Star clusters: basic galactic building blocks
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First results of the Southern Open Cluster Study

K. Kinemuchi,[1,2] A. Sarajedini,[2] D. Geisler,[1] F. Mauro,[1] G. Carraro,[3] S. Kafka[4] and E. Jeffery[5]

[1]Departamento de Astronomía, Universidad de Concepción, Concepción, Chile
email:[kkinemuchi, dgeisler, fmauro]@astro-udec.cl

[2]Department of Astronomy, University of Florida, 211 Bryant Space Science Center, Gainesville, FL 32611, USA
email: [kinemuchi, ata]@astro.ufl.edu

[3]European Southern Observatory
email: gcarraro@eso.org

[4]SSC/Caltech, Pasadena, CA 91125, USA
email:stella@caltech.edu

[5]Department of Astronomy, University of Texas at Austin, Austin, TX 78712, USA
email: ejeffery@astro.as.utexas.edu

Abstract. Galactic open clusters are excellent laboratories to study stellar populations that are coeval and have a common chemical composition. These clusters allow for the investigation of stellar and chemical abundance evolution, binary star systems, mass and luminosity functions, Galactic metallicity gradient, and disk structure, among other things. The Southern Open Cluster Study (SOCS) is a database of a select set of 24 open clusters with a broad range of ages and metallicities. It is an extension of the northern *WIYN* Open Cluster Study (WOCS). The main goal of both studies is to obtain comprehensive photometric, spectroscopic, and astrometric information of these key open clusters. Here, we provide an overview of the SOCS survey and present results of the wide-field photometry on two SOCS clusters, NGC 3532 and Tombaugh 2.

Keywords. surveys, open clusters and associations: individual (NGC 3532, Tombaugh 2)

1. Introduction

The Southern Open Cluster Study (SOCS) is a comprehensive study of 24 carefully selected southern open clusters. This survey is the southern extension of the northern survey, the *WIYN* Open Cluster Study (WOCS; Mathieu 2000; Sarajedini *et al.* 2003). The SOCS survey has similar science goals as the WOCS study, primarily to provide a complete and detailed analysis of the clusters through photometry and spectroscopy. This database will be an excellent resource for other studies related to open clusters and their stellar populations.

The primary goals of the SOCS survey can be described by three aspects: photometry, spectroscopy, and astrometry. Presently, our photometric campaign is nearly complete. We have achieved both wide-field and deep pencil-beam photometry for color–magnitude diagrams in a variety of optical bandpasses. For the spectroscopy of the SOCS clusters, we will obtain chemical abundances and stellar radial velocities. Combining all available kinematic resources, we will determine precise positions and proper-motion membership of the cluster stars. We will improve the astrometric information for all our SOCS clusters.

The open clusters selected for SOCS have a wide range in age (0.04–8.9 Gyr) and metallicity ($-0.5 < [\mathrm{Fe/H}] < +0.1$). A list of the SOCS clusters is presented in Table 1.

Table 1. SOCS clusters and their parameters.

Name	RA (2000)	Dec (2000)	$(m-M)$ (mag)	[Fe/H] (dex)	Age (Gyr)
NGC 2204	06:15:33	−18:39:54	12.4	−0.3	0.8
NGC 2243	06:29:34	−31:17:00	13.4	−0.4	4.5
NGC 2287	06:46:01	−20:45:24	9.3	+0.04	1.9
NGC 2360	07:17:43	−15:38:30	11.7	−0.2	0.6
Tombaugh 2	07:03:05	−20:49:00	15.9	−0.4	1.0
Melotte 66	07:26:23	−47:40:00	13.6	−0.4	2.8
NGC 2423	07:37:06	−13:52:18	...	...	...
NGC 2451	07:44:27	−37:40:00	7.6	−0.5	0.04
Berkeley 39	07:46:42	−04:36:00	13.8	−0.2	7.9
NGC 2477	07:52:10	−38:31:48	11.3	+0.01	0.7
NGC 2516	07:58:04	−60:45:12	8.4	+0.06	0.1
NGC 2506	08:00:01	−10:46:12	13.0	−0.4	1.1
NGC 2547	08:10:09	−49:12:54	8.4	−0.16	0.36
NGC 2539	08:10:37	−12:49:06	10.9	+0.13	0.37
NGC 2546	08:12:15	−37:34:42	10.2	+0.12	0.74
IC 2395	08:42:30	−48:09:00	9.5	...	0.16
NGC 2660	08:42:38	−47:12:00	13.2	−0.2	1.1
NGC 3532	11:05:39	−58:45:12	8.6	−0.02	0.3
NGC 3680	11:25:38	−43:14:36	10.1	−0.1	1.2
NGC 3960	11:50:33	−55:42:24	12.7	−0.2	0.7
NGC 4103	12:06:40	−61:15:00	12.0	...	0.27
CR 261	12:37:57	−68:22:00	12.5	−0.1	8.9
NGC 5822	15:04:21	−54:23:48	10.3	−0.02	0.7
IC 4651	17:24:49	−49:56:00	10.1	+0.1	1.1

To demonstrate the spatial distribution of the open clusters, Figure 1 shows where the clusters are located in an Aitoff plot with Galactic coordinates. Figure 2 shows the metallicity distribution of the SOCS clusters with respect to log(age).

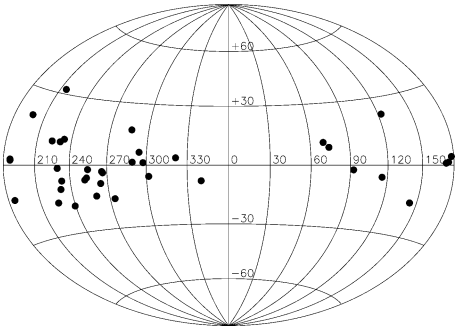

Figure 1. Aitoff plot in Galactic coordinates of the WOCS/SOCS clusters.

2. Data acquisition for photometry

For the wide-field photometry, all data were obtained at the *Warsaw 1.3m telescope* at Las Campanas Observatory and the *1.0m telescope* at Cerro Tololo Inter-American Observatory (CTIO), Chile. The open clusters were observed in 2005 and 2007 during four separate observing runs. The *Warsaw telescope* had a MOSAIC CCD camera with a field of view of $34' \times 34'$. The open clusters were observed in the Johnson $BVRI$ filters

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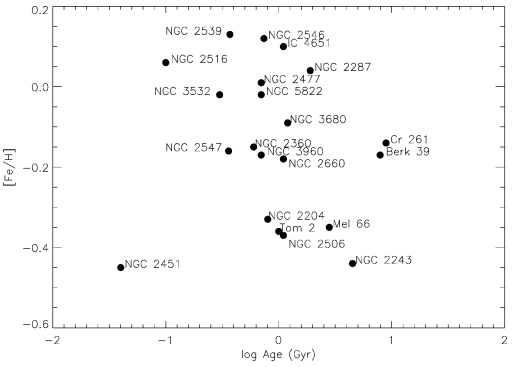

Figure 2. Distribution of the SOCS clusters with respect to metallicity and log(age).

with three different exposure times. Six open clusters were observed in $UBVRI$ filters at the *CTIO 1.0m*, which covered a smaller region ($20' \times 20'$).

To perform point-spread-function photometry on the images, we developed a pipeline which interfaced with the stand-alone version of DAOPHOT IV (Stetson 1987, 1994). All data from the *Warsaw 1.3m telescope* were processed and each open cluster is being systematically photometered. In these proceedings, we present our preliminary results of two SOCS clusters from our photometric campaign.

3. Wide-field photometry results

We present color–magnitude diagrams (CMDs) of the SOCS open clusters NGC 3532 and Tombaugh 2. We provide our results with a preliminary photometric calibration of the CMDs. Further work is underway to determine the final standard calibration and to perform a careful analysis of the stellar populations.

3.1. *NGC 3532*

For this relatively metal-rich open cluster, we present in Figure 3 the CMD. Even with the strong field contamination, we can clearly see the cluster's main sequence and a hint of the turnoff. Data for this CMD was culled primarily from the inner three MOSAIC chips of CCD camera at the *Warsaw telescope*.

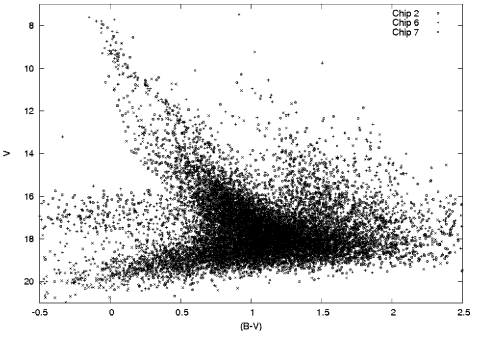

Figure 3. Color–magnitude diagram of NGC 3532.
(Data from the three inner MOSAIC chips.)

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3.2. *Tombaugh 2*

Data for Tombaugh 2 were also obtained at the *Warsaw 1.3m* in 2007. The CMD in Figure 4 is also done with a preliminary calibration, but the diagram is composed of data from all eight chips of the MOSAIC camera. There is still heavy field contamination. However, one can see the main-sequence turnoff and the stars associated with the cluster's red clump. Standard calibration and analysis of Tombaugh 2 is currently underway.

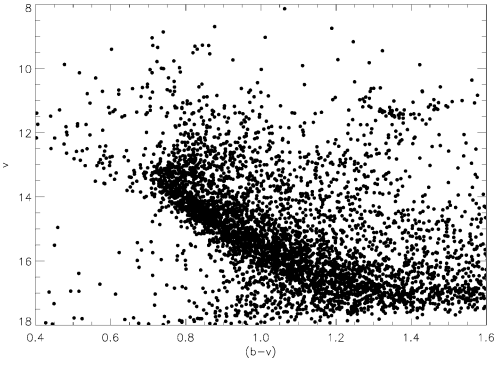

Figure 4. CMD of Tombaugh 2.

4. Future work

The SOCS project is now finishing up the optical-photometry portion but has delved into near-infrared (NIR) photometry. We have NIR data for two SOCS clusters taken with the ISPI instrument at the CTIO *Blanco 4.0m telescope*. The NIR data will be particularly useful in understanding the binary-star population in these open clusters (see Robitaille *et al.* 2007; Frinchaboy & Nielsen 2008). Projects are planned for the spectroscopy of the SOCS clusters, mainly to investigate their chemical abundances in detail.

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