NOAO Observing Proposal *Survey proposal* **Panel:** *For office use.*
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Southern Standard Stars for the $u'g'r'i'z'$ System

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Abstract of Scientific Justification *(will be made publicly available for accepted proposals)***:**
The Sloan Digital Sky Survey (SDSS) has been obtaining engineering and commissioning imaging data for over a year and the survey is expected to get underway and generate science quality data in early 2000. Though the SDSS is geared to the northern hemisphere, as the survey photometric system ($u'g'r'i'z'$) gains acceptance within the astronomical community, the need for southern standard stars will increase.

To maintain continuity with the SDSS northern and equatorial standard stars we propose to develop of a series of southern standards with the $u'g'r'i'z'$ filters for use by the astronomical community. These southern standards will be developed using the same observers, reduction software and observing and selection procedures as the initial SDSS standard system.

Summary of observing runs requested for this project

Run	Telescope	Instrument	No. Nights	Moon	Optimal months	Accept. months
1	CT-0.9m	CFIM + T2K	7	grey	Aug - Jul	Aug - Jul
2						
3						
4						
5						
6						

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

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.*

The Sloan Digital Sky Survey (SDSS) has been obtaining engineering and commissioning imaging data for over a year and the survey is expected to get underway and generate science quality data in early 2000. The SDSS imaging camera (Gunn et al. 1998) utilizes a new five-band (u', g', r', i', z') photometric system (Fukugita et al. 1996) which will rapidly generate more photometric data than has been obtained in the entire history of astronomy. Though the SDSS is geared to the northern hemisphere, as the photometric system gains acceptance within the astronomical community, the need for southern standard stars will increase. For example, the Visual & Infrared Survey Telescope for Astronomy (VISTA), a 4-m class telescope to be built by the United Kingdom in the Southern Hemisphere, has recently announced they will use the SDSS filter system. Also, the NASA NSTARS program, which will compile a complete census of stars and brown dwarfs within 25 pc of the Sun, will use SDSS filters. In addition, instruments projected for use on existing or new spacecraft will make use of the SDSS filters. For example, the Advanced Camera for Surveys (ACS), to be deployed in the next HST servicing mission, will include SDSS filters, as will the Space Interferometry Mission (SIM). Astronomers will also want to use SDSS filters for followup ground observations based upon data from these space missions. Further, we (the SDSS calibration group) have been receiving requests from individuals for southern standards — well beyond the scope of our survey requirements.

Establishment of the SDSS standard star system, a network of about 200 stars in the northern hemisphere and near the equator (Smith et al. 1998), is nearing completion. The observations are completed for setup of the inital system and this should be released in mid 2000 (Smith et al. 2000). Since the SDSS is geared to the north, the initial standard system is essentially limited to the northern hemisphere. Though there are stars near the equator this is not an ideal situation for southern hemisphere observers. While the large northern observational databases in the $u'g'r'i'z'$ and $UBVRI$ systems are adequate to provide *rough* transformations for $\approx$5% photometry (based on our reductions) or when working far from the closest standard stars, 1-2% all-sky precision requires a set of well placed standards in all parts of the sky.

In an effort to maintain a single standard star system and avoid problems such as those which have developed in the $UBVRI$ system where multiple investigators have created secondary standard stars (e.g. Menzies et al. 1991; Taylor & Joner 1996), we propose to develop a series of southern SDSS standards ourselves. To maintain consistency within the existing network, we will use the same observers, reduction software and selection and observing techniques for these additional stars. Employing the same strategy used in the initial system setup we would make use of existing standard fields to minimize the time required to find variable stars, good red–blue pairs, etc. The initial effort in the southern hemisphere would involve approximately 100 potential photometric standards, chosen so that two red–blue pairs would be available at each hour of RA in different declination bands. These two bands would be concentrated between $-30^\circ < \delta < -45^\circ$ and $-60^\circ < \delta < -75^\circ$.

REFERENCES:

Fukugita et al. 1996 AJ, 111, 1748.
Gunn et al. 1998 AJ, 116, 3040.
Menzies et al. 1991 MNRAS, 248, 642.
Smith et al. 1998 BAAS 30, 1244.
Smith et al. 2000 in preparation.
Taylor & Joner 1996 AJ, 111, 1338.

Management Plan *Describe the overall plan for conducting the proposed survey, including the experimental design, survey deliverables, staffing requirements, and a list of observing runs. See the Survey Program instructions for details.*

Experimental Design:

The CTIO 0.9-m plus Tek2k CCD (13' FOV) closely mimics the system used in the establishment of the SDSS standard star system (USNO 40-inch, 11' FOV, SITe chip). We will begin the southern standard development using existing standard fields to minimize contamination by variable stars. Though dark–grey time is requested, some grey–bright time could be used in this project where the position of the moon would be an additional observing constraint for the targets.

We will select a series of about 96 stars to be placed onto the $u'g'r'i'z'$ system. The color range chosen would be similar to those already in development in the north; $-0.37 \lesssim (B-V) \lesssim 2.33$ or $-0.61 \lesssim (g'-r') \lesssim 2.21$. These would be in the declination range $-75^\circ < \delta < -20^\circ$, with the goal to have a red–blue pair at every hour of RA in two declination bands — $-45^\circ < \delta < -20^\circ$ and $-75^\circ < \delta < -60^\circ$. Theses stars would be tied to the existing (northern) system via the equatorial standards and the few "southern" stars (about 15) in the system. Observations of the northern zeropoint sdF stars will not be necessary as we have additional sdF stars closer to the equator. However, it would be possible to observe one of the northern zeropoint stars once a night at high airmass to check the consistency of our reductions.

The request for long term survey status and approximately 84 nights spread over four years is driven by the time required to obtain about 10-12 observations of each star in different observing seasons. This allows our reductions to check for and remove any zeropoint changes. Further, this minimizes the chance that severe weather problems during any single observing session will compromise the calibration work. For comparison, we have used over 180 nights on the USNO 40-inch in the past 2 years to establish the $\sim$ 200 northern and equatorial standard stars. (JAS made all the observations for calibrating these standards.) The other telescope being used in the SDSS standard effort is the 0.5-m at Apache Point Observatory. This telescope is dedicated to monitoring the sky conditions during the imaging camera runs and observing the survey calibration patches. Due to the time constraints imposed on it by the survey, this telescope is not available for continuing the establishment of additional standards, only the continued monitoring of existing ones. Further, both of these telescopes are in the northern hemisphere and not applicable for the southern work proposed herein.

The initial standard fields would be drawn from (but not limited to):
- Landolt, 1983 AJ 88, 853 (good pairs to -75°);
- Graham, 1982 PASP 94, 244 (the E-regions at -45°);
- Menzies et al. 1989 SAAOC 13, 1 (E- and F- regions and the MCs);
- Walker, 1995 AJ 110, 638 and 1992 AJ 104, 1395 (fields near the LMC);
- Walker, 1995 PASP 107, 683 (standards near the SGP).

The data will be reduced at Fermilab using MTPIPE, the SDSS software package used for the reductions and calibrations of the Northern and equatorial SDSS standards. [MTPIPE was developed at Princeton and Fermilab for the reduction of SDSS standard stars and for the calibration of calibration patches for the SDSS 2.5m telescope. One of use (DLT) is the present MTPIPEline Coordinator; the other (JAS) reduced the Northern and equatorial SDSS standard star calibration data using MTPIPE.]

Survey Deliverables:

The end-product of this program will be a calibrated set of approximately 96 $u'g'r'i'z'$ standard stars

in two declination bands provided as a service to the astronomical community for high-accuracy photometry in the southern hemisphere.

Staffing Requirements:

- J. Allyn Smith – head of project and main observer
- Douglas L. Tucker – deputy head of project and main data reducer
- Occasional summer student to help out with reductions.

List of Observing Runs:

We request 7 nights per run, 3 times a year (separated by approximately 4 month intervals), for 4 years (a total of 84 nights over the course of this program).

Run	Telescope	Instrument	Semester	No. Nights	Moon	Optimal Months	Acceptable Months
1	CT-0.9m	CFIM + T2K	2000b	7	grey	Sep	Aug - Oct
2	CT-0.9m	CFIM + T2K	2001a	7	grey	Jan	Dec - Feb
3	CT-0.9m	CFIM + T2K	2001a	7	grey	May	Apr - Jun
4	CT-0.9m	CFIM + T2K	2001b	7	grey	Oct	Sep - Nov
5	CT-0.9m	CFIM + T2K	2002a	7	grey	Feb	Jan - Mar
6	CT-0.9m	CFIM + T2K	2002a	7	grey	Jun	May - Jul
7	CT-0.9m	CFIM + T2K	2002b	7	grey	Nov	Oct - Dec
8	CT-0.9m	CFIM + T2K	2003a	7	grey	Mar	Feb - Apr
9	CT-0.9m	CFIM + T2K	2003b	7	grey	Jul	Jun - Aug
10	CT-0.9m	CFIM + T2K	2003b	7	grey	Dec	Nov - Jan
11	CT-0.9m	CFIM + T2K	2004a	7	grey	Apr	Mar - May
12	CT-0.9m	CFIM + T2K	2004b	7	grey	Aug	Jul - Sep

Release of Data *Describe the timeline and mechanism for the release of data subsets, the complete dataset, and catalogs to the astronomical community.*

We expect this project to take about 4 years. Therefore, the final calibrated southern standard star network will not be completed until after all 4 years of observations are made. Nonetheless, a preliminary set of calibrated standards will be made available via a website approximately one year after the first observation run, and updates will be made at a rate of roughly once a year thereafter until the end of the project. The project will be completed approximately one year after the final observations with a paper submitted to a major astronomical journal containing the final version of the southern standard star network; this final version will also be made available via a website.

Previous Use of NOAO Facilities *List allocations of telescope time on facilities available through NOAO to the Principal Investigator during the past 2 years, 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.*

During the past 2 years, Smith has been the PI on two proposals. Both used University of Michigan time on the Curtis-Schmidt. The first was to obtain $u'g'r'i'z'$ photometry of LCRS galaxies to establish a photometric redshift relation in SDSS filters. Though hampered by poor weather, we obtained usable data for about 2200 galaxies. A paper with the results and a catalog of the photometric data has been submitted for publication.
Sowards-Emmerd, D., Smith, J.A., McKay, T.A., Sheldon, E., Tucker, D.L. and Castander, F. J."A Catalog of SDSS Photometry for LCRS Galaxies" 2000, submitted to A.J.
The second project was to obtain $u'g'r'i'z'$ photometry of a series of open clusters of known ages and metallicities to study how these variables change in the SDSS filter system. This run is in progress as we write this proposal.

No previous time has been allocated for the proposed survey project.

Why CTIO? *(For CTIO proposals only.) Explain why access to the southern hemisphere is needed to achieve your scientific goals.*

Access to CTIO is required to reach the proposed southern stars, down to about $\delta = -75^\circ$.

Observing Run Details for Run 1: CT-0.9m/CFIM + T2K

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 WIYN-2hr, WIYN-SYN, YALO, and Gemini runs).*

We will observe several stellar fields for the purpose of creating a series of southern hemisphere standard stars in the SDSS $u'g'r'i'z'$ filter system. The instrument combination specified closely matches the system used for the setup of the initial SDSS standard star network (USNO 40-inch, 11' FOV). The observations will require several nights spread over the year for overlap of the zero points. Use of existing standard star fields which have already identified any variables will allow us to minimize the observing time (note, however, that we have used 190 nights for the northern hemisphere system setup). The stars will be relatively bright ($10 < V < 14$) for the initial system extension development. The exact fields will be chosen once final observing dates are known; however, a partial list of the reference fields is given in the "Experiment Design" section.

Instrument Configuration

Filters: u'g'r'i'z'	Slit:	Fiber cable:
Grating/grism:	Multislit:	Corrector:
Order:	$\lambda_{\rm start}$:	Collimator:
Cross disperser:	$\lambda_{\rm end}$:	Atmos. disp. corr.:

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