OBSERVING REQUEST
University of Arizona Observatories

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

The Supernova Spectropolarimetry (SNSPOL) Project; Using SPOL to Probe the 3-D Nature of Supernova Explosions

P.I.: Grant Williams (MMTO; *gwilliams@as.arizona.edu*; 520-621-1269)

CoI(s): Paul Smith (SO), Nathan Smith (SO), Peter Milne (SO), Chris Bilinski⋆ (SO)

Abstract of Scientific Justification

With the resources available at Steward Observatory we are uniquely poised to make a significant contribution to the understanding of the three dimensional nature of supernova explosions. To do so requires regular access to telescopes of various aperture, from modest to large, and a sensitive polarimeter. Here we are proposing to use the 61" Kuiper, the 90" Bok, and the 6.5-m MMT (using director's time) telescopes together with the SPOL instrument to identify spherical asymmetries in supernovae and monitor their evolution. Polarimetry allows us to probe scales in a supernova that cannot be imaged from earth or space. Spectropolarimetry enhances the power of this technique by allowing us to probe the geometry of specific ionic species, a very powerful tool in the study of supernovae. In recent years, evidence has grown that nearly *all* supernovae have departures from spherical symmetry. These findings, together with advances in computing power that enable full 3-D modeling, have lead to suggestions that asymmetries are not just observable consequences of supernovae but may in fact be a *necessity* of the explosion mechanism. We propose to use SPOL to observe the brightest core collapse and thermonuclear explosions during multiple epochs. Our goal is to complete a long-term *comprehensive* survey of all types of supernovae. The principal objective of this effort is to improve our understanding of the predominance and characteristics of asymmetries in the different types of supernovae. September 1, 2014 marked the beginning of the third year of a three year NSF/AAG grant that was awarded to carry out this survey. To date we've observed 48 supernovae, 36 of which have been observed during multiple epochs. In this proposal we are requesting seven additional nights to continue to build on this survey.

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	90"	f/9	SPOL	*		1	grey	Jan	Jan–Feb	yes	no
2	90"	f/9	SPOL	*		1	grey	Feb	Jan–Mar	yes	no
3	90"	f/9	SPOL	*		1	grey	Mar	Feb–Apr	yes	no
4	90"	f/9	SPOL	*		1	grey	Apr	Mar–May	yes	no
5	90"	f/9	SPOL	*		1	grey	May	Apr–Jun	yes	no
6	90" or 61"	f/9	SPOL	*		1	grey	Jun	May–Jul	yes	no
7	90" or 61"	f/9	SPOL	*		1	grey	Jul	Jun–Jul	yes	no

or:

Run	Telescope	Cage	Instrument	PI	AO	Nights	Moon	Scheduling Optimal	Scheduling Acceptable	Sharing Poss.	Sharing Adv.
1a	61"	f/13	SPOL	*		1	grey	Jan	Jan–Feb	yes	no
2a	61"	f/13	SPOL	*		1	grey	Feb	Jan–Mar	yes	no
3a	61"	f/13	SPOL	*		1	grey	Mar	Feb–Apr	yes	no
4a	61"	f/13	SPOL	*		1	grey	Apr	Mar–May	yes	no
5a	61"	f/13	SPOL	*		1	grey	May	Apr–Jun	yes	no

Scheduling constraints and unusable dates *(up to 4 lines)*: Nights should be scheduled adjacent to (either before or after) or during the time awarded to Paul Smith's Fermi blazar proposal. We are requesting one night every month at either the 90" or 61". *NOTE: There was not enough room above to include all the alternative requests, i.e. 6a and 7a at the 61".*

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	SN 2014??			$V \leq 16.0$
2	SN 2014??			$V \leq 16.0$
3	SN 2015??			$V \leq 16.0$
4	SN 2015??			$V \leq 16.0$
5	SN 2015??			$V \leq 16.0$
6	SN 2015??			$V \leq 16.0$
7	SN 2015??			$V \leq 16.0$

Approval for Instrument Use from PI: Paul Smith, the PI of SPOL, is a CoI on this proposal. He has approved the use of the instrument.

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
Chris Bilinski	Nathan Smith		no	yes

Scientific Justification

This long-term proposal is very similar to proposals we submitted in 2012a, 2013A and 2014A. For the benefit of the newer TAC members, we've kept most of the text from the **Scientific Justification** and **Experimental Design** with the exception of the **Selected Results** section. Here, we are proposing to continue our ongoing program to study supernovae using spectropolarimetry in collaboration with D. Leonard (SDSU), J. Hoffman (Denver) and their students. September 1, 2014 marked the beginning of the third year of a three year NSF/AAG grant to complete this work. Our collaboration met in mid-September to discuss plans for the future. Although the project has been even more successful than anticipated, rather than submitting a new NSF proposal this November, we've opted to request a one year no-cost extension next September. This will give us an additional year to advertise our results and to add to our publication list, thereby improving our case for a continuation of the project.

Motivation

In a 2008 *Annual Reviews of Astronomy and Astrophysics* paper Wang & Wheeler (2008) wrote:

> "Virtually all supernovae are significantly aspherical near maximum light . . . "

During the past six years the observational evidence in support of that statement has continued to grow. Additional support for the aspherical nature of supernovae (SNe) comes from 3-D modeling, which has only recently been enabled by advances in computing technology and more sophisticated numerical techniques. Some of these models, which can include the oft neglected role of rotation and/or magnetic fields, are revealing phenomenon that simply could not occur in lower dimensions. Some results are even suggesting that asphericity is a *necessary and key* component of the explosion mechanism itself (e.g. Standing Accretion Shock Instability or SASI, Ott et al. 2008). Observations are currently ahead of modeling when it comes to core collapse supernova (SN) explosions. Therefore, observers, through observations such as those proposed here, need to inform modelers about the nature of the explosions. In the future, observers will be tasked with confirming testable predictions from these models.

The Power of Polarimetry

In this new era of detailed 3-D modeling, it is becoming increasingly common for theorists, modelers and observers alike to tout the power of polarimetry (and especially spectropolarimetry) in understanding both normal SNe and unusual transients. Observations of the closest SN in the modern era, SN 1987A, have revealed asphericity through direct imaging. However, all other SNe are too distant to learn anything about the shape of the explosion using normal or even high resolution imaging. Therefore, it is necessary to utilize polarimetry to discriminate between spherical and non-spherical explosions. Polarimetry is capable of probing down to and below an effective spatial resolution of 10μarcsec for a typical SN photosphere of 10^{15} cm at 10 Mpc (Wang & Wheeler 2008).

Current Transient Surveys are Finding Interesting Supernovae

In recent years, a number of surveys that are capable of finding transients outside of bright host galaxies, potentially at epochs long before peak brightness, have led to a pool of very interesting and unfamiliar events. Examples range from extremely energetic explosions (broad lined SNe, pair-instability SNe, etc.) to very nearby SNe (e.g. SN 2011fe in M101). These non-directed surveys, which are the precursors to LSST, include the Intermediate Palomar Transient Factory (iPTF), Catalina Sky Survey (CSS), and Pan-STARRS. Although they have a significantly lower etendue than LSST, they are identifying transients at a rate that is none-the-less proving difficult for proper follow-up. The most interesting of these transients are not "normal" SNe and as such are some of the most urgent to study. Furthermore, these exceptional events demand

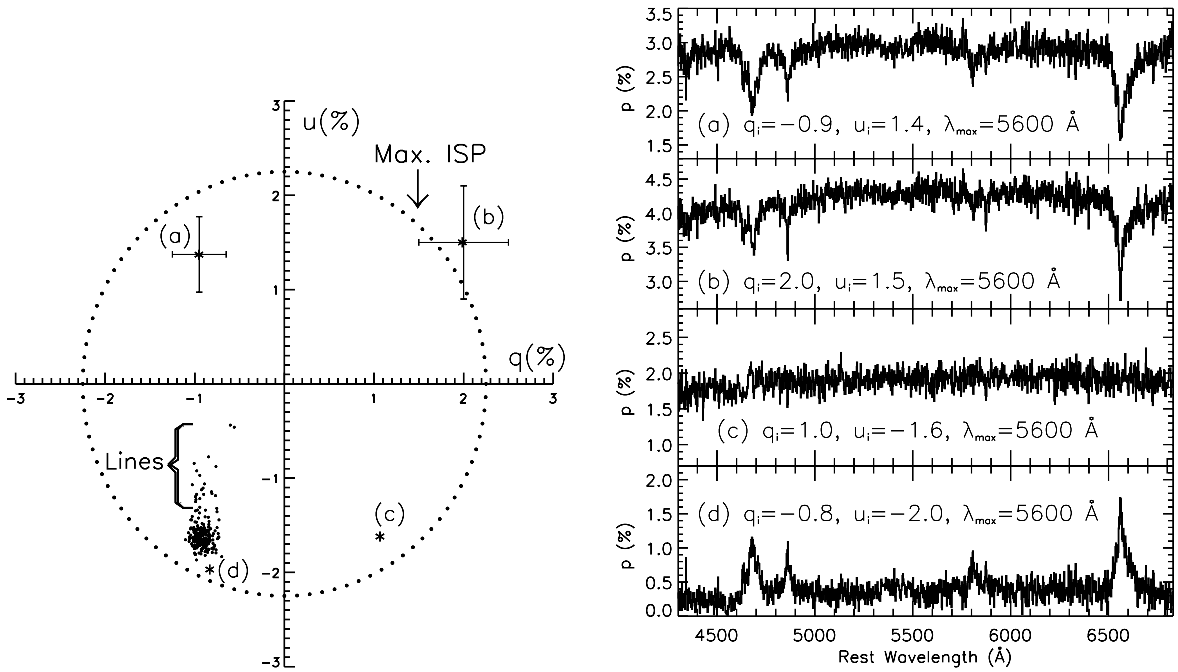

Figure 1: The importance of determining the interstellar polarization (ISP). (*a*) Observations of SN 1998S in the q-u plane together with four possible values of the ISP labeled a–d; (*b*) The resultant intrinsic polarization for the four different estimates of the ISP. (Leonard et al. 2000),

observations using "non-traditional" tools in order to fully understand their nature. Spectropolarimetry is one of these non-traditional tools. Therefore, we are fortunate at Steward Observatory to have access to a very mature and sensitive spectropolarimeter, SPOL.

The Importance of Multi-Epoch Observations; Separating Intrinsic and Interstellar Polarization

Any polarimetric measurement of an astrophysical source is a combination of an intrinsic component and an interstellar component. Interstellar polarization (ISP) originates from dust aligned with magnetic fields in either the Milky Way and/or, in the case of extragalactic targets, the target's host galaxy. For Milky Way sources, the ISP is a function of Galactic coordinates and distance (Serkowski et al. 1975). Therefore, a common technique for determining the ISP in the direction of Galactic targets is to measure the polarization of equally distant stars along similar lines-of-sight. For extragalactic sources, the unknown and difficult to measure host galaxy ISP complicates the determination of its contribution. If the ISP component cannot be measured or estimated and then removed, the intrinsic polarization of the source is not well constrained. Any physical model of the source determined from it's polarization is, in that case, on much less solid footing.

Figure 1, adopted from Leonard et al. (2000), demonstrates the importance of correctly determining the ISP. The spectropolarimetric data, i.e. the normalized Stokes Parameters q and u, are plotted for the type IIn SN 1998S on the left. Each of the points represents one bin in wavelength space. The continuum is shown as the cluster of points near $q = -0.9$, $u = -1.7$ and the emission lines, labeled as "Lines", extend above the continuum toward more positive values of u. The maximum value of the ISP, inferred from the estimated reddening limit, is 2.25%. This is represented by the dotted circle since that technique yields only degree of polarization and not the position angle. Possible values for the ISP based on different assumptions are labeled as (a), (b), (c), and (d). In q-u space, polarization vectors are additive and so the intrinsic polarization of the supernova as a function of wavelength is a set of vectors originating at one of the ISP locations, (a), (b), (c), or (d), and ending at each of the measured points. The right hand plot shows the resultant intrinsic polarization as a function of wavelength for the four possible ISP values. The intrinsic supernova polariza-

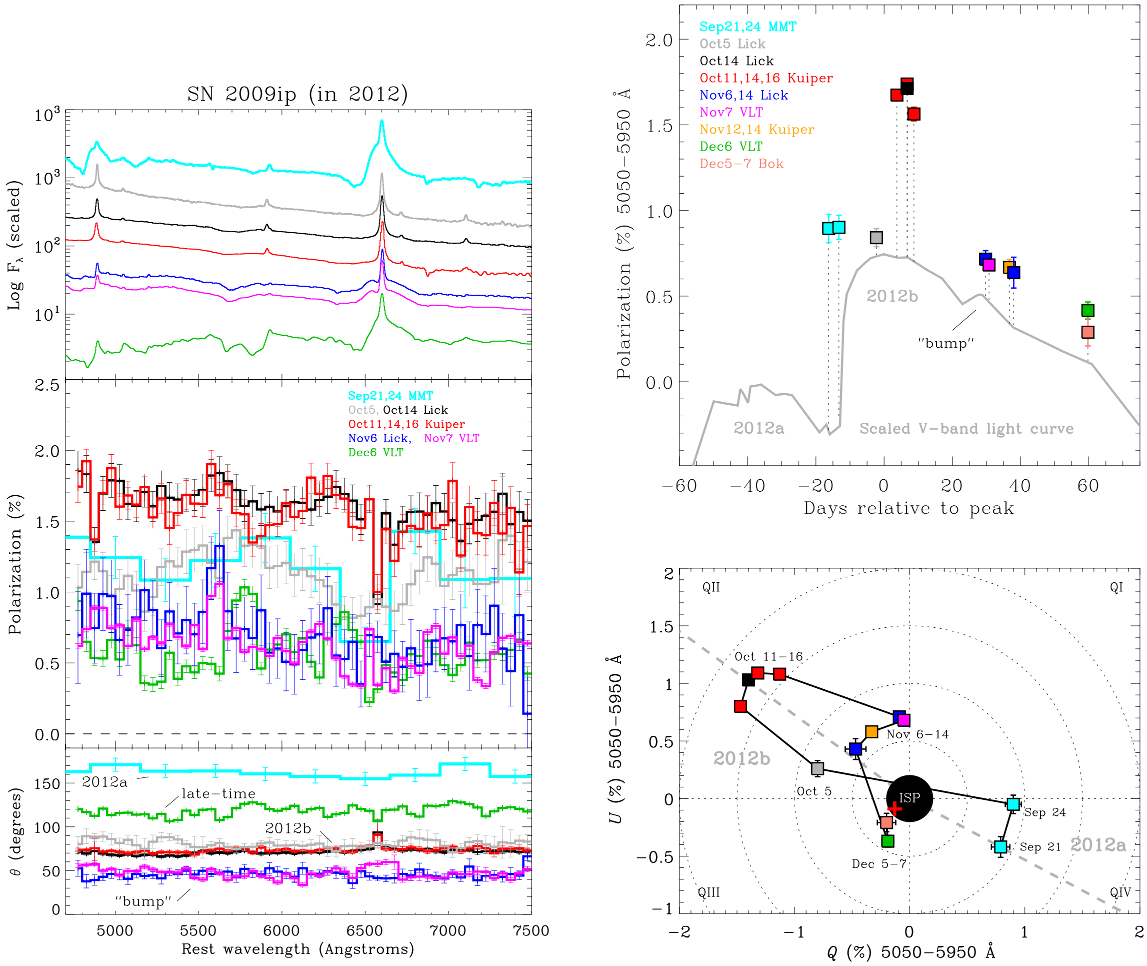

Figure 2: Results from observations of the type IIn SN 2009ip. (*a*) Multiepoch flux, degree of polarization and position angle as a function of wavelength. (*b*) The continuum polarized light curve (top) and the evolution in the Stokes q-u plane (bottom). (Mauerhan et al. 2014)

tion is a strong function of the ISP that's chosen. In cases (a) and (b) the intrinsic continuum polarization is large ($> 2.5\%$) and the degree of polarization in the lines is reduced. In case (c) the polarization in the lines is nearly the same as the polarization in the continuum, however the position angle changes. Finally, for case (d) the intrinsic continuum polarization is low and the polarization increases in the lines.

Although it is extremely difficult to determine the ISP for most extragalactic targets, SNe have an important characteristic that helps circumvent this difficulty: they evolve over short time scales. This evolution and subsequent temporal behavior, together with a logical assumption or two, allows one to use multi-epoch observations to hone in on the true ISP value.

Although multi-epoch spectropolarimetric observations of SNe are key to extracting the intrinsic polarization, most SN polarization observations have been confined to a single epoch. Wang & Wheeler (2008) included a comprehensive table of all SN polarization measurements through 2008. At the time there had been 94 published SN polarization observations. Of those, 55 or nearly 60% had been observed only once. Another 19 (20%) had been observed only twice. Therefore only 20 supernovae had been observed during three or more epochs. A literature search between 2008 and 2013 revealed spectropolarimetric observations of an additional twelve supernovae: SN 2005ke (3), SN 2006my (1), SN 2006ov (3), SN 2007aa (3), SN 2007gr (1), SN 2007sr (1), SN 2008ax (3), SN 2009dc (2), SN 2009jf (1), SN 2009mi (1), SN 2010jl

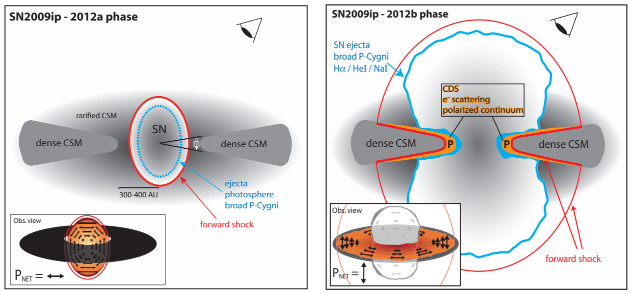

Figure 3: Illustration of the possible configuration of SN 2009ip based on data obtained as part of the SNSPOL project. The left figure show the configuration prior to the CSM interaction, 2012a phase, and the right figures shows the configuration during CSM interaction, 2012b phase. (Mauerhan et al. 2014),

(1), and SN 2012fr (4). The number in parentheses indicates the number of observed epochs. This proposal sets out to substantially increase the number of multi-epoch spectropolarimetric observations of supernovae. Each multi-epoch observation will help constrain the ISP and therefore provide a more solid physical interpretation of the intrinsic polarization.

Selected Results

As a demonstration of the power of multi-epoch spectropolarimetric observations, here we highlight results from our observations of the type IIn **SN 2009ip** (which actually exploded in 2012 rather than 2009, Mauerhan et al. 2014). Figure 2, adopted from Mauerhan et al. (2014), shows (*a*) the flux, degree of polarization and position angle for SN 2009ip at multiple epochs and (*b*) the continuum polarized light curve (top) and the evolution in the Stokes q-u plane (bottom). The data for these plots includes observations from all three of the telescopes used for this project, i.e. 61" Kuiper, 90" Bok and 6.5-m MMT. Data from Lick's Shane 3-m and the VLT are also included and show a very good agreement with the SPOL data at similar epochs.

The importance of well sampled multiepoch observations is evident in the plot of the data in the Stokes q-u plane. The initial continuum polarization is likely a result of partial absorption by toroidal circumstellar material (CSM). As the SN evolves, the data cross the origin of the q-u plane and loop at 180 degrees relative the early data. An angle of 180 degrees in the q-u plane corresponds to 90 degrees on the sky. Therefore, we have interpreted this as increasing interaction with the equatorial CSM. This interpretation is represented by illustration in Figure 3.

References

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Li, W., Leaman, J., Chornock, R., Filippenko, A. V., Poznanski, D., Ganeshalingam, M., Wang, X., Modjaz, M., Jha, S., Foley, R. J., & Smith, N. 2011, Monthly Notices of the Royal Astronomical Society, 412, 1441

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Ott, C. D., Burrows, A., Dessart, L., & Livne, E. 2008, The Astrophysical Journal, 685, 1069

Serkowski, K., Mathewson, D. S., & Ford, V. L. 1975, Astrophysical Journal, 196, 261

Wang, L., & Wheeler, J. C. 2008, Annual Review of Astronomy & Astrophysics, 46, 433

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)***

Because a supernova photosphere recedes through the ejecta with time, multi-epoch observations will probe different depths in the ejecta. The typical result is that specific absorption or emission lines will dramatically change in either degree of polarization, position angle or both.

Our goal is to obtain at least three well sampled epochs of spectropolarimetric data for each target supernova. Ideally, these epochs would span the evolutionary periods of the SN: well before peak (~ -14 days), near peak (~ 0 days) and at least one measurement after peak ($\sim +14$ days). However, from a sky brightness/background polarization perspective this fourteen day cadence is far from ideal since it is one half a lunation. Furthermore, the epoch of a given observation is at the mercy of the explosion and discovery dates for each SN. Therefore, the instrument and telescope availability is the principal driver in our request for time.

If P. Smith's Fermi blazar monitoring proposal is successful, SPOL is likely to be scheduled on either the 61" or 90" approximately one week every month. We would like to piggy-back on that program and therefore request that one night be added to each of those runs for this program. The observing time for the entire SPOL run will utilize a queue mode thereby optimizing the efficiency for both the blazar monitoring program and the SN program.

The use of SPOL in queue mode is extremely valuable to the success of this program. It essentially *guarantees* that our high priority SN targets will be observed once per month. Losing time because of weather for even a single month could have a negative impact on the results for multiple targets. However, the queue arrangement virtually eliminates that risk. The impact of any time lost to weather will be minimized because it will be spread over the entire run rather than a single night.

Because of the evolution of SNe and the resultant change in apparent magnitude, having access to telescopes with multiple apertures with the same instrument is a powerful capability. Again, in an ideal case, we'd be able to choose the telescope based on the brightness of our highest priority targets but, since we do not know a priori how bright a given target will be during our run, we have no preference for a specific aperture for a given run. However, it is critical that we utilize the larger 90" telescope in order to obtain good signal-to-noise on our fading targets as frequently as possible during the seven month proposal period.

Finally, the observations proposed here will be augmented with observations at the MMT. Twice per semester we will schedule two to three director's discretionary nights on the MMT with SPOL to enable observations of targets that have either faded or are intrinsically faint. This is also critical to the program since measuring polarization at a level of $\sim 0.1\%$ is extremely difficult and becomes even more difficult as a given SN ages.

We initially used the SN rates published in Li et al. (2011) to estimate the number of potential new SPOL targets per semester. We estimated that roughly one *new* SN will be observable every month. In practice we have been able to observe a slightly higher number of approximately 1.25 new SN every month. The number that are observable during any one epoch will depend on discovery date relative to peak and the decay rate, which is largely a function of type. Of the eight to nine new SNe per semester, we will be able to observe three to four targets per observing run.

Although this program will be observed in queue mode, we expect to observe the equivalent of approximately three to four supernovae per scheduled night. With the goal of obtaining at least three to four epochs for each target, we request observations over both semesters, or a total of ~ 11 nights, to complete a sample of SN targets of all types. At the end of the year we will have observed approximately fourteen targets over approximately three epochs.

By its nature, this survey requires a long-term commitment to achieve observations of multiple supernovae of every type during multiple epochs. Our goal is to continue to make observations beyond the third year of the NSF/AAG grant funding and therefore, to ensure continuity, we are requesting long-term status for this proposal.

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**)*

This is our fourth long-term proposal for this project. We were granted long-term status in 2012, proposals L51 & L57, in 2013, proposals L60 & L54, and in 2014, proposals L56 & L56. During the 2015A semester we are requesting a single night every month, i.e. a total of seven nights. These nights should be added to, either before or after, the nights awarded to P. Smith's Fermi blazar proposal. We also plan to request one night per month during the 2015B semester, i.e. an additional four nights.

Since there will be new potential SN targets every month, this project could continue indefinitely. Our NSF proposal has been funded through August 2015 but we plan to request a one year no-cost extension and therefore we plan to continue observing through at least the 2015B semester. Although we can obtain useful data during just a single semester, the best and most comprehensive results will be obtained over a longer timescale. This will enable multiple epoch observations for several supernovae of different types. Therefore we are submitting a long-term proposal to continue the project for another year. We are requesting a total of 11 nights, one per month (excluding summer shutdown) over the course of the year.

This project was awarded four nights in 2012a, three nights in 2012b, four nights in 2012c, seven nights in 2013A, four nights in 2013B, seven nights in 2014A and four nights in 2014B. Twenty of the 33 nights were scheduled on the 90" (1/28/12, 2/12/12, 3/26/12, 7/23/12, 9/7/12, 12/4/12, 1/18/13, 2/1/13, 3/4/13, 5/14/13, 7/2/13, 11/25/13, 12/25/13, 2/7/14, 3/1/14, 3/25/14, 5/21/14, 7/19/14, 9/19/14 & 12/26/14) and thirteen nights were scheduled on the 61" (4/28/12, 5/16/12, 6/19/12, 10/11/12, 11/8/12, 4/15/13, 6/1/13, 9/11/13, 10/12/13, 4/25/14, 6/19/14, 10/27/14 & 11/27/14). Although scheduled classically, the observations for this program are being obtained in a queue mode along with proposals from P. Smith and C. Maleszewski. This significantly increases the probability that all of our SN targets will be observed each month. In addition to the time awarded through the TAC, 21.5 nights of director's discretionary time have been scheduled on the MMT with SPOL (4/13-15/12, 7/11-13/12, 9/20/12, 9/23/12, 1/7-9/13, 6/13-14/13, 10/27-29/13, 4/18-20/14, 7/2/14 & 12/13-14/2014).

Observations to date have been extremely successful in terms of observing coverage. Table 1 provides a log of observations for this project. Since we combine multiple nights into a single epoch, the table provides both number of nights and number of epochs. This already represents one of the best spectropolarimetric surveys of SNe, particularly since most types of supernovae have been observed.

We are spearheading this project and are collaborating with D. Leonard at San Diego State University, J. Hoffman at University of Denver and L. Dessart at Laboratoire d'Astrophysique de Marseille, France. Almost all of the observations for this program will be obtained on UAO telescopes. We are not requesting MMT time in this proposal since we plan to use director's discretionary time at the MMT. D. Leonard may have limited access to spectropolarimetry data obtained at the Shane 3-m Telescope at Lick Observatory and has a different project to study type IIP SNe at VLT. Although the Steward data alone would provide a very good data set, occasionally augmenting this with the Shane and/or VLT data will help fill in the time coverage and help confirm SPOL results.

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**)*

⋆ To date, we've been awarded 33 nights for this project spanning the last three years. Those nights were distributed between semester and telescope as follows:

2012a @ 90": 1/28, 2/12, 3/26, **2012a @ 61":** 4/28, **2012b @ 90":** 7/23, **2012b @ 61":** 5/16, 6/19, **2012c @ 90":** 9/7, 12/4, **2012c @ 61":** 10/11, 11/8, **2013A @ 90":** 1/18, 2/1, 3/4, 5/14, 7/2, **2013A @ 61":** 4/15, 6/1, **2013B @ 90":** 11/25, 12/25, **2013B @ 61":** 9/11, 10/12, **2014A @ 90":** 2/7, 3/1, 3/25, 5/21, 7/19, **2014A @ 61":** 4/25, 6/19, **2014B @ 90":** 9/19, 12/26, **2014B @ 61":** 10/27, 11/27.

Observations obtained during these observing runs are shown in Table 1. All the data for all of the runs prior September 2014 have been reduced. Results from four supernovae, SN 2010jl, SN 2011fe, SN 2011dh & SN 2012au, were presented in a block of four posters highlighting results from the SNSPOL project at the 223rd AAS Meeting in Washington, DC in January 2014. Also, graduate student C. Bilinski presented a poster providing an overview of the project and results at the conference "F. O. E. Fifty One Erg" in Raleigh, NC May 13–17, 2013. In addition to Mauerhan et al. (2014), there are currently six publications in preparation that focus on six individual events: SN 2010jl (Williams et al.), SN 2011dh (Mauerhan et al.), SN 2011fe (Milne et al.), SN 2012au (Hoffman et al.), SN 2013ej (Leonard et al.). & SN 2014ab (Bilinski et al.). We hope to submit most of these papers prior the 2014B proposal deadline.

Table 1: SPOL observations of supernovae through September 2014.

Target	SN Type	Telescope	# of Nights	# of Epochs
SN 2010jl	IIn	61”	11	4
		90”	18	6
		MMT	1	1
SN 2011cc	IIn	90”	1	1
SN 2011dh	IIb	61”	2	1
		90”	2	1
SN 2011fe	Ia	61”	1	1
		90”	13	6
		MMT	1	1
SN 2011ht	IIn	90”	7	2
PTF11iqb	IIn	90”	1	1
SN 2012A	IIP	61”	3	1
		90”	17	3
		MMT	1	1
SN 2012ab	IIn	90”	1	1
		MMT	1	1
SN 2012aw	IIP	61”	11	3
		90”	11	2
		MMT	3	2
SN 2012au	Ib	61”	11	3
		90”	6	1
		MMT	2	2
SN 2012bv	II	MMT	2	1
SN 2012cg	Ia	61”	11	2
SN 2012ch	IIP	MMT	2	1
SN 2012ec	IIP	61”	6	2
		90”	11	4
		MMT	3	2
SN 2012ej	Ic	61”	2	1
		90”	2	1
		MMT	4	2
PTF12gzk	Ic-Pec	61”	1	1
		MMT	4	1
SN 2009ip	IIn	61”	6	2
		90”	3	1
		MMT	3	1
SN 2012fg	IIb	90”	10	2
		MMT	2	1
SN 2012fh	Ic	61”	1	1
		90”	13	4
		MMT	2	1
SN 2012ho	IIP	MMT	1	1
SN 2012ht	Ia	90”	2	1
		MMT	1	1
SN 2013ab	IIP	61”	5	2
		90”	5	2
		MMT	2	1
SN 2013ak	IIb	61”	4	1
		90”	1	1
SN 2013am	II	61”	8	2
		90”	3	1
		MMT	1	1
SN 2013bi	IIP	61”	4	1
		90”	5	2
		MMT	2	1
SN 2013bu	II	61”	4	1
		90”	3	1
		MMT	2	1
SN 2013df	IIb	90”	2	1
		MMT	2	1
iPTF13bvn	Ib	90”	3	1
SN 2013ee	II	90”	4	1
		MMT	1	1
SN 2013ej	IIP	61”	4	2
		90”	5	2
		MMT	2	1
SN 2013ff	Ic	90”	4	1
		MMT	3	2
SN 2013fs	IIP	61”	3	1
		90”	4	2
		MMT	2	1
SN 2013fw	Ia-HV	MMT	1	1
SN 2013ge	Ic	90”	6	2
SN 2013hj	II	90”	2	1
		MMT	1	1
SN 2014A	IIP	90”	1	1
		MMT	2	1
SN 2014G	IIL	90”	7	3
		MMT	1	1
SN 2014J	Ia-HV	90”	6	4
		MMT	1	1
SN 2014L	Ic	90”	8	3
		MMT	2	1
SN 2014ab	IIn	61”	8	2
		90”	7	2
		MMT	2	1
SN 2014ad	Ic	61”	2	1
		90”	4	2
		MMT	1	1
SN 2014ao	Ia	61”	3	1
		MMT	1	1
SN 2014as	BL-Ic	MMT	2	1
SN 2014bc	IIP	90”	1	1
ASASSN-14az	IIb	61”	5	1
		90”	3	2
SN 2014ce	II	90”	3	1
SN 2014cx	II	90”	2	1
SN 2014cy	IIP	90”	2	1