The Globular Cluster M69: Color-Magnitude Diagram and Variable Stars

M. E. Escobar, M. Catelan, M. Zoccali (PUC), H. A. Smith (MSU), B. J. Pritzl (Macalester), A. Layden, J. Gregorsok (BGSU), D. L. Welch (McMaster), T. Webb (Leiden)

Abstract We present BV photometry and the results of a search for stellar variability in the Galactic globular cluster M69. The resulting color-magnitude diagram shows a great contamination by field stars. In our variability search we found 62 variable stars, 54 of which being new discoveries.

M69 is a fairly metal-rich globular cluster ([Fe/H]= -0.71) that is considered part of the bulge population of GCs. Although it has a red HB, some recent studies have suggested a blue extension on its HB. This means that it may have an unknown RR Lyrae (RRL) star population. It this is the case, we could be in presence of another second-parameter metal-rich Galactic GC, as the well-known cases of NGC 6441 and NGC 6388. The study of this types of clusters is essential in our understanding of the second-parameter phenomena.

This work is based on *B*,*V* images collected with the Warsaw 1.3m telescope in Las Campanas over a one-week run in April 2003. The images were taken using the 8k CCD camera, a 8-chip array. Here we present the results of the first three chips, covering a field of 27'x18'. The photometry was performed using DAOPHOT II / ALLFRAME (Stetson 1987) and the variability search was made with ISIS 2.2 (Alard 2000) and the task TRIAL of ALLFRAME.

Color-Magnitude Diagram

Due to the location of M69 near the Galactic center, its Color-Magnitude Diagram (CMD) shows severe contamination by field stars (Fig. 1). To obtain a cleaner CMD we performed a statistical star subtraction. We compared M69's CMD with the CMD of a control field located at 9.4' from the cluster. In addition, we apply a star selection by magnitude and distance from the cluster centre. The resulting CMD is showed in Fig. 2. We can see a deep CMD that shows a stubby red Horizontal Branch (HB), but no HB blue extension could be confirmed or rule out only in the basis of this CMD, being also necessary to analyze the RRL star population. Since M69 and 47 Tucanae ([Fe/H] = -0.76) share similar CMD morphology and metallicity, we compared our calibrated photometry with 47 Tuc's ridgeline as published by Hesser et al. (1987) (Fig. 2). We found $\Delta(m\text{-}M)_0 = 1.54$, which is consistent with the values published by Harris (1996, revision 2003). The reasonable match between the M69 data and the 47 Tuc ridgeline confirms that the clusters have similar metallicities and ages.

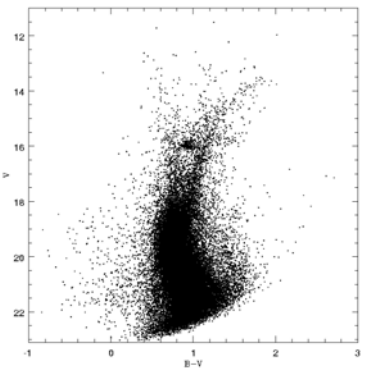

Fig. 1: Color-magnitude diagram for M69. We can see how the field star contamination prevents to visualize clearly all the evolutionary sequences.

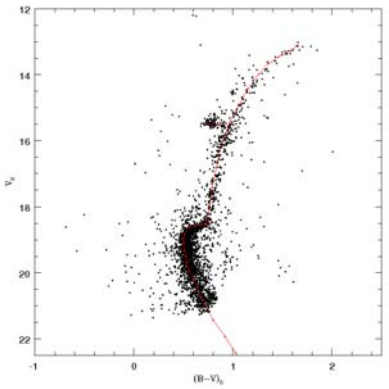

Fig. 2: Comparison between M69 CMD and the ridgeline of 47 Tucanae. This CMD was obtained performing a statistical star subtraction and also applying a star selection in terms of their magnitudes and distance from cluster centre.

Variable Stars

We detected 62 variable stars, 8 of which had already been detected and/or catalogued. The majority of the 54 newly discovered variable stars are short-period variables, among which we confirm 9 RR Lyrae stars, 7 SX Phe and 11 eclipsing binaries (see Fig. 3). Also we were able to detect 18 LPV candidates, but no period determination or light curve construction was possible for these kind of variable stars due to the limited timespan of our observations. We located the RRL stars in the M69 CMD using the ALLFRAME magnitudes, which represent a reasonable first approximation (see Fig. 4). We discard cluster membership for 6 of the 9 new RRL found, based in both, distance to the cluster core and photometric information. For the remaining 3 candidates, only one fall inside M69's tidal radius but it is located slightly below HB level, being their HB star status under discussion. For the other two stars, we could discard their membership only by looking their distances from cluster centre, but a more precise determination of their mean magnitudes are needed to definitely rule out this possibility.

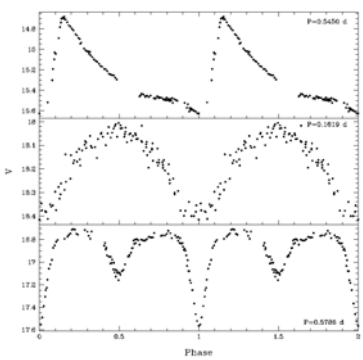

Fig. 3: Examples of *V*-band light curves for three types of short-period variable stars found in our search. From top to bottom: a RR Lyrae star, a SX Phe and a eclipsing variable star candidate. Their periods (in days) are indicated in each panel.

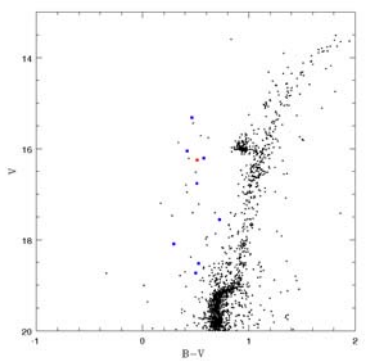

Fig. 4: M69 CMD zoom-in of the HB and RGB areas, showing the location of the 9 newly RR Lyrae stars discovered (squares). The red square represent a RRL star candidate whose HB status is still uncertain (see text).

By the analysis of M69's CMD and its RRL star population we conclude that M69 don not have a blue HB extension as suggested by Ferraro et al. (1994) and then it would not be another second-parameter Galactic GC.

The analysis of the properties of 3 RRL stars detected is still in progress, being not possible to perform a Oosterhoff group classification for M69 at this point of time.

More analysis will be done in order to stablish with accurancy cluster properties as well as variable star population properties for this cluster.

Acknowledgments: MEE and MC were supported by Proyecto Fondecyt Regular #1071002; MEE also acknowledges Proyecto ALMA-Conicyt #3107001 and Proyecto Financiamiento Basal PFB06 for their support. HAS was supportted by NSF grant AST 02-05813; and BJP by a CAREER award AST 99-84073.