

**National Research Council of Canada, Herzberg Institute of Astrophysics**  
**DAO 1.8-m TELESCOPE OBSERVING TIME REQUEST**  
**Quarter: 2004C**

1. Title of the Program (*may be made publicly available for accepted proposals*):  
**Sloan Photometric Metallicity Estimators from Spectroscopically Confirmed High-Metallicity, Solar-Type Stars**

2. Principal Investigator: **Chris Laws**  
 Postal address: University of Washington, Astronomy Department Box 351580 Seattle, WA 98195-1580  
 Fax: (206) 685-0403                      Phone: (206) 221-7949                      E-mail: laws@astro.washington.edu

3. Co-Investigators:  
 Ana Larson    Institute: University of Washington    E-mail: larson@astro.washington.edu

4. Summary of the Program (*may be made publicly available for accepted proposals*):  
 We propose to collect high S/N, 5-color Sloan Filter photometric data for approximately 30 nearby, metal-rich, Solar-type stars. Each of our targets has been previously identified via either high-resolution spectroscopic studies or analyses of Stromgren colors to have  $[Fe/H] > 0.00$  – in some cases in excess of  $[Fe/H] = 0.40$ . This program is being carried out in conjunction with an ongoing survey, led by the PI, of photometrically identified high-metallicity systems using the ARC Echelle Spectrograph at Apache Point Observatory. The goal of our study is to develop a spectroscopically calibrated set of photometric metallicity estimators utilizing the Sloan color set, and specifically tailored to identify high-metallicity systems. Additionally, this program is being carried out in collaboration with the University of Washington's Undergraduate Observing Program, and has been designed to provide our students with an observing experience which is straightforward in its execution, yet scientifically timely and useful to the wider astronomical community.

5. Summary of the Observing Run Requested:

Instrument	Detector	Filters and/or Central Wavelengths			
Optical Imaging	SITe5 - imaging	Sloan u',g',r',i',z' filters.			
# of nights	Contract?	Moon (d)	Opt. LST at 0:00 HST	Min. LST at 0:00 HST	Max. LST at 0:00 HST
4	NO	14	Any	N/A	N/A

6a. Is this a Thesis Project?    NO                      6b. If yes, indicate supervisor:    —

7. Special instrument or telescope requirements:

8. Scheduling constraints and non-usable dates:  
 We request that observing dates be assigned on weekends, ideally including a Thursday or a Monday night, between July 1 and August 20, 2004 to accomodate the schedules of our student observers.

9. Is this program conducted in relation with other observations (optical, radio, space)?  
 NO

**10. Scientific Justification and References** (*science background and objectives of the proposed observations: 1 page maximum*):

Current studies of stars known to harbor planetary companions have revealed that these systems are to be preferentially found amongst stars with metallicities equal to or greater than that of the Sun (Reid 2002; Laws et al. 2003). This suggests that metallicity is at a minimum an important factor in the formation of planetary systems, and that it may also play more of a role in the star formation process than previous studies (i.e. of the stellar IMF (Kroupa, 2001)) have suggested. For this reason – the identification of likely populations of planet-bearing stars – precise and accurate measurements of stellar metallicity have become increasingly desirable. While high-resolution spectroscopic studies remain the most robust method of determining  $[\text{Fe}/\text{H}]$  values, such work is both observationally and analytically expensive and makes extremely large surveys for high-metallicity systems technically unfeasible.

Photometric studies, on the other hand, are much more readily carried out and extensive databases of photometric data already exist. In particular, the Sloan Digital Sky Survey contains 5-color photometry for tens of millions of stars – a number that no foreseeable high-resolution spectroscopic survey could hope to match – and theoretical studies suggest that the Sloan color system should be sensitive to  $[\text{Fe}/\text{H}]$  for solar-type stars (Nordhaus et al., 2002). However, estimates of metallicity based on broad-band photometry are considerably less precise than spectral results, with typical random errors  $> 0.1$  dex, compared to  $\sim 0.03$  dex from high-resolution spectra (Martell and Laughlin, 2002; Kotovena et al. 2002). Furthermore, Laws et al. 2003 found that existing photometric metallicity estimation methods suffer a systematic negative offset of  $\sim 0.1$  dex for stars with  $[\text{Fe}/\text{H}] > 0.00$  – most likely due to the lack of significant numbers of high metallicity stars in earlier calibration studies.

We therefore propose to gather high S/N photometric data in the 5-color Sloan filter set from a subset of  $\sim 30$  stars drawn from a cohort of  $\sim 300$  nearby, F-K dwarfs which we have identified through either (or both) Stromgren colors or Echelle spectra as being high-metallicity systems. All of our target stars are brighter than 9th magnitude in V, and most are brighter than  $V = 7.0$ , allowing for ready observation of multiple stars in even the short and frequently interrupted summer nights of Victoria. These data will be combined with additional spectra from the PI's ongoing survey work at Apache Point Observatory as needed to provide a spectroscopically calibrated formulation for estimating  $[\text{Fe}/\text{H}]$  values – and in particular the identification of high-metallicity systems – from Sloan colors alone.

Finally, the PI and Co-PI note that this project is being proposed as one which will be carried out by properly trained and supervised students from the University of Washington's Undergraduate Observing Program. This summer class is designed to serve as an introduction to advanced observing techniques and to prepare each student for the realities of modern astronomical observations using research-grade facilities. As such, we have specifically tailored our program to provide the students with a project which is straightforward in its execution – bright stars, standard photometric practices – while remaining timely, scientifically meaningful, and of general use to the broader astronomical community.

---

**Bibliography**

- Kotoneva, E., Flynn, C., & Jimenez, R. 2002, MNRAS 335, 1147.  
Kroupa, P. 2001, MNRAS 322, 231.  
Laws, C. et al. 2003, AJ 125, 2664.  
Martell, S. & Laughlin G. 2002 ApJ 577L, 45.  
Nordhaus, M. K. et al. 2002, 201st AAS Meeting, 16.12; BAAS 34, 1126.  
Reid, I. N. 2002, PASP 114, 306.

## 12. Targets:

Object/Field	$\alpha$	$\delta$	Epoch	Mag/Flux	Comment
HD159063	17:31:54.1	+16:49:26.5	2000	6.98	
HD159222	17:32:00.9	+34:16:16.1	2000	6.52	
HD162826	17:51:14.0	+40:04:20.8	2000	6.55	
HD164922	18:02:30.8	+26:18:46.8	2000	7.01	
HD165567	18:04:43.1	+40:05:03.0	2000	6.52	
HD170469	18:29:10.9	+11:41:43.7	2000	8.21	
HD182488	19:23:33.9	+33:13:18.9	2000	6.37	
HD182572	19:24:58.2	+11:56:39.9	2000	5.17	
HD183650	19:29:21.4	+31:36:31.1	2000	6.95	
HD186408	19:41:48.9	+50:31:30.1	2000	5.99	
HD186427	19:41:51.9	+50:31:02.9	2000	6.25	
HD187123	19:46:58.1	+34:25:10.2	2000	7.83	
HD190007	20:02:47.0	+03:19:34.1	2000	7.46	
HD190360	20:03:37.4	+29:53:48.4	2000	5.73	
HD192344	20:14:09.7	+06:35:20.3	2000	7.71	

## 13. General Target Information:

This target list is provided only as an example. We have more than 100 stars in our set of possible metal-rich systems which can be observed this summer from DAO, and the decision as to precisely which stars to observe will be determined based upon the exact dates assigned and the availability of spectra from ongoing observations at Apache Point Observatory. All magnitudes provided are V-band.

14. Publications Resulting from DAO Observations (*only the 12 most recent contained in the database are displayed*):

Larson, A.M., Yang, S.L.S., Walker, G.A.H. 1999, ASP Conf. Series 185, 170, 193

Larson, A. M., Irwin, A. W., Yang, S. L. S., Goodenough, C., Walker, G. A. H., Walker, A. R., and Bohlender, D. A. 1993, PASP, 105, 825

Larson, A.M., et al 1993, IAU Colloquium 139, 139, 384

**Disclaimer:** *In submitting this application, I acknowledge that I am aware of DAO's policy concerning public access to data after a proprietary period of one year.*

*Signature: signed via "POOPSY"*