Search for variables in the globular cluster M 56

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The latest Catalogue of Variable Stars in Galactic Globular Clusters (Clement et al. 2001) lists 12 variables in the field of the cluster M 56 (NGC 6779). Five of them are surely non-members. Russeva (1999) reported four additional long period red variables which are probable members. On the base of photographic surveys V4 and V12 proved to be RR Lyrae and V1 a BL Her type star (Wehlau & Sawyer Hogg 1985). The core of the cluster, however, has not investigated yet in the points of view of variability.

We carried out the first CCD variable search in the globular cluster M 56 in the framework of the globular cluster variable star survey at Konkoly Observatory.

The data

The observations were made by a CCD camera attached to the 1m f/13.6 RCC telescope of the Konkoly Observatory located in the mountain station at Piszkéstető. The camera made by Photometrics Inc. and contains a Thomson TH7896M 16 bits chip with 1024×1024 pixels. It yields a $5' \times 5'$ field of view and $0.''288$/pixel resolution. The total amount of frames were 83 and 27 in the Johnson V and Cousins $I_{\rm C}$ bands, respectively. The

Table 1: Log of observations of M 56 at Konkoly Observatory

Date	No.		seeing
	I	V	[arcsec]
2 Jun 2000	8	12	1.5
3 Jun 2000	6	24	0.8
4 Jun 2000	6	22	0.9
5 Jun 2000	7	25	1.1

exposition time was 5 minutes for both colors during all nights. The Table 1 shows the log of observations.

The basic reductions steps, zero offset correction for each frame with its overscan value and flat fielding were made using standard tasks of IRAF[1]. Due to the quality of the camera (see for details Bakos 2000) other corrections were unnecessary.

Search for variables

The reduced images were processed using the facilities of the Image Subtracion Method (ISM, Alard & Lupton 1998, Alard 2000) as implemented in the software package ISIS-2.1[2] . All frames were shifted to a common grid and 15 from the best seeing V filter images were combined to a reference frame (see Fig. 1). Then we assume all the individual frames as a convolution of the reference image and a kernel function. The algorithm determines the kernel functions (which varies both in space and time) and subtracts each frame from the convolved reference image. The method conserves the flux of non-variable objects, and it handles the time and space variation of background as well.

A tipical result can be seen in Fig. 2. The two short period

[1]IRAF is distributed by the NOAO, operated by the Association of Universities for Research in Astronomy Inc., under contract with the NSF.

[2]Available via anonymous ftp from `http://www.aip.fr/users/alard/package.html`

variables of the field, V1 and V4 are clearly seen. The subtracted images show inhomogeneity at some positions where saturated (or nearly saturated) stars are. Due to this phenomenon the variability image made by ISIS software (Fig. 3) shows both real variables and very bright stars. However, these two groups can be separated very well by thier radial profiles: variables show standard Gaussian profile while bright stars have strange irregular ones.

The standard deviation of the ISM photomery was $\sigma_{\Delta I} = 200$ ADU, which means $\sigma_{\rm m} = 0.^{\rm m}01$ at $16.^{\rm m}5$ and $\sigma_{\rm m} = 0.^{\rm m}1$ at $19^{\rm m}$. That is, we could detect any variable with period between $\sim 0.01 - 5$ days and amplitude higher than $\sim 3\sigma_{\rm m}$. But no new variable has been found.

Colour–magnitude diagram

We prepare the V vs. $V - I$ colour–magnitude diagram (CMD) using the V reference frame and an I image combined from 5 good seeing CCD picture. PSF photometry have been implemented for both frames by standard process using IRAF/DAOPHOT task. The result is shown in Fig. 4.

In the CMD 4550 stars are plotted down to $22^{\rm m}$. To tie our observational magnitudes into the international colour system we used the only CCD study (Rosenberg et al. 2000) as a source of standard magnitude values. We choose a set of common stars which are brighter than $17^{\rm m}$ and separate enough. The resultant sequences consist of 61 and 64 stars for V and I, respectively. The relationship between observational and international colours are highly linear for both filters. Since the equations obtained by linear regressions are $V = 0.995v + 1.549$ and $I = 1.003i + 0.168$, we approximate both slopes as 1 and adopt constant zero point shifts, namely, $V = v + 1.476 \pm 0.043$ and $I = i + 0.209 \pm 0.051$.

The question of membership

In our special point of view the most important part of the CMD is the the area of instability strip. Accepting reddening value $E(B-V)$ as 0.20 (Rosenberg et al. 2000) the RR Lyrae instability strip is between $0.61 < V - I < 0.86$. We marked 19 stars locating there by larger coloured symbols in Fig. 5. Two of them are known variables and members: V1 and V4 (red points).

Are marked stars members of the cluster or not? The two radial velocity study Webbink (1981) and Harris et al. (1983) assign 11 stars which are surely members. Using these stars

Table 2: Positions and relative proper motions of suspected instability strip stars. Column 1 denotes Küstner's number, 'F' comment indicates a probable field star.

No.	x [″]	y [″]	μ_x [″/100 y]	μ_y [″/100 y]	comment
146	−104.81	58.69	−0.201	0.479	F
177	−78.52	86.16	0.086	−0.488	F
262	−13.78	31.48	−0.277	0.076	
278	−3.37	27.96	−0.079	−0.038	
297	2.69	−92.52	0.112	−0.112	
321	14.47	134.92	0.316	0.324	F
329	21.19	75.81	0.138	0.239	
342	29.10	0.45	−0.116	0.084	
361	44.12	−30.64	−0.169	0.068	
392	70.04	−96.41	−0.019	0.661	F
430	105.58	−10.24	0.092	0.170	
434	116.37	103.78	0.219	0.593	F
	−20.49	−12.43			
	−10.75	−15.57			
	−3.90	−2.62			
	90.73	49.98			
	117.40	134.96			

as a reference we transformed the Küstner catalogue positions (Küstner 1920) into our frame. We can identify 12 stars among 17 stars lying in the instability strip with Küstner's stars. Determined relative proper motions (where $\mu_{\rm cluster} = 0$) are shown in Table 2. We found five probable field stars on the basis of membership criteria $|\mu| < 0.''3$ /100 years given by Rishel et al. (1981) (denoted by open symbols in Fig. 5). Since the proper motion information alone is not sufficient to decide the membership we cannot take a definite statement for other 7 stars. In the case of remaining 5 stars we have no any informations about their membership.

Although, the statistics of the field stars in the galactic direction of M 56 allow that all marked stars are in the field, radial velocity measurements would be necessery to solve the problem.

References

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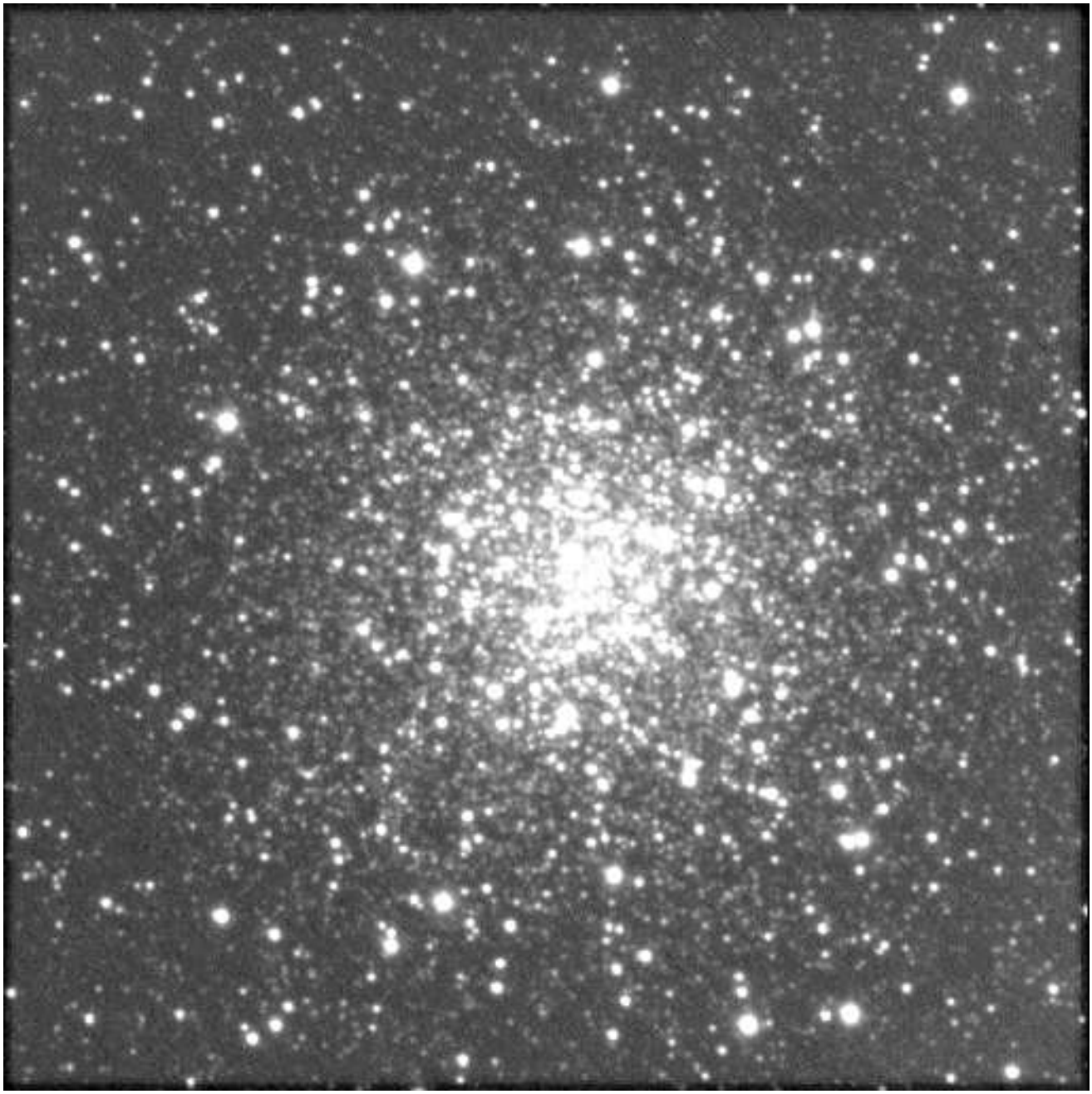

Figure 1: The V reference image of M 56 combined from 15 CCD frames with 5 min exposition time. North is down, east is to the left, the field is $5' \times 5'$.

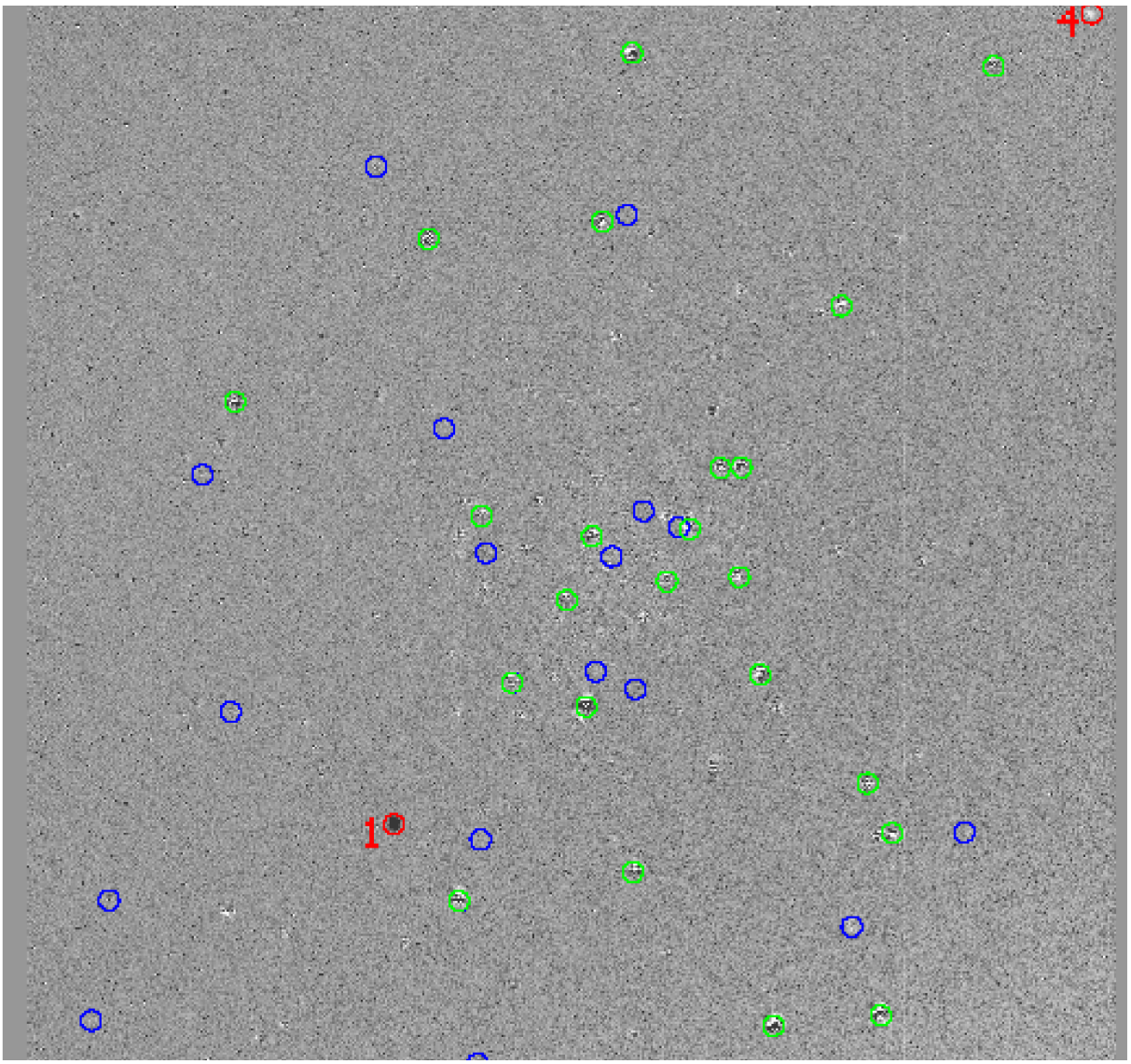

Figure 2: A sample subtracted image of M 56. The field is the same as in Fig. 1. Blue circles denote the suspected variability strip stars, red ones show the known variables. The brightes stars are marked by green symbols. (Some of them are long period red variables.)

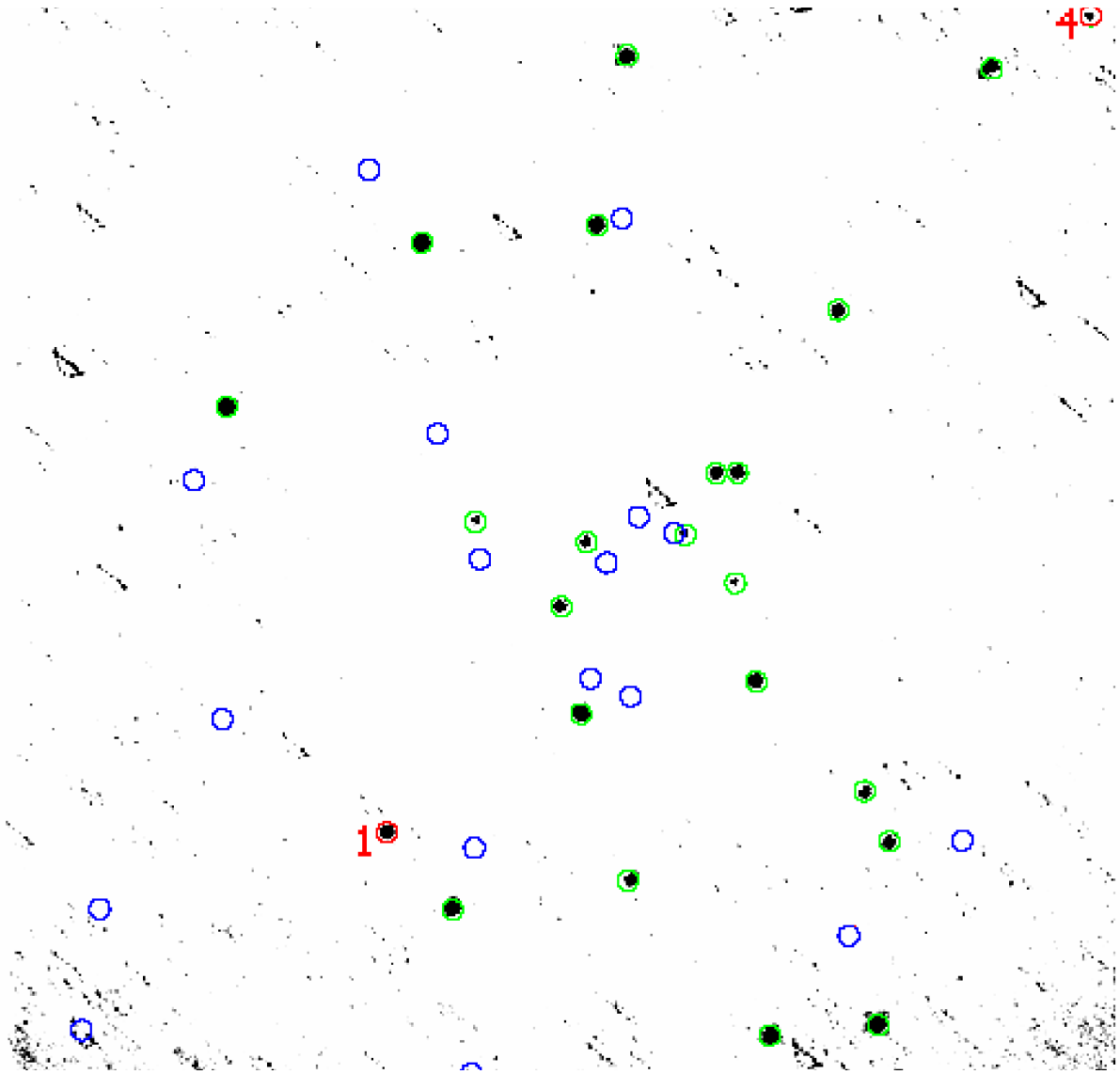

Figure 3: The variability image of M 56 obtained from ISM. The field and notation are the same as in Fig. 2

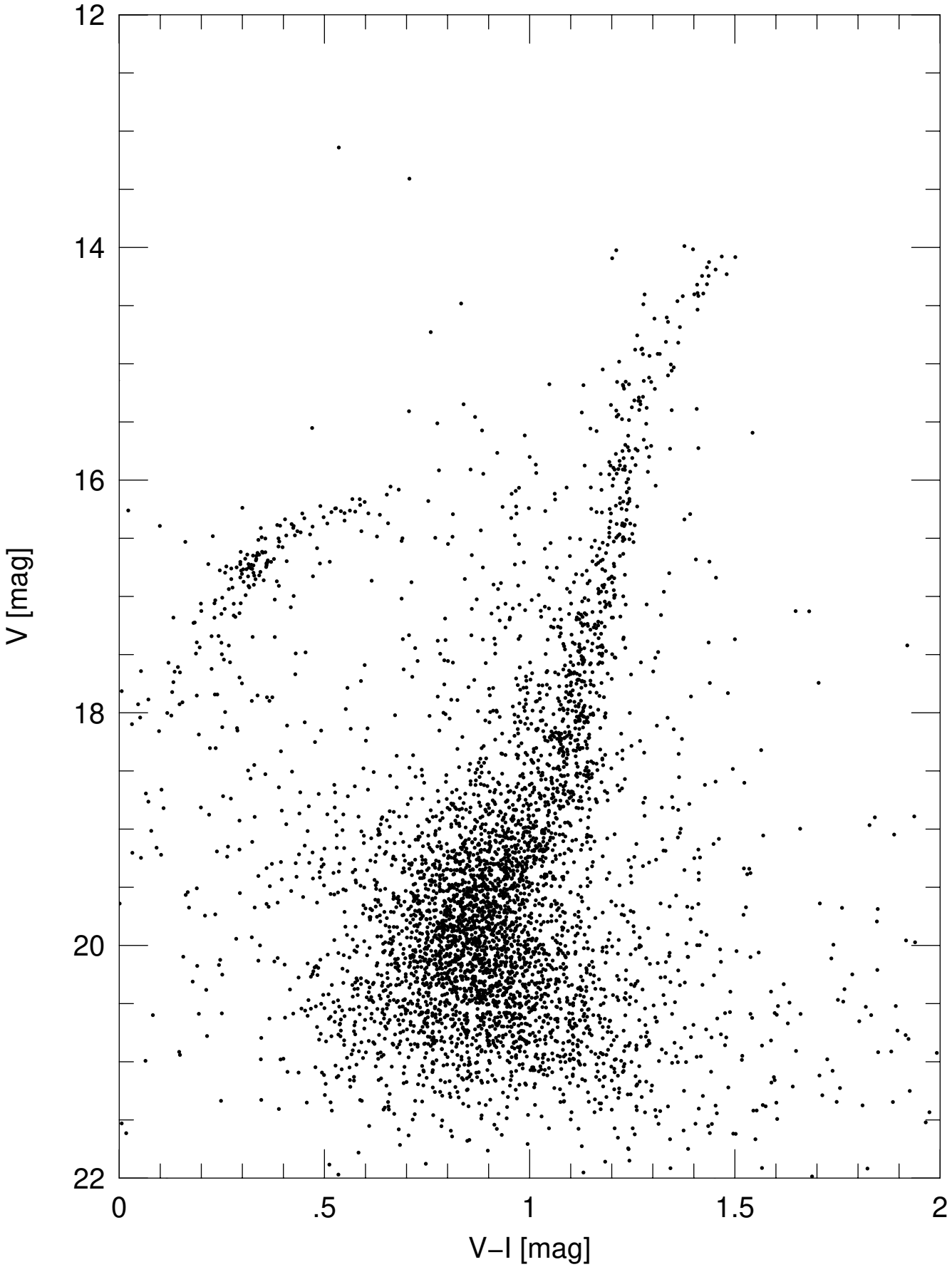

Figure 4: The colour–magnitude diagram of M 56.

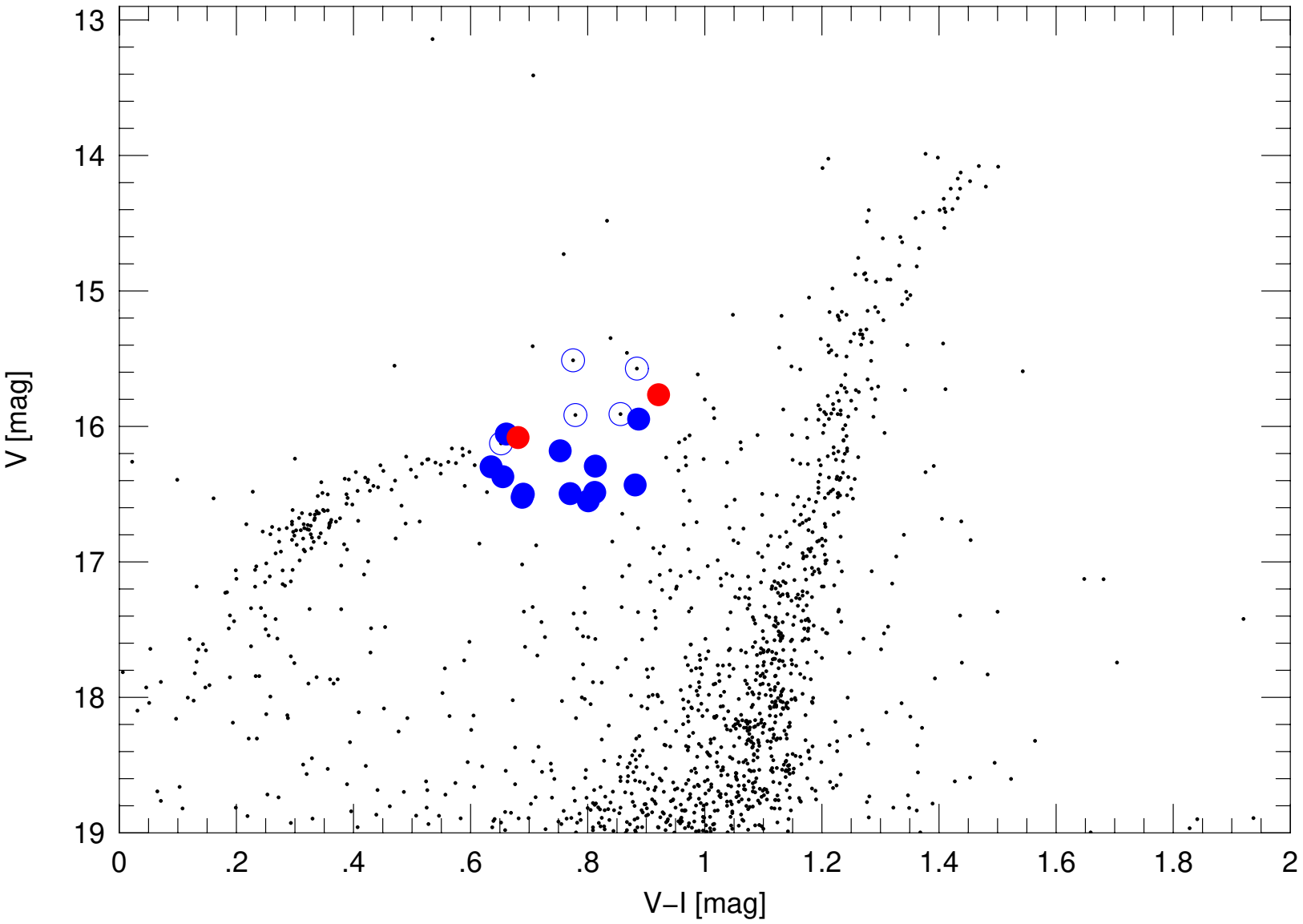

Figure 5: Stucture of the instability strip of M 56. The red points denote the variables V1 and V4, blue symbols the investigated suspected variable strip stars. The probable non-members are marked by open symbols.