Resubmission of 12B-0500

NOAO Observing Proposal *Standard proposal* **Panel:** *For office use.*
Date: September 27, 2016 **Category:** Cosmology

Final Calibrations for the "SweetSpot" Survey

Abstract of Scientific Justification *(will be made publicly available for accepted proposals)*:

The SweetSpot program (2012B-0500) observed 114 SNeIa during its six semester run. Host galaxy template images were gathered during the main survey and in additional time allotted in 2015B and 2016A semesters (2012B-0500, 2015B-0347). Only two templates are left until we have collected all necessary reference images to allow accurate measurement of the SN flux and thus distance for the supernova observed in the last semesters of SweetSpot. With the addition of standard stars of varying colors, we will also improve the calibration of WIYN's PWV system.

Summary of observing runs requested for this project

Run	Telescope	Instrument	No. Nights	Moon	Optimal months	Accept. months
1	WIYN	WHIRC	1	bright	April - May	Mar - May
2						
3						
4						
5						
6						

Scheduling constraints and non-usable dates *(up to six lines).*

The two targets are at very different locations on the sky but can be observed on one well placed night in April or May. However, they may also be done on 2 separate partial nights, including T&E nights.

Investigators *List the name, status, and current affiliation for all investigators. The status code of "P" should be used for all investigators with a Ph.D. or equivalent degree. For graduate students, use "T" if this proposal is a significant part of their thesis project, otherwise use "G".*

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Scientific Justification *Be sure to include overall significance to astronomy. For standard proposals limit text to one page with figures, captions and references on no more than two additional pages.*

How Standard are Type Ia Supernovae Standard Candles in the Near-Infrared? In our quest toward precision measurements of dark energy with Type Ia supernovae (SNeIa) [1, 21, 14, 7, 13, 4, 3] we have became limited by systematic errors due to our incomplete understanding of SNIa colors, dust, and their host environments. SNeIa are superior distance indicators in the NIR, with more standard peak H magnitudes and relative insensitivity to reddening [18, 16, 15]. As a result, unlike optical Type Ia SNe, which are *standardizable* candles, NIR SNe Ia appear to be truly *standard* candles at the ~ 0.10–0.15 mag level (~ 5–7% in distance) [16, 17, 22, 6, 20, 2, 8].

Motivated by this opportunity, the "SweetSpot" (PI Wood-Vasey; [20]) and the "CSP-II" (PI M. Phillips; [5, 19]) programs were undertaken to build a comprehensive sample of SNeIa observed in the NIR in the nearby Hubble flow. The scientific goals of SweetSpot are: **(1)** Testing if SNeIa are better standard candles in the NIR. **(2)** Breaking the color-dust degeneracy with NIR observations. **(3)** Investigating the nature of SNIa host galaxies using NIR and optical observations **(4)** Connecting local flows and motions with SNIa NIR to galaxies and convergence.

Throughout the SweetSpot program, we have been obtaining host galaxies templates for SNeIa from the previous year with significant underlying host galaxy flux. We here request time an additional semester to observe the host galaxies from the final year of SweetSpot (2014B–2015A) that we were unable to gather in the previous two semesters. Without the final host galaxy template references, one SN at our target redshift of 0.05 will only have an H-band light curve, which will make it difficult or impossible to calibrate and thus unusable. The K_s observations are used to help constrain dust and color, but only a small percentage of our targets have K_s observations. It is important to take advantage of the ones that do such as the second target, which needs only a K_s template. Obtaining final host galaxy images free from the contamination of the SN light will be critical in obtaining accurate apparent brightness measurements for the SN light curve, and will also help provide measurements of the host galaxy stellar mass along with detailed morphology.

Improved Calibration:

A dual-band GPS system was installed at KPNO in 2015 March to measure the variable amount of precipitable water vapor (PWV) in the atmosphere. This system is a key part of determining the full effective system transmission function in the NIR (and in general for $\lambda > 700$ nm), where the edges of the filter bandpasses can be affected by the variable absorption lines from water vapor. Observing the same fields for these 2 supernovae and the standard SweetSpot calibration star fields with the dual-band GPS system running for another semester will provide important information to tie down our WIYN+WHIRC magnitudes of the stars in the SN fields we use for calibration. Furthermore, we plan to use additional standard stars with a wider range of colors from 0–1 mags at airmasses of 1–2. These will provide improved calibration since all previous standard stars have approximately the same color. We will use the focus of spending this additional time with the system to provide to all KPNO the water absorption spectral response function based on the observations of the GPS PWV system.

References

[1] Astier, P., et al. (2006) *A&A*, 447, 31.

[2] Barone-Nugent, R. L. et al. (2012) *MNRAS*, 425, 1007.

[3] Betoule, M. et al. (2014) *A&A*, 568, 22.

[4] Conley, A., et al. (2011), ApJS, 192, 1

[5] Contreras, C., et al. (2010) *AJ*, 139, 519.

[6] Folatelli, G., et al. (2010) *AJ*, 139, 120.

[7] Hicken, M., et al. (2009) *ApJ*, 700, 1097.

[8] Kattner, S. et al. (2012) *PASP*, 124, 114.

[9] Kauffmann, G., Heckman, T. M., and White, S. D. M. (2003) *MNRAS*, 341, 33.

[10] Kelly, P. L., et al. (2010) *ApJ*, 715, 743.

[11] Kelly, P. L., et al. (2015) *Science*, 2015 Mar 27. arXiv:1410.0961.

[12] Kennicutt, R. C. (1998) *ARA&AA*, 36, 189.

[13] Kessler, R., et al. (2009) *ApJS*, 185, 32.

[14] Kowalski, M., et al. (2008) *ApJ*, 686, 749.

[15] Krisciunas, K., et al. (2007) *ApJ*, 133, 58.

[16] Krisciunas, K., Phillips, M. M., and Suntzeff, N. B. (2004) *ApJL*, 602, L81.

[17] Krisciunas, K., et al. (2005) *AJ*, 130, 350.

[18] Meikle, W. P. S. (2000), *MNRAS*, 314, 782.

[19] Stritzinger, M., et al. (2011), *AJ*, 142, 156.

[20] Weyant, A. et al. (2011) *ApJ*, 784, 105.

[21] Wood-Vasey, W. M., et al. (2007) *ApJ*, 666, 694

[22] Wood-Vasey, W. M., et al. (2008) *ApJ*, 689, 377.

Experimental Design *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. (limit text to one page)*

We request a total of 1 night for WHIRC observations of host galaxies of SNeIa and standard stars.

We will observe the 2 host galaxies from SweetSpot that will require template observations due to significant inferred host galaxy light contributions at the location of the SNeIa. We are only requiring one filter per object. We have gathered the other 1–2 filters in previous semesters but were unable to observe these two due to unforeseen time constraints.

We will also observe ~ 3 standard stars in all 3 filters throughout the night.

These observations will be undertaken with WHIRC in J, H, and K_s and provide reference flux values critical to obtaining SN lightcurves and improved PWV calibration. The host galaxy observations will also generate maps of the host galaxy at the high resolutions offered by the WIYN+WHIRC system for general study of detailed NIR morphology and host galaxy mass.

Proprietary Period: 18 months

Use of Other Facilities or Resources *(1) Describe how the proposed observations complement data from non-NOAO facilities. For each of these other facilities, indicate the nature of the observations (yours or those of others), and describe the importance of the observations proposed here in the context of the entire program. (2) Do you currently have a grant that would provide resources to support the data processing, analysis, and publication of the observations proposed here?"*

1) These observations will complement the data from other nearby supernova groups such as KAIT, the CfA Supernova group, and the Carnegie Supernova Project to produce the most complementary data sets to enable explorations of optical vs. NIR distance estimation, color, and host galaxy properties. The first steps toward higher redshift are currently being undertaken on *HST* through the RAISIN project (PI R. Kirshner). Farther in the future and going farther in the past, the nearby NIR SNIa set will provide a reference anchor for future higher-redshift restframe NIR work with *JWST* and *WFIRST*. ANY PWV WORK THAT CAN BE CITED?

2) The PI is currently funded by NSF AST-1028162 to carry out the SweetSpot program and related nearby SNIa work. This grant will continue to support graduate students to do the observations, analysis and publications for these proposed observations.

Previous Use of NOAO Facilities *List allocations of telescope time on facilities available through NOAO to the PI during the last 2 years for regular proposals, and at any time in the past for survey proposals (including participation of the PI as a Co-I on previous NOAO surveys), together with the current status of the data (cite publications where appropriate). Mark with an asterisk those allocations of time related to the current proposal. Please include original proposal semesters and ID numbers when available.*

This proposal will provide final capstone data for our NOAO Survey program "Type Ia Supernovae in the Near-Infrared: A Three-Year Survey toward a One Percent Distance Measurement with WIYN+WHIRC" $\boxed{\star}$ 2012B-0500, and a final installment of WHIRC host galaxy templates that went uncompleted in the follow up program "Final Host Galaxy Observations for "SweetSpot": Calibrating the Supernova Host Galaxy Light and Environment" $\boxed{\star}$ 2015B-0347. We observed 114 SNeIa and 1 SN Ibn during the main program. This Survey program has resulted in one publication to date, [20]. A first data release paper with 74 SNeIa and 31 light curves is currently in preparation and anticipated to be submitted for publication this fall. Final data reductions of all targets have already begun in preparation for the second and full data release

PI Wood-Vasey was involved in the 6-year ESSENCE Supernova Survey (PI Suntzeff) that used the CTIO 4.0-m Blanco telescope to discover and study 200 Type Ia Supernovae to measure the dark energy equation-of-state during the past 8 billion years. This survey has so far led to 9 refereed publications with several more either submitted or in preparation for the coming year.

R. J. Foley et al. (2009), AJ, 137, pp. 3731-3742.
R. J. Foley et al. (2008), ApJ, 684, pp. 68-87.
S. Blondin et al. (2008), ApJ, 682, pp. 724-736.
A. C. Becker et al. (2008), ApJL, 682, pp. 53-56.
T. Davis et al. (2007), ApJ, Vol. 666, pp. 716-725.
W. M. Wood-Vasey et al. (2007), ApJ, Vol 666, pp. 694-715.
G. Miknaitis et al. (2007), ApJ, Vol 666, pp. 674-693.
S. Blondin et al. (2006), AJ, Vol 131, pp. 1648-1666.
K. Krisciunas et al. (2005), AJ, Vol. 130, pp. 2453-2472.

Observing Run Details for Run 1: WIYN/WHIRC

Technical Description *Describe the observations to be made during this observing run. Justify the specific telescope, the number of nights, the instrument, and the lunar phase. List objects, coordinates, and magnitudes (or surface brightness, if appropriate) in the Target Tables section below (required for queue and Gemini runs).*

We need to obtain 2 host galaxy references. Observations need to be at least 3 times as long as the longest exposure of the field when the supernova was live (assuming 1" seeing). Our template observations need have better signal to noise than our supernova observations for accurate template subtractions. LSQ14xi was observed in J for 41 minutes: its host galaxy needs 123 minutes which translates to five 5x5x15" scripts yielding 125 open shutter minutes. ASASSN-15fs was observed in Ks for 16 minutes: its host galaxy needs 48 minutes which translates to two 5x5x15" scripts yielding 50 open shutter minutes. Each dither script take $\sim$ 33 minutes to run for a total of 3.8 hours, plus $\sim$ 40 minutes to set up both fields (check focus, position, use WTTM if possible). We need roughly an hour and a half for standard star observations. This totals to approximately 6 hours or 1 night in April or May. Any extra time can be filled with standard star observations.

Nights do not need to be photometric. The night sky is bright in the NIR regardless of the phase of the Moon; therefore, observations during bright time are acceptable.

Instrument Configuration

Filters: J, H, Ks	Slit:	Fiber cable:
Grating/grism:	Multislit:	Corrector:
Order:	λ_{start}:	Collimator:
Cross disperser:	λ_{end}:	Atmos. disp. corr.:

R.A. range of principal targets (hours): 12 to 19

Dec. range of principal targets (degrees): -14 to +44

Special Instrument Requirements *Describe briefly any special or non-standard usage of instrumentation.*

Target Table for

Obj ID	Object	α	δ	Epoch	Mag.	Filter	Exp. time	# of exp.	Lunar days	Sky	Seeing	Comment
001	**LSQ14xi**	**12:30:41.2**	**-13:46:22**	**2000.00**	**unknown**	**J**	**60**	**125**	**14**	**phot**	**1**	
002	**ASASSN-15fs**	**18:58:40.8**	**+43:28:08**	**2000.00**	**12**	**Ks**	**60**	**50**	**14**	**phot**	**1**	

NOAO observing proposal LaTeX macros v3.0.