

# The Globular Cluster NGC 5286: Color-Magnitude Diagram and Variable Stars

M. Zorotovic (ESO/PUC), M. Catelan, M. Zoccali (PUC),  
H. A. Smith (Michigan State Univ.), B. J. Pritzl (UW Oshkosh)

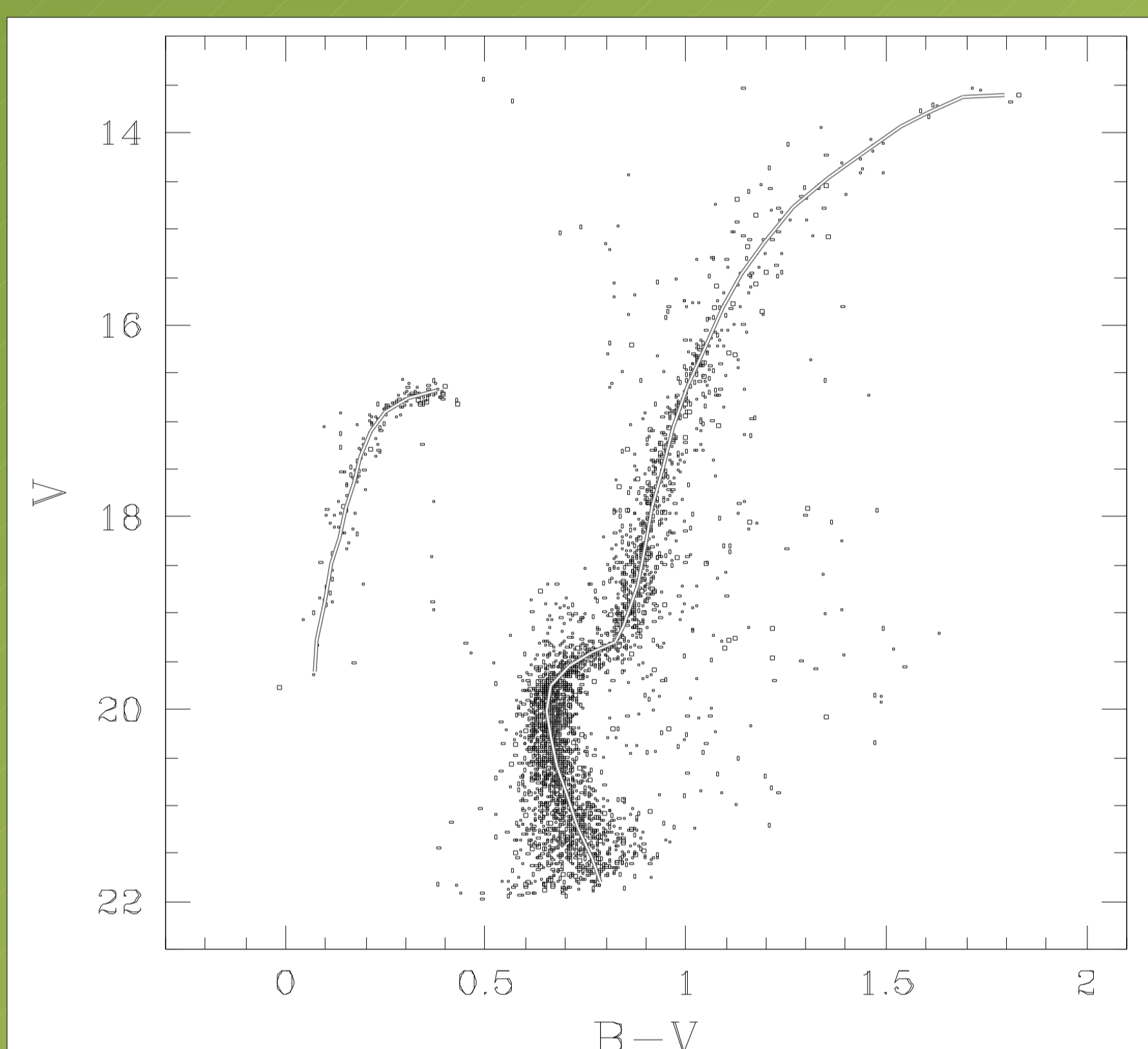
## Abstract

We present  $BV$  photometry and the results of a search for stellar variability in the globular cluster NGC 5286 (Zorotovic et al. 2009a, 2009b), which has tentatively been associated with the Canis Major dwarf spheroidal galaxy. Our results indicate an Oosterhoff type II for the cluster, which is unusual for an object of extragalactic origin.

**The Cluster:** NGC 5286 is a globular cluster of intermediate metallicity ( $[Fe/H] = -1.67$ ) in Centaurus. It is very bright ( $M_V = -8.61$ ) and fairly compact, with a half-light radius of only  $0.69'$  (values from Harris 1996). To our knowledge, no modern variability study has been carried out for this cluster. A study of its variable star population appears especially interesting in view of its **suggested association with the Canis Major dwarf spheroidal galaxy** (e.g., Crane et al. 2003).

**Images:**  $B, V$  images were collected over a one-week run in April 2003 with the Warsaw 1.3m telescope at Las Campanas Observatory. The images were taken using the 8kCCD camera, an 8-chip array.

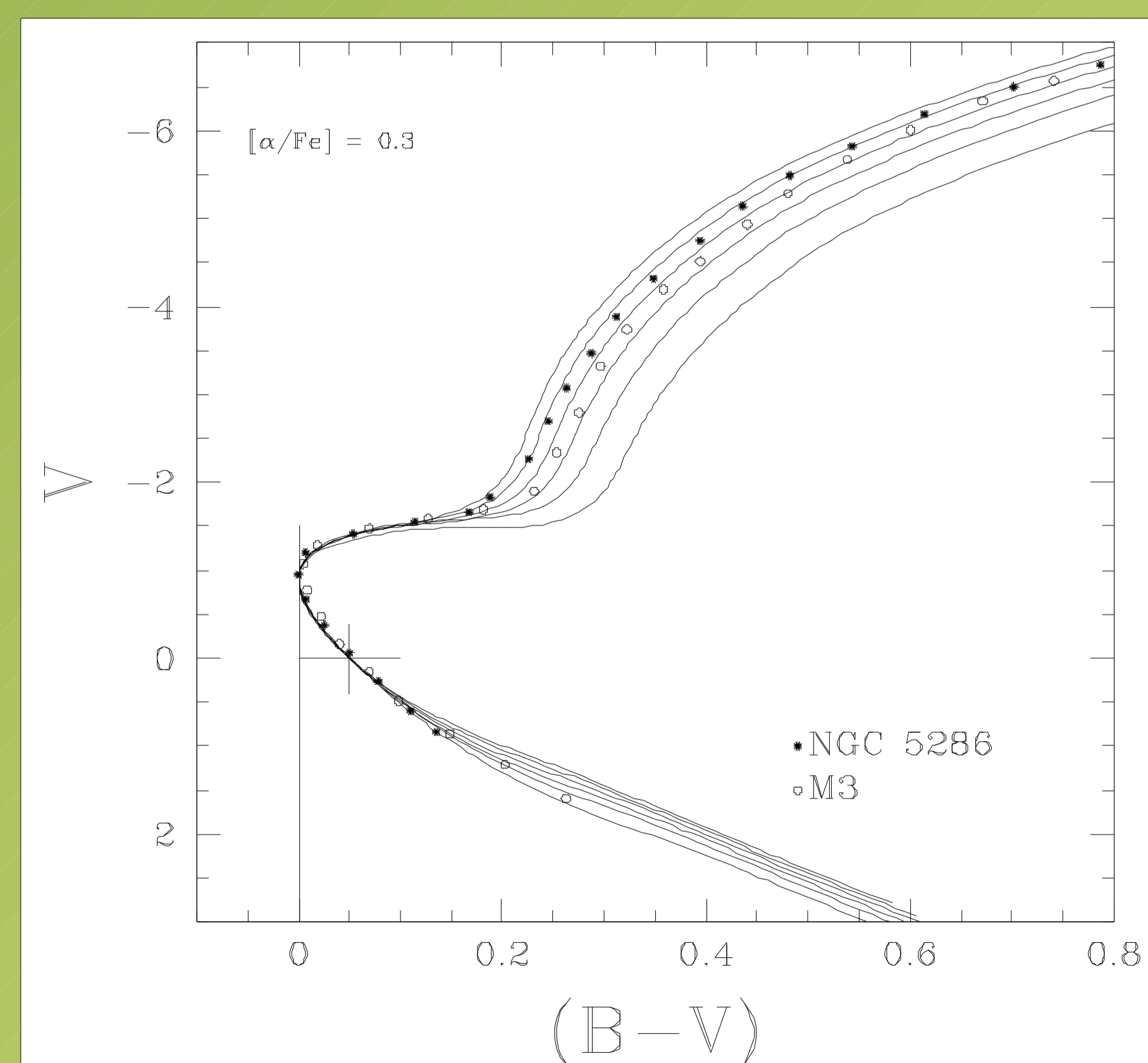
Here we present the results for chip 2, covering a field of  $9' \times 17'$ , and where the cluster dominates. We use chip 3 to select field stars to perform statistical decontamination. The photometry was performed using DAOPHOT II/ALLFRAME (Stetson 1987), and the variable stars search was carried out with ISIS v2.2 (Alard 2000).



**Fig. 1:** Color-magnitude diagram for NGC 5286.

**Color-Magnitude Diagram:** Figure 1 shows the CMD obtained using PSF photometry.

We compare NGC 5286 with M3, a well-studied cluster of similar metallicity. Figure 2 shows the fiducial points of M3 (Rey et al. 2001) and NGC 5286. Vandenberg et al. (2006) isochrones for  $[Fe/H]_{ZW} = -1.71$ ,  $[\alpha/Fe] = 0.3$  and ages ranging from 8 to 18 Gyr are also shown.



**Fig. 2:** Comparison of M3 and NGC 5286 with theoretical Vandenberg isochrones. Models and data were registered as recommended in Stetson et al. (1999).

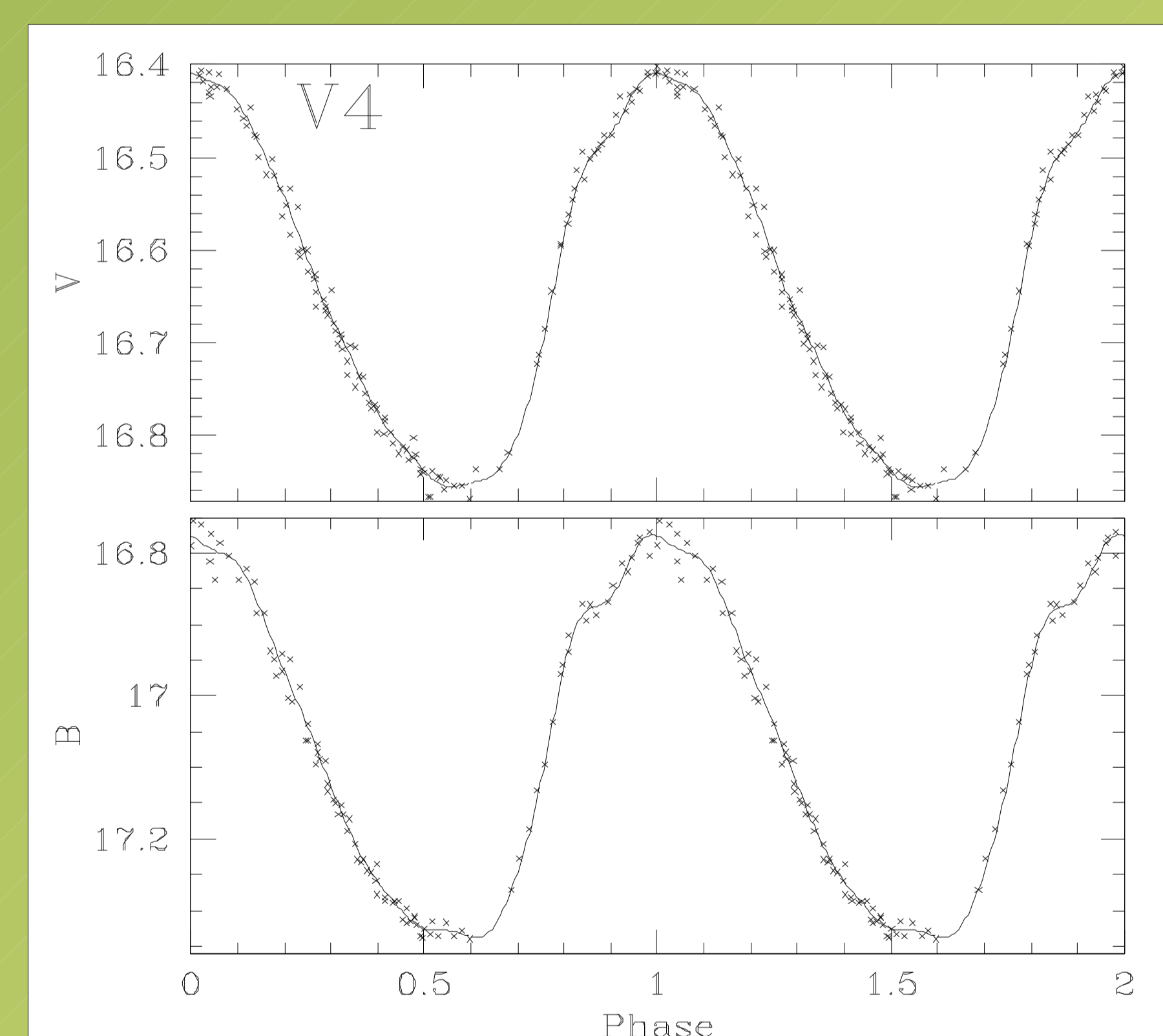
As in Stetson et al. (1999), the isochrones and fiducial points for both clusters were shifted horizontally to match each other's turnoff colors (*vertical line*), and then shifted vertically to register the point on the upper main sequence that lies 0.05 mag redder than the turnoff (*cross*). Based on this figure, we can see that NGC 5286 is around 2 Gyr older than M3.

**Metallicity:** Ferraro et al. (1999) derived a set of metallicity indicators in terms of RGB parameters. We use equations from Table 4 in Ferraro et al. to estimate the metallicity for NGC 5286 (Table 1). We obtain a mean value of  $[Fe/H]_{CG97} = -1.47 \pm 0.02$  in the Carretta & Gratton (1997) scale and a global metallicity  $[M/H] = -1.26 \pm 0.02$ . That give us a value of  $[Fe/H]_{ZW} = -1.70 \pm 0.10$  in the the Zinn & West (1984) scale, in good agreement with Harris (1996).

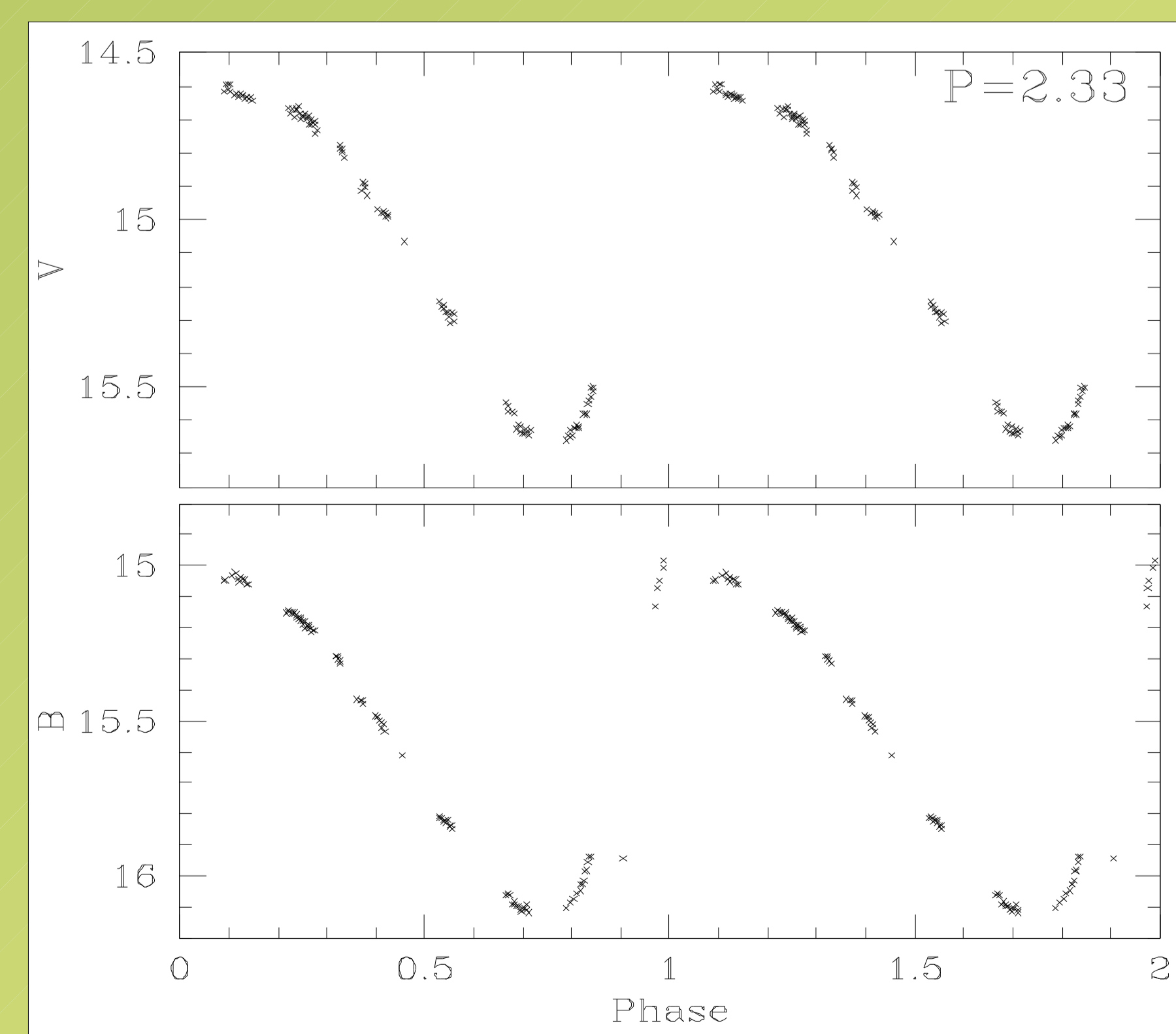
Parameter	$[Fe/H]_{CG97}$	$[M/H]$
$(B - V)_{0,g} = 0.762$	-1.48	-1.27
$\Delta V_{1,1} = 2.154$	-1.48	-1.28
$\Delta V_{1,2} = 2.470$	-1.46	-1.27
$\Delta V_{1,4} = 2.950$	-1.44	-1.24
$S_{2,5} = 5.648$	-1.50	-1.25
$S_{2,0} = 6.903$	-1.47	-1.26
Mean	$-1.47 \pm 0.02$	$-1.26 \pm 0.02$

**Table 1:** NGC 5286 metallicity estimates based on a variety of RGB parameters.

**Variable Stars:** In our variability search we found 51 RR Lyrae stars (22 RRc, 29 RRAb), 4 LPV's, and 1 type II Cepheid (BL Herculis). Periods were derived using phase dispersion minimization (PDM; Stellingwerf 1978).



**Fig. 3:** Examples of  $V$ -band light curves for one RRAb variable (*top*) and one RRc variable discovered (*bottom*) in NGC 5286.



**Fig. 4:**  $V$  and  $B$ -band light curves for the type II Cepheid discovered in our field.

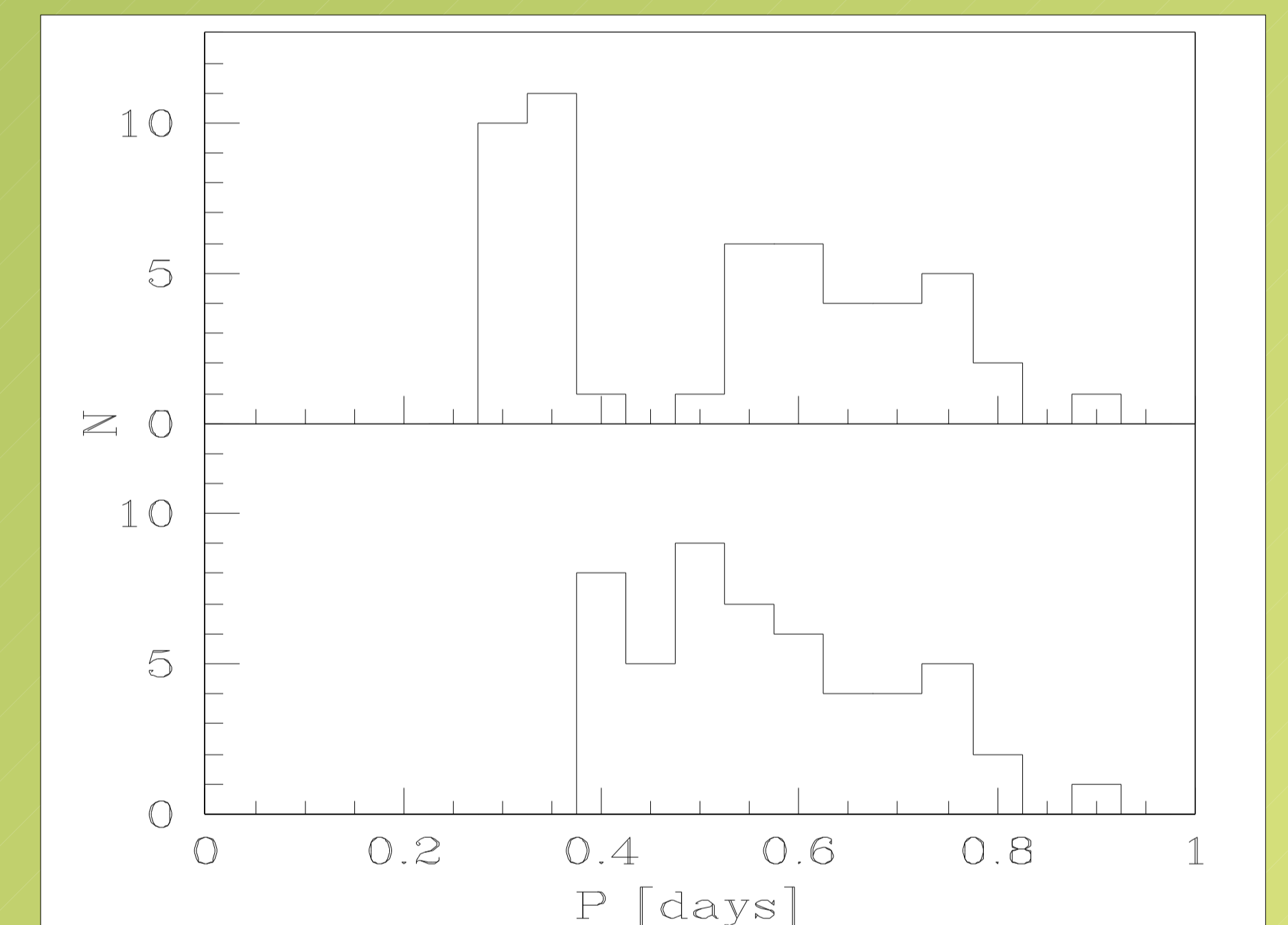
Figure 3 shows an example of 2 RR Lyrae variables detected (1 RRAb and 1 RRc). Crosses represent the data, while the continuous line shows a Fourier fit. Figure 4 shows the  $B$  and  $V$  light curves for the detected Cepheid.

For the RR Lyrae variables, we also performed a Fourier analysis to obtain several parameters, revealing a metallicity of  $[Fe/H]_{ZW} = -1.68$ , in good agreement with the value previously found.

**Oosterhoff Type:** Figure 5 shows the period distribution for our RRL variables, suggesting an Oosterhoff (1939) type II for the cluster. Average periods and c-type number ratio are as follows:

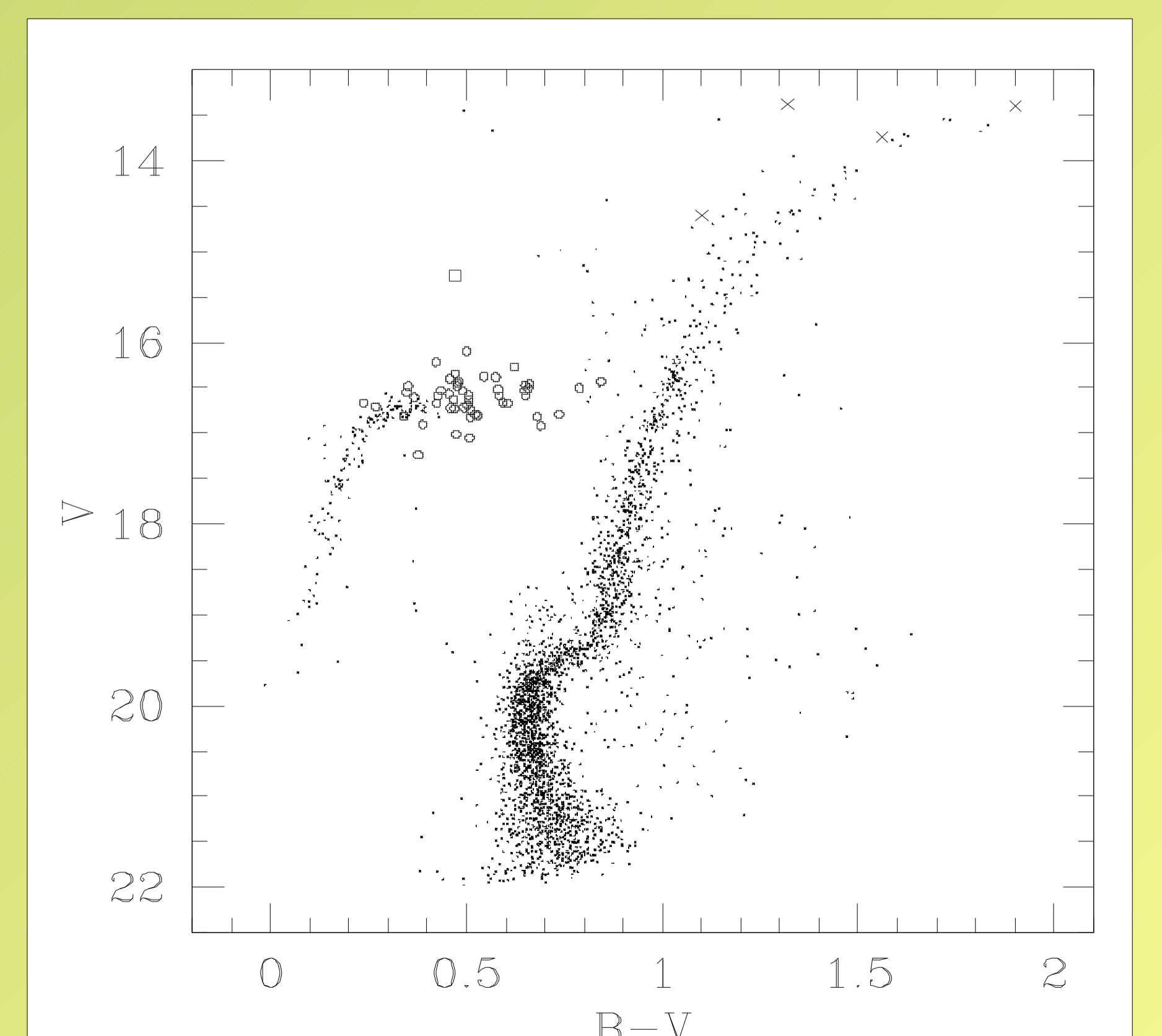
$$\begin{aligned} \langle P_{ab} \rangle &= 0.652 \text{ d} \\ \langle P_c \rangle &= 0.333 \text{ d} \\ N_{RRc}/N_{tot} &= 0.43 \end{aligned}$$

Clement et al. (2001) found the mean periods for RRAb variables in Galactic globular clusters to be 0.559 days for Oosterhoff type I clusters and 0.659 days for type II clusters. Our values, in addition to the position of the cluster in a period-amplitude diagram (not shown), confirm NGC 5286 as an OII cluster. This is unusual for globular clusters of extragalactic origin (Catelan 2009), which may pose a problem for its suggested association with the CMa dwarf spheroidal galaxy.



**Fig. 5:** *Top:* Period histogram for the NGC 5286 RR Lyrae stars. *Bottom:* Same as in top but fundamentalized the periods of the RRc's

Using the average magnitudes obtained with the Fourier analysis, we have also located the variable stars in the NGC 5286 CMD (Fig. 6). We can see that all the RR Lyrae stars (*open circles*) are properly located at the HB level. The 4 LPV's (*crosses*) are around the RGB/AGB and are probably Mira or SR stars. The type II Cepheid (*open square*) is also shown.



**Fig. 6:** NGC 5286 CMD, indicating the location of the 57 variable stars detected.

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