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C32, A Young Star Cluster in IC 1613

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ABSTRACT

The Local Group irregular galaxy IC 1613 has remained an enigma for many years because of its apparent lack of star clusters. We report the successful search for clusters among several of the candidate objects identified many years ago on photographic plates. We have used a single HST WFPC2 pointing and a series of images obtained with the WIYN telescope under exceptional seeing conditions, examining a total of 23 of the previously published candidates. All but six of these objects were found to be either asterisms or background galaxies. Five of the six remaining candidates possibly are small, sparse clusters and the sixth, C32, is an obvious cluster. It is a compact, young object, with an age of less than 10 million years and a total absolute magnitude of $M_V = -5.78 \pm 0.16$ within a radius of 13 pc.

Subject headings: galaxies: individual (IC 1613) – galaxies: star clusters

1. Introduction

Baade (1963) remarked on the fact, which he obviously considered remarkable, that the irregular galaxy IC 1613, a member of the Local Group that he had studied quite intensively, appeared to be devoid of star clusters. This fact was again discussed by van den Bergh (1979), who compared IC 1613 with the SMC, pointing out that the SMC's many rich clusters are so conspicuous that, if IC 1613 has any, they should show up clearly on available plate material. Hodge (1978) had searched photographic plates taken with the Palomar Observatory's 5m and the Lick Observatory's 3m telescopes and published a list of 43 possible candidates for clusters, all of which were very inconspicuous, none having more than 6 resolved stars on the best images. Clearly, these objects were not comparable to the rich star clusters of the Magellanic Clouds, but he thought that at least some of them might be similar to small Galactic open clusters like the Pleiades. More recently Freedman (1988), in her CCD-based study of the color-magnitude diagram (CMD) of a portion of IC 1613, noted that she could not identify those candidate clusters that should have been visible on her images. On the other hand, Georgiev et al. (1999) observed a field centered on the most active area of star formation (east of our present field), identified 12 of the earlier cluster candidates and measured integrated UBV magnitudes for eight, six of which they found to have colors indicating ages of less than 10 million years. They also identified two new small, young clusters. They searched for massive clusters, either young or old globular clusters, but found none. For a related discsussion of the young massive cluster populations in galaxies and their correlations with integrated galaxy properties see Larsen & Richtler (2000).

Thus it has been clear that IC 1613 must be poor in rich star clusters compared with the Magellanic Clouds, a fact which van den Bergh at-

tributed to the lack of a history of strong shocks. But it has not been clear whether or not IC 1613 is lacking in a significant number of normal open clusters, as most of the published candidate clusters have not been examined on anything but the original photographic plates. This paper reports the results of a study of some of these candidates using HST and WIYN[1] telescope images.

2. Observational Material

For our cluster search we have used multi-color images of IC 1613 that were obtained to study the stellar populations in IC 1613 , which have been fully discussed elsewhere (Cole et al. 1999). One set of images is a single pointing of HST centered near the geometrical center of IC 1613 at RA = 1^h 04^m 48.7^s, declination = $+02^\circ$ $07'$ $06.2''$ (J2000). WFPC2 images were taken with the F439W, F555W and F814W filters. All are available from the HST Data Archive (PID 6865). The other set was obtained by the WIYN telescope at Kitt Peak towards the same position using a CCD detector and B, V and I filters, taken under 0.6 arcsec seeing conditions.

Both sets of images are centered on the HI "hole" (Skillman 1987; Lake & Skillman 1989; Westpfahl et al. 1996) at the center of the galaxy and do not include the most active star-forming regions, which are concentrated primarily to the east of these images (Hodge 1978; Hodge et al. 1990; Price et al. 1990). The WIYN images are 6.8 arc minutes on a side, providing an area of 46.24 square arc minutes, while the entire area of IC 1613, to the V = 25 magnitudes per square arcsec isophote, is 283 square arc minutes. Thus the region surveyed here is about 16% of the main body of the galaxy.

3. Survey Results

The HST images included only two of the previously-identified cluster candidates, nos. 22 and 33, both of which had been considered faint and doubtful. The HST images revealed both to be small asterisms, with no indication of the presence of any physical clustering of stars (Fig. 1).

The WIYN images covered an additional 21 candidate clusters. One of these, cluster C32, has the appearance of a true, small but bright cluster (Fig. 2). Five other candidates are possible examples of small, very sparse clusters, for which the WIYN images are not definitive. The others are either small asterisms or background galaxies with foreground stars superimposed, making them appear to be star clusters when imaged with insufficient resolution. Table 1 lists the candidates examined and their disposition.

4. Cluster C 32

Cluster C32 (Fig. 2) is a small cluster located near the center of OB association No. 5 (Hodge 1978). The OB association is involved with HII region S2 (Sandage 1971), which is cataloged as HLG 13 (Hodge et al. 1990). The cluster is thus located in a small area of current star formation. The entire WIYN image is shown in Figure 3 with the position of C32 indicated.

Figure 4 shows the radial distribution of stars in the cluster and its surroundings. The half-light diameter of the cluster is only of the order of 2.0 arcsecs. One arcsec at IC 1613's distance (Lee et al. 1993) corresponds to 3.5 parsecs, implying that cluster C32 is approximately 7 parsecs across, making it similar in size to many small young open clusters in the Milky Way Galaxy.

Photometry of the stars in the WIYN B and V images was extracted using the PSF-fitting software DAOPHOTII and ALLSTAR (Stetson 1994). The magnitude zeropoints were determined via comparison with the B and V photometry of Freedman (1988). We first determined an astrometric solution for the WIYN data using the Digitized Sky Survey images available from the Space Telescope Science Institute. We then matched together the positions of relatively bright stars measured by Freedman in her Field 1 that appear in our WIYN images. The average offset between our instrumental psf-fit magnitudes and Freedman's photometry was determined using a total of 24 and 25 stars in B and V, respectively. The rms scatter for the sample of comparison stars was 0.05 magnitudes in both filters.

Figure 5 is a color-magnitude diagram that shows the positions of the few well-separated stars

[1]The WIYN Observatory is a joint facility of the University of Wisconsin-Madison, Indiana University, Yale University, and the National Optical Astronomy Observatories.

of C32 detected in both B and V superimposed on the CMD of the entire field of the WIYN images. Clearly the cluster is very young, with a main sequence that extends to $M_V = -5$. There are too few stars to establish a definitive age from the CMD, but the cluster is clearly younger than about 10 million years, a conclusion that agrees with its position in a young OB association that is enveloped in an HII region.

To measure the integrated magnitude and color of C32, we first calculated the background as the mean flux in an annular region between $6''$ and $8''$ from the center of C32. This value was then subtracted from the flux within a circular aperture of radius 13 pc. The error in the flux was determined by randomly choosing 100 aperture centers within a $1.6' \times 1.6'$ area surrounding C32. At each of these positions, we calculated the flux and background using the same aperture and sky annulus as used for the cluster. The resulting flux values had an average of zero and a standard deviation that we assume as the probable error in the aperture magnitude of C32. Assuming a foreground reddening of E(B−V)= 0.025 (Schlegel et al. 1998), the integrated color and magnitude of C32 within a radius of 13 pc are $M_V = -5.78 \pm 0.16$ and $(B-V)_0 = -0.19 \pm 0.08$. These values of color and absolute magnitude are fully consistent with those of small young star clusters in other galaxies, such as M31 (Hodge et al. 1987).

It is interesting to make a quantitative comparison of the cluster density in IC 1613 with that in other galaxies. We have counted the number of star clusters found in the LMC on small-scale plate surveys (approximately equivalent in physical scale and limiting absolute magnitude to the WYIN survey of IC 1613) in three areas each equal in physical size to the WYIN IC 1613 field and located at a corresponding optical surface brightness. While we have found only one certain star cluster in the IC 1613 field, the LMC fields averaged 81 ± 9 clusters. Details of this comparison, as well as comparisons with other galaxies, are given in Hodge (2000).

5. Conclusions

We have surveyed the central area of IC 1613 for star clusters. There are no globular clusters or massive young clusters present, but there are six very sparse groupings that may be open clusters like some of the smaller ones in our Galaxy. One of them, previously cataloged as C32, is a very young cluster embedded in an HII region and surrounded by an OB association. When the uncertain nature of many of the cluster candidates, their very small sizes and their implied small stellar populations are taken into account, it is clear that IC 1613 is a cluster-poor galaxy.

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Figure Captions

Fig. 1.— The WFPC2 V image of the central area of IC 1613 with the positions of cluster candidates C22 and C33 indicated.

Fig. 2.— Cluster C32, from the WIYN image in V.

Fig. 3.— The entire WIYN V image of the central $6.8' \times 6.8'$ area of IC 1613 with North up and East to the left. The position of cluster C32 is indicated.

Fig. 4.— The radial profile of cluster C32 (large dots and solid line), determined from the WIYN V image. The horizontal line indicates the average value in an annular region between $6''$ and $8''$ from the center of C32. The dashed line is the profile of an isolated star in the image scaled to the peak brightness of C32.

Fig. 5.— The color-magnitude diagram of cluster C32 (large dots) and the field of the entire WIYN image. The error bars represent the average errors in color and magnitude as a function of magnitude.

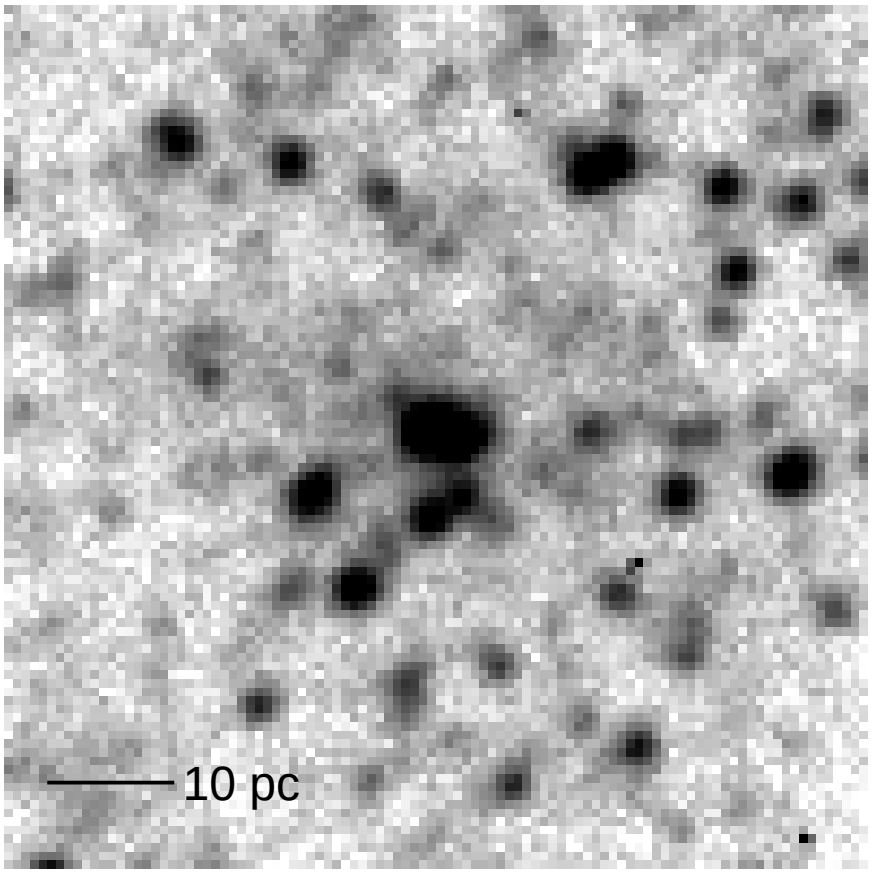
This 2-column preprint was prepared with the AAS LaTeX macros v5.0.

TABLE 1
THE NATURE OF THE CLUSTER CANDIDATES

Cluster No. from Hodge (1978)	Description
C 9	asterism
C 19	probable asterism
C 20	asterism
C 21	galaxy
C 22	asterism
C 23	possible red cluster
C 24	asterism
C 25	asterism
C 26	possible cluster
C 27	possible cluster
C 28	possible cluster
C 31	asterism
C 32	cluster
C 33	asterism
C 34	galaxy pair?
C 35	asterism
C 36	asterism
C 37	asterism
C 38	asterism
C 39	asterism or galaxy
C 41	asterism
C 42	possible loose cluster
C 43	probable asterism

This figure "fig1.jpg" is available in "jpg" format from:

http://arXiv.org/ps/astro-ph/0002439v1


10 pc

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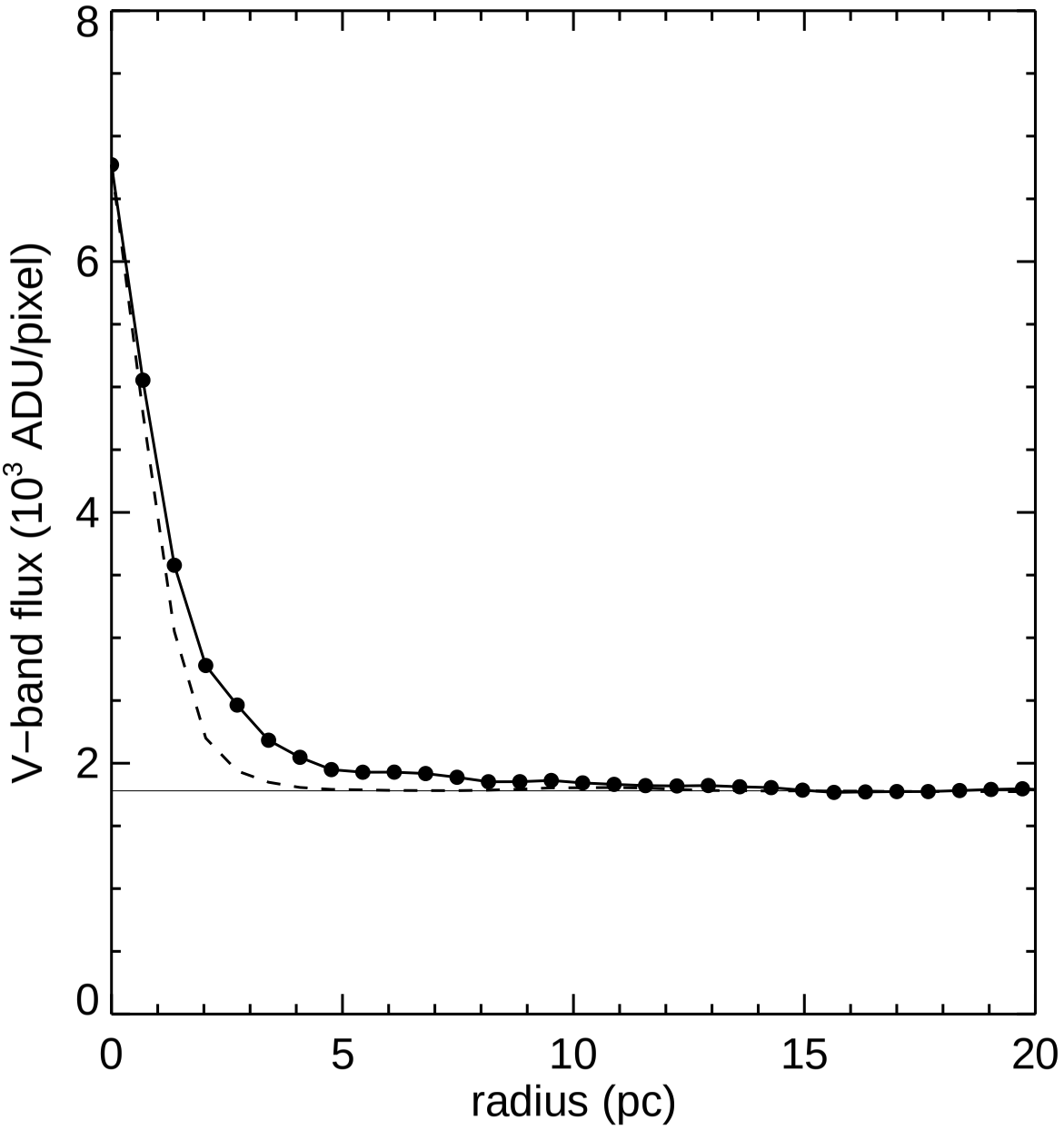
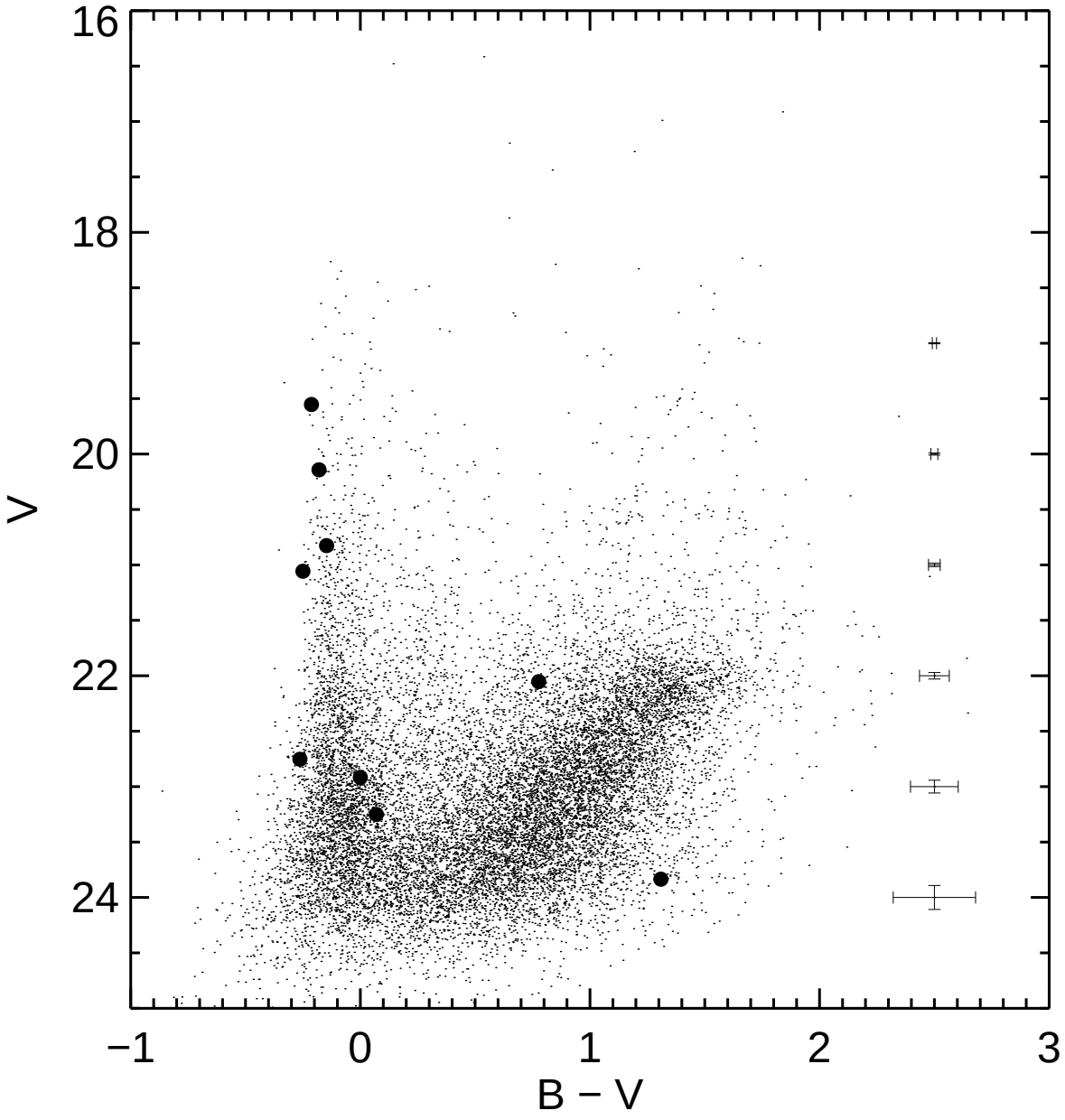

8
6
4
2
0
V−band flux (10^3 ADU/pixel)
0
5
10
15
20
radius (pc)


16
18
20
22
24
V
−1
0
1
2
3
B − V