multiple observations of a transiting planet, which are essential for ensuring that instrumental systematics, observing conditions, and large starspots do not influence the observed transit depth.

Ground-based transit spectroscopy is already an exciting and important field, but its importance is set to increase dramatically given the launch of the Transiting Exoplanet Survey Satellite (TESS) planned for 2017. TESS will survey the entire sky for transiting planets around nearby stars *bright enough* to be studied in great detail, in contrast to the Kepler-discovered planets. TESS is expected to detect several thousand transiting planets with sizes down to 1 $R_\oplus$. *Most of the TESS-discovered planets will be characterized via ground-based transmission spectroscopy, making this technique extremely important for the near future.*

As of now, the few ground-based studies that present optical spectra of transiting planets demonstrate the feasibility of the approach, but only scratch the surface of the achievable science. For example, Bean et al. (2011) have used VLT/FORS to obtain a transmission spectrum of GJ 1214b covering 0.61–0.83 μm in 20 nm bins with a typical 1σ uncertainty of 0.12%, providing the first insights into its optical spectrum. Using Gemini/GMOS, Gibson et al. measured the transmission spectra of WASP-29b (2013a) and HAT-P-32b (2013b) in $\sim$ 14 nm bins spanning 515 to 720 nm and 520 to 930 nm with typical precisions of $\sim$ 1 and $\sim 2 \times 10^{-4}$ in transit depth, respectively. Non-detections of Na features in these spectra rule out clear atmospheres for both of these planets. Similarly, Stevenson et al. (2014) used Gemini/GMOS to probe the limb of WASP-12b from 0.7 to 1.0 μm, measuring planet-to-star radius ratios which, along with existing space-based measurements, show the complete transmission spectrum of this planet to be fit well by a simple Rayleigh scattering model.

The logical next step is to expand transmission spectroscopy not only to a larger sample of planets, but also to the entire optical atmospheric window between $\sim$0.4 μm to 0.8 μm to provide powerful new constraints on planetary atmospheres from hot Jupiters to super-Earths. We propose here to utilize the efficient IMACS spectrograph on the Magellan Baade telescope to achieve this goal. Similarly to the VLT, GTC, and Subaru, Magellan/IMACS is also capable of such detections (see *Experimental Setup*) and our recent observations are demonstrating this (Jordán+13; Espinoza, Rackham+14, in prep.; Rackham+14, in prep.; **Fig. 1**).

The Two Strategic Goals of the ACCESS Survey: 1) To establish the largest and most comprehensive library of transmission spectra for transiting exoplanets to date, ranging from inflated hot Jupiters through hot Neptunes to super-Earths. This will enable comparative studies of these atmospheres, an essential step for testing and further developing exoplanet atmosphere models. 2) To develop a leadership position in ground-based exoplanet transmission spectroscopy to play a key role in the characterization of transiting planets to be discovered by TESS, which is expected to be the next revolution in the field of transiting exoplanets. With time allocations through the four core partners (UA, CfA, Católica, & Carnegie), the survey can be carried out without imposing significant time pressure on any single TAC.

Immediate Science Goals: The goal of the proposed observations is to probe the continuum slope and molecular and atomic absorption features in transmission spectra of eight unexplored transiting planets spanning sub-Neptune through super-Jupiter scales. Our targets range in radii between 4-23 $R_\oplus$ and have equilibrium temperatures between 900-2200 K (**Fig. 2**), thereby sampling a wide range of atmospheric conditions. With each of these targets, we aim to search for the Rayleigh scattering slope and the strong molecular and atomic absorption features predicted in their transmission spectra. The strength of the absorption features will constrain the atmospheric scale heights, and the continuum increase in the blue optical due to Rayleigh scattering will provide estimates of the atmospheric mean molecular masses (cf. Benneke & Seager 2012). These measurements will also be sensitive to absorption by TiO/VO in these atmospheres, therefore indicating the presence or lack of thermal inversions (cf. Fortney+08, Huitson+13) and allowing us to further test the proposed relationship between stellar activity and temperature inversions (Knutson+10). Below, we describe in more detail two representative planets in our sample and the achievable science they present.

Our lowest-mass target this semester is **GJ 3470b**, a hot and low-density Neptune-sized exoplanet (M_p=14 $M_\oplus$, $\rho_p = 1.2 \pm 0.3$ g cm^{-3}, Biddle+14). Orbiting a relatively bright (V=12.3), nearby (30.7 pc) M-dwarf host star, this low-mass target is well-suited for in-depth characterization but mostly unexplored. Existing photometric observations in the optical (Fukui+13, Nascimbeni+13, Biddle+14) show a pronounced increase in the transit radius toward the blue optical, which points to scattering in a cloud-free, H-dominated atmosphere, making this the least massive known exoplanet with a clear atmosphere amenable to transmission spectroscopy. We will clarify the nature of this exciting result at higher resolution by simultaneously probing the transmission spectrum of GJ 3740b across the optical, and use the measured scattering slope to estimate its atmospheric mean molecular mass.

On the high-mass end of our sample, **WASP-17b** is typical of our proposed targets. On a 3.7-day orbit around an F6 dwarf star, WASP-17b has a very low bulk density (M_p = 0.49 M_J, R_p=1.74 R_J, ρ=0.12 g cm^{-3}, Anderson+10) owing to its large radius, which is $\sim$0.4 R_J larger than predicted by theoretical models of highly irradiated giant planets (e.g. Fortney+07). Its concomitant low surface gravity gives it one of the largest atmospheric scale heights of any known planet, which has been confirmed via narrow-band transit observations centered on the Na I D doublet (Wood+11, Zhou+12) and a detection of water at 1.4 μm with HST/WFC3 (Mandell+13). As with our other targets, WASP-17b is a therefore a prime candidate for in-depth characterization through transmission spectroscopy due to its large scale height, bright host star (V = 11.6), and large transit depth (1.7%).

While each of these planets are interesting on their own, they will also contribute to our ACCESS exoplanet spectral library which will enable detailed comparative modeling of exoplanet atmospheres.

References: Anderson+10 ApJ 709, 159; Bean+11 ApJ 743, 92; Benneke & Seager ApJ, 753, 100; Berta+12 ApJ 747, 35; Biddle+14 MNRAS 443, 1810; Charbonneau+02 ApJ 568, 377; Deming+13 ApJ 774, 95; Fortney+08 ApJ 678, 1419; Fortney+07 ApJ 659, 1661; Fraine+14 Nature 513, 526; Fukui+13 ApJ 770, 95; Gibson+13a MNRAS 428, 3680; Gibson+13b MNRAS 436, 2974; Huitson+13 MNRAS 434, 3252; Jordán+13 ApJ 778, 184; Knutson+14a arXiv:1403.4602; Knutson+14b Nature 505, 66; Knutson+11 ApJ 735, 27; Knutson+10 ApJ 720, 1569; Kreidberg+14 Nature 505, 69; Mandell+13 ApJ 779, 128; Morley+13 ApJ 775, 33; Nascimbeni+13 A&A 559, A32; Pont+13 MNRAS 432, 2917; Stevenson+14 AJ 147, 161; Teske+13 MNRAS 431, 1669; Wood+11 MNRAS 412, 2376; Zhou+12 MNRAS 426, 2483.

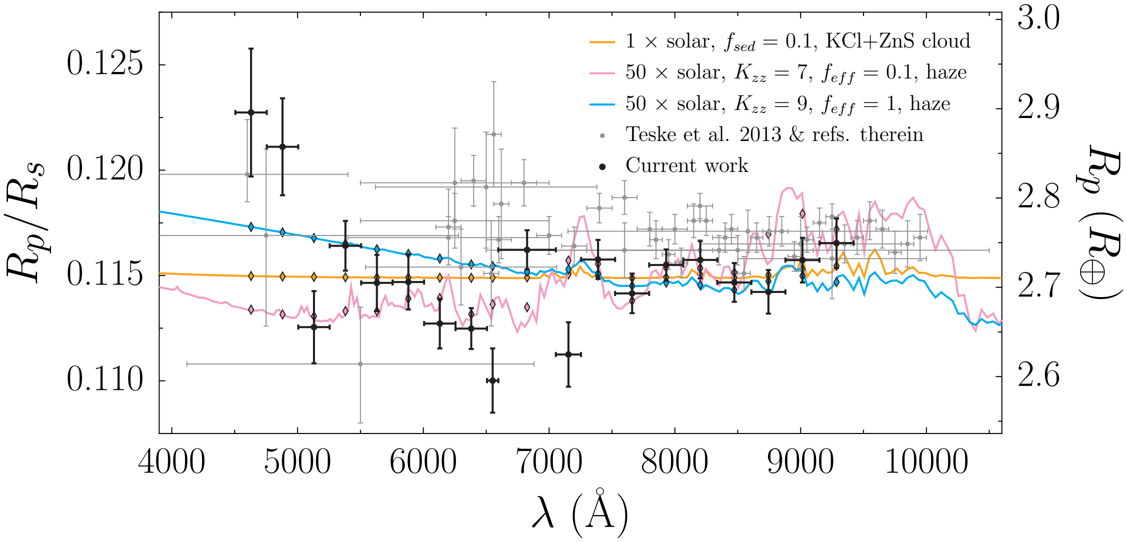

Figure 1 *Transmission spectrum of GJ 1214b from Magellan/IMACS (Rackham+14, in prep.).* This ACCESS dataset, combined from three transit observations, represents the first transmission spectrum of a super-Earth measured simultaneously across the entire optical spectrum. Building upon existing work on this well-studied target, our dataset provides: 1) the finest-resolution measurements for $\lambda < 6500$ Å, a region only studied previously with broadband photometric measurements; and, 2) the largest wavelength coverage for a self-consistent spectrum, measured simultaneously using the same observational, data reduction, and systematics removal procedures. The relative flatness of the spectrum in the red optical requires the presence of high-altitude equilibrium clouds or a photochemically produced haze layer (as in shown models from Morley+13). The apparent slope in the blue may point to scattering in the upper atmosphere above the opaque layer.

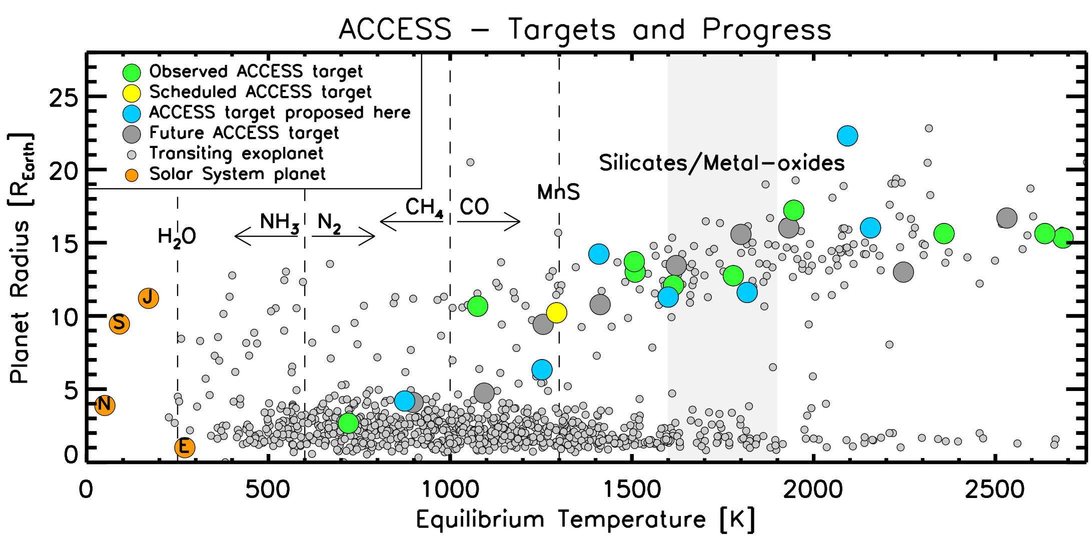

Figure 2 *Temperature-radius distribution of known exoplanets and four Solar System planets*. We show ACCESS targets for which we have already collected transmission spectra in green, those with allocated telescope time in yellow, 2015A targets in blue, and the remaining planets in our sample in dark gray. Vertical dashed lines give condensation temperatures for important atmospheric constituents. Our sample spans the known exoplanet population, probing a wide range of physical and chemical atmospheric conditions.

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)***

The ACCESS survey is establishing the largest exoplanet optical transmission spectral library. The goal of this proposal is to expand on the ACCESS survey by probing the transmission spectra of eight unexplored transiting exoplanets which sample sub-Neptune through super-Jupiter scales.

Targets: We selected our targets based on three criteria: First, each of these planets provides insights into exciting and timely questions on exoplanet atmospheres; second, they allow spectroscopic studies due to their relatively deep transits; and third, they sample well the Neptune-Jupiter mass range and allow for powerful comparative studies. We aim to refine the spectral continuum slopes of each of these planets to constrain the contribution of Rayleigh scattering to their transmission spectra, and thus the mean molecular masses of their atmospheres. We aim additionally to search for the strong atomic features of Na and K, which can be used to constrain atmospheric compositions and scale heights. With our larger and hotter targets spanning sub-Saturn to super-Jupiter scales, we will sample atmospheric conditions across a range of temperatures in which the condensation of silicates and metal oxides are predicted to strongly influence atmospheric conditions (see Fig. 2). The proposed measurements are sensitive to absorption by TiO/VO in the upper atmospheres of these planets, and will therefore constrain the presence or lack of atmospheric thermal inversions, shedding further light on the effects of stellar activity in hot, close-in gas giants.

Number of transits: Two or more transits are commonly used in the literature to ensure that systematics do not influence the measured transit depths. Repeated transit measurements also can be used to eliminate or reduce the effects of large starspots on the observed transit depth. However, observability windows for well-positioned transits generally only last a few months. Considering these factors, we aim to obtain at least two transit observations from each of our targets while they are observable in 2015A. With data from at least two transits, we will be able to proceed with publications quickly without having to wait until 2016A for confirmations of single-transit spectra. Of the 4.5 nights of Magellan time we have been awarded since 2013A, we have lost 1.5 nights to a combination of telescope problems and weather (see Previous Use section). Therefore, in order to ensure swift publication of results, we request three transits with Magellan/IMACS for each of our targets, except for WASP-17b, for which only two transits are observable (**Table 1**).

Instrumentation: *Magellan/IMACS* provides a $12'$ radius circular, unvignetted field of view, which we will combine with the 300 lines/mm grism ($\lambda_c = 0.665\mu$m) covering 0.365–0.974 μm with a resolution of R$\sim$1,080 or 1.34 Å/pixel. We will conduct the observations in 2×2 binning mode to decrease readout times to $\sim$ 30 seconds, reducing the duty cycle and boosting the efficiency of the observations. We will use multiple comparison stars in the fields to obtain simultaneous spectral series. The slits in our custom multi-slit masks will be $12''$ wide to eliminate slit losses and $22''$ long to thoroughly sample the sky background. We will fit and remove common systematics via a detrending procedure based upon a principal component analysis of the comparison star lightcurves. The data will be binned to $\sim$250 Å bins to increase the SNR. We followed a similar approach for our successful pathfinder WASP-6b study (Jordán+13), which reached a 0.8 mmag rms in 200 Å bins. Our observations of GJ 1214b show similar levels of precision in 250 Å bins (Rackham+14, in prep.; see Fig. 1).

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**)*

The ACCESS survey is a joint project with four equal partners; correspondingly, we request ∼1/4 of the time through each of the Arizona, CfA, Chilean, and Carnegie TACs. We note that the UA investigators are primarily responsible for the reduction, analysis, and publication for the data taken during UA time. The joint project allows us to carry out a uniquely ambitious exoplanet spectroscopy survey while combining personnel, expertise, and pipelines for data reduction.

Transit observations are differential measurements, requiring continuous data before, during, and after the event. Our experience shows that ∼1.5 hour baselines on both sides of the transit provide sufficient sampling of the instrumental and atmospheric conditions. Therefore, the observation start and ends times in Table 1 include the total duration of the transit and 1.5-hr pre- and post-baselines. The duration of the each transit listed in Table 1 is less than half of the usable dark time for the night in which it occurs. Therefore, we only request a half-night to observe any one of these transits. We have prioritized transits that fit into the first or second half of the night.

We propose to observe a total of 23 transits from eight planets this semester in the ACCESS survey, requiring a total of 11.5 nights of telescope time (23 half-nights). From the Arizona TAC we request 1/4 of the total required time, i.e. 6×0.5 nights selected from Table 1. Thus, we request the following time allocation through the Arizona TAC:

Magellan/Baade: 3 nights with IMACS.

In Table 1 we provide the UT dates and times of observable transits for our targets in 2015A, sorted by priority. Our highest priority targets are listed first in the table. Similarly, the order of the observable transits for each target reflect our priorities.

Past Time Requests: In 2013A we were awarded with 1 night with Baade/IMACS, 1 night with Clay/MIKE, and 1 night with MMT/Hectospec. We were awarded with 1 night with MMT/Hectospec in 2013B, 1 night with Magellan/IMACS in 2014A, and 1.5 nights with Magellan/IMACS in 2014B.

Future Time Requests: We are undertaking an ambitious multi-institutional survey to assemble the first consistent, comprehensive optical spectral library of transiting exoplanets. The goal of the survey is to allow quantitative comparative studies of the planetary atmospheres in a wavelength regime yet poorly explored and to enhance existing space-based UV and NIR/MIR data by completing the often missing optical wavelength range. We anticipate this to be a very productive survey with significant impact.

Our survey design requires that we collect data from at least 2 transits of each of our 28 targets, meaning that we will need to observe a total of 56 transits. Over the past four semesters, we have obtained Magellan/IMACS time for 20 successful observations of 11 targets (Fig. 2) through the UA, CfA, and Católica, with one transit obtained through MIT time. With the addition of Carnegie as a core survey partner, we aim to complete the survey by the end of 2015B, observing 8 targets in 2015A and 9 targets in 2015B.

When BINOSPEC becomes available on the MMT (likely 2015B), we will aim to extend our survey to northern planets with this instrument. Until then, we are focusing on southern targets using IMACS, an instrument which we have shown to be a powerful tool for ground-based transmission spectroscopy and one for which we already have a robust data reduction pipeline (cf. Jordán+13).

In total, our approach will require ∼2-3 night allocations per semester on Magellan and MMT from each of the partners (i.e., 4×3 Magellan nights from UA+CfA+Católica+Carnegie in 2015A and 2015B, and 2×2 MMT nights from UA+CfA in 2015B) – thus, the survey will not represent a major drain on any institute's resources, but will gradually build up a powerful and unique sample of transmission spectra.

Table 1. *Nights with observable transits in 2015A.* Each observable transit would only require a time allocation for half of the night. The order of the targets reflect our priorities, with the highest priority targets listed first. Similarly, the possible nights for each target are listed by priority.

Target	Transits Requested	Possible Night[1]	Obs. Start (UT)	Mid-transit (UT)	Obs. End (UT)
WASP-16b	3	May 23/24	00:31	02:58	05:26
		Apr 28/29	01:44	04:11	06:39
		Jun 17/18	23:19	01:47	04:14
		Apr 03/04	02:58	05:26	07:54
HAT-P-26b	3	Apr 16/17	02:26	05:09	07:53
		Mar 30/31	03:55	06:39	09:23
		May 20/21	23:28	02:12	04:55
GJ 3470b	3	Jan 01/02	03:16	05:34	07:53
		Jan 11/12	03:30	05:48	08:07
		Jan 21/22	03:44	06:03	08:21
WASP-43b	3	Feb 01/02	04:05	06:09	08:14
		Mar 26/27	01:06	03:11	05:15
		Mar 13/14	00:43	02:48	04:52
		Apr 17/18	00:16	02:20	04:25
		Feb 14/15	04:26	06:31	08:36
		Jan 19/20	03:43	05:48	07:53
		Feb 19/20	01:35	03:39	05:44
		May 09/10	23:26	01:31	03:36
		Apr 08/09	01:29	03:34	05:39
		Mar 08/09	03:34	05:39	07:44
		Feb 27/28	04:49	06:53	08:58
WASP-103b	3	May 10/11	03:12	06:00	08:48
		Jun 05/06	01:10	03:58	06:45
		Jun 18/19	00:09	02:57	05:45
		Jun 17/18	01:56	04:44	07:32
		Jun 04/05	02:57	05:45	08:33
WASP-39b	3	May 12/13	01:01	03:55	06:49
		May 08/09	23:41	02:35	05:29
		May 16/17	02:20	05:14	08:08
WASP-17b	2	Jun 18/19	00:02	03:43	07:24
		Jun 03/04	01:25	05:06	08:48
CoRoT-11b	3	Jun 13/14	02:45	05:30	08:15
		Jun 10/11	02:53	05:38	08:23
		Jun 07/08	03:02	05:47	08:32
		May 29/30	03:27	06:12	08:57
		May 26/27	03:35	06:20	09:05
		May 23/24	03:44	06:29	09:14
		May 20/21	03:52	06:37	09:22
		May 17/18	04:01	06:46	09:31
		May 14/15	04:09	06:54	09:39
		May 11/12	04:18	07:03	09:48
		Jun 01/02	03:18	06:03	08:48

[1]Each row represents one night that contains an observable transit, i.e. May 23/24 stands for the night beginning May 23 and ending May 24.

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)***

⋆ In 2013A we were awarded with 1 night with MMT/Hectospec, 1 night with Baade/IMACS, and 1 night with Clay/MIKE. Half of a night of the MMT observations was lost due to weather; the other yielded a useable dataset. We are currently working on exploiting the time-resolved spectra of the 200+ comparison stars collected with Hectospec to fully understand the systematic variations in the target spectrum due to the instrument and observing conditions. Preliminary results from the Magellan observations are shown in Fig. 1. We expect to publish these results this year (Rackham+14, in prep.).

In 2013A PI Rackham was awarded with 3 nights on VATT/VATT4K. Of these, 1.5 nights were lost to weather and 1.5 nights yielded usable data. These data will be published with the Magellan/IMACS results on GJ 1214b.

⋆ In 2013B we were awarded with 2×0.5 nights on MMT/Hectospec. The October half-night was lost to weather and no data were acquired. Two papers published in November 2013 revised the target planet's ephemerides enough to make the planned December transit unobservable, so we returned the time for that half-night to the Hectospec queue.

⋆ In 2014A we were awarded with 1 night on Magellan/IMACS. The transit was not observed due to problems with the instrument and telescope.

⋆ In 2014B we were awarded with 3×0.5 nights on Magellan/IMACS. One half-night was lost to a combination of telescope problems and weather. The other two yielded useful data, which were are currently analyzing (Rackham+15, in prep.)