Wide-Field Imaging Survey of the Dwarf Irregular Galaxy NGC6822

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1. Introduction

The dwarf irregular galaxy NGC6822 is one of well-studied galaxies in the Local Group (e.g., Gallart et al. 1996; Wyder et al. 2000). Being located at relatively close to us but at isolated environment, it is a good target to investigate the resolved stellar population and gas content (and connection between them) in detail. This galaxy is also notable by active star-forming regions which are well resolved and detailed study have been carried out.

Recent discovery of extended HI gas around NGC6822 by de Blok and Walter (2000) draws an interest : what is going on around this galaxy viewed in large scale ? To answer this question, it is necessary to search for the stellar population which should be distributed around the galaxy. We therefore carried out a wide-field optical imaging survey around NGC6822. The optical information, together with gas information, will shed light on the nature - formation and evolution - of NGC6822.

2. The Observation and Data Analysis

The data was obtained with Subaru Prime Focus Camera (Suprime-Cam) on the 8.2m Subaru Telescope (Fig. 1) on Oct 14 and 18, 2001. Suprime-Cam is a mosaic CCD camera consists of 10k x 8k pixels. Ten MIT 2k-4k CCDs are tiled in 5x2 array which covers a field of view of 34'x27' with 0.2 arcsec per pixel sampling. We observed 2 fields centered on NGC6822 in B, Rc and Ic bands (Fig. 2). The total exposure times for each field are 1440sec (B), 2160sec (Rc) and 1320sec (Ic), respectively, and typical image size was about 0.8 arcsec (FWHM).

FIg.1 8.2-m Subaru Telescope at Mauna Kea.

The data have been reduced with a dedicated software for Suprime-Cam data analysis and mosaic images for each band are created. The objects which are brighter than 2-sigma of sky background are detected from these images and photometric parameters are measured (deblending is carried out if an detected object has multiple peaks). The number of objects detected are 287907 (B), 274433 (Rc) and 331115 (Ic), respectively. Note that many objects are missing at the center of the galaxy where stars are so crowded that the detection software does not work well. Stars are discriminated from background galaxies using shape parameters.

In the following analysis, we use B- and R-band data since I-band image is saturated at fainter magnitude than others due to high sky background. The final catalog consists of 63058 stars down to m_B=24 (extinction corrected), which corresponds to B=0.5. We adopt distance modulus of (m-M)=23.49 and extinction correction given in Gallart et al. (1996).

3. Color-Magnitude Diagram (CMD)

The color-magnitude diagram (CMD) of stars in the surveyed field is shown in Fig. 3. Magnitudes at which saturation of CCD begins (m_B=17.9 and m_R=18.6) are drawn as red lines for reference. The notable featurs are,

- blue branch at B-R=0 which consists of young MS stars in NGC6822,
- yellow branch at B-R=1 which consists of foreground Galactic stars (though the brightest ones are saturated),
- red stars at B-R> 2.5.

Note that the saturation in R-band does not allow us to investigate the red super giants in NGC6822.

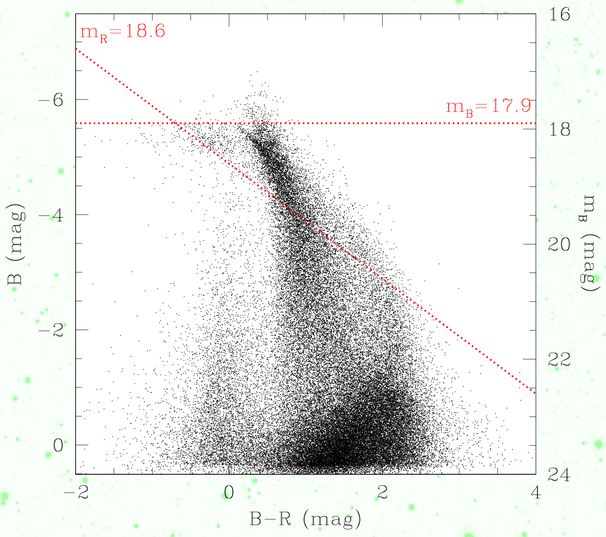

Fig.3 Color-Magnitude Diagram of stars in the surveyed field.

4. Spatial Distribution of Stars

4.1. Red Star Distribution

The spatial distribution of redder stars than B-R=2.4 is shown in Fig. 4. Stars around the main body of NGC6822 (8000<x<10000, 4500<y<8500) are not detected due to the limitation of the detection software. We found that red stars are distributed almost spherically around the center of NGC6822 and this red star halo expands to about 3kpc in diameter. These stars are thought to be 1-10 Gyr old AGB stars with certain metallicity (Gallart et al. 1994).

4.2 Blue Star Distribution

Fig. 5 shows the spatial distribution of blue stars (B-R<0.5).Stars around the galaxy center are not detected due to the limitation of the detection software. We found completely different distribution for blue stars: they spread widely from south-east to north-west where number density of stars is low. This blue star distribution implies that there were recent star formation activities along this direction.

This blue star distribution almost coincides with the HI distribution reported by de Blok & Walter (2000; See Fig. 6). This suggests that these stars had formed from HI gas. Hence, the investigation of stellar population in this region is necessary to understand the nature of HI gas distribution. We further investigate the stellar population in different regions denoted in Fig. 5 in the following.

5. Stellar Population in the Outer Regions of NGC6822

5.1. CMDs of Different Regions around NGC6822

Fig. 7 shows CMDs in different regions around NGC6822. There are blue stars fainter than B=-4 in the regions named "Cluster", on the other hand we see paucity of blue stars in the regions named "Field". Foreground Galctic stars are prominent at every region, which prevent us from investigating true CMDs of stars in NGC6822.

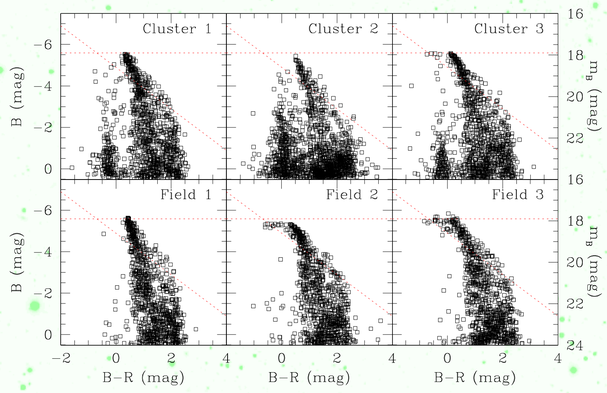

Fig.7 CMDs in different regions around NGC6822

5.2. Foreground Subtracted CMDs

The stellar population of Cluster regions is investagated subtracting foreground Galactic stars statistically. We regard Field 1-3 to be regions where stars belong to NGC6822 are rare and foreground stars are dominant. Figs. 8, 9 and 10 show the statistically foreground star subtracted CMDs for Cluster 1-3. About 950 foreground stars out of 1100-1500 stars in cluster regions are subtracted. There is remarkable blue branch of MS stars in every CMD. A group of stars which is found at B=-4 could be an artifact from statistical subtraction and saturation of CCD.

The most probable isochrone which explains the CMDs are also plotted in the figure as solid line and those of different ages are also plotted as dotted lines. We adopt a set of isochrones provided by Girardi (2001).

Cluster 1:
The best fit isochrone to the CMD seems to be that of Z=0.0004 and Age of $10^{8.25}$ yrs if we neglect a star group at B=-4. However, there are several faint red stars which seems to be older than MS stars (for example, age of $10^{8.75}$ yrs). In this case, multiple star-formation activity is necessary for this region.

Cluster 2:
The best fit isochrone to the CMD is same as that for Cluster 1 though red stars at B-R=1 are seems to be missing. It should also be mentioned that redder stars than B-R=2, which are missing in Cluster 1 and 3, are seen in this region. As is suggested by Gallart et al. (1994), these stars are thought to be intermediate to old AGB stars with certain metallicity. In Fig. 9, isochrone of Z=0.004 and Age of $10^{9.5}$ yrs is plotted in magenta line which support the finding of Gallart et al. (1994).

Cluster 3:
The CMD is primarily explained by an isochrone of Z=0.0004 and Age of $10^{8.25}$ yrs.
The CMD resembles that for Cluster 1.

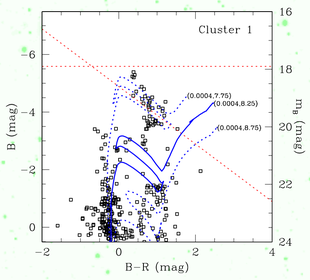

Fig.8 CMD for Cluster 1

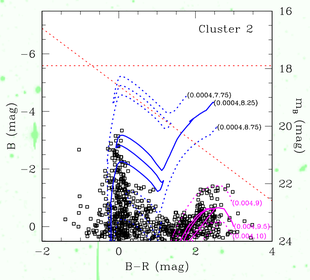

Fig.9 CMD for Cluster 2

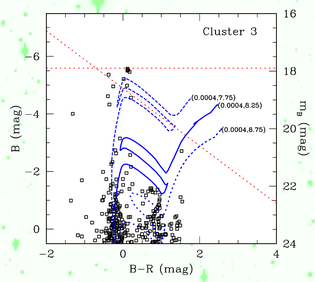

Fig.10 CMD for Cluster 3

6. Globular Cluster Candidates

We have examined the image and found two possible globular clusters. One candidate (GC1) is located at about 3kpc away from the galaxy center and the other (GC2) is at about 1.5kpc where is the edge of the red star sphere (See Fig. 4). Figs. 11 and 12 show the images of the candidates and thier radial profiles. Total magnitudes and colors are summarized below.

	B(mag)	B-R(mag)
GC1	-4.73	1.22
GC2	-5.31	1.19

The CMD for GC1 (Fig. 13) shows that

- GC1 seems to contain both red AGB/RGB stars and blue MS stars.
- Isochrone of Z=0.004 and Age of 1 Gyr seems to explain the CMD, which means GC1 had formed from metal-enriched gas.

We could not obtain CMD for GC2 since GC2 is not well resolved.

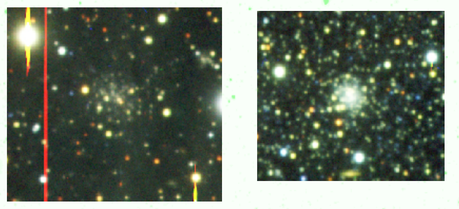

Fig.11 Images of GC candidates (Left: GC1, Right: GC2)

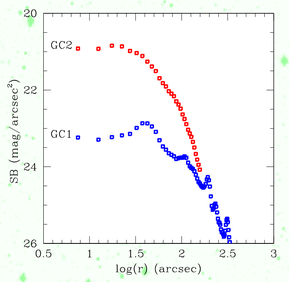

Fig.12 Radial profiles of candidates

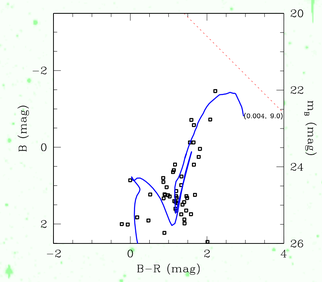

Fig.13 CMD for GC1

7. Discussion

7.1. Interaction Scenario

de Blok & Walter present an interaction scenario for NGC6822 beased on their HI observation. They suggest that a passage of north-west gas cloud triggers the recent (100Myr) star formation activity found in NGC6822.

The extended blue stellar population which are found to have formed a few 100Myr ago suggests that there occured a large-scale star formation activity over NGC6822. We found that intermediate-age to old stars with certain metallicity are populated only around the galaxy center and are seems not to be disturbed, suggesting that the interaction was not a big event which affects the shape of galaxy. In summary, our finding indicates that the interaction of small system with metal poor gas had occured a few 100Myr ago, which supports the interaction scenario given by de Blok & Walter.

7.2. Cluster 1 : A Forming Dwarf Galaxy ?

Cluster 1 is one of interesting regions since it seems to separate from NGC6822 (See Fig. 5 and 6). It is mentioned in de Blok & Walter (2000) that this "cloud" has a mass of 1.4×10^7 Ms and is suggest to be a separate system.

The CMD for cluster 1 indicates that blue stars are likely to have formed from metal-poor gas. If this is indeed the case, it is very interesting because the system has spent most of life time without star-formation activity. A mechanism to keep the system bind while supressing star formation should be considered. A deep imaging survey may reveal hidden metal poor old stellar population embeded in the system.

We estimate the total magnitude of Cluster 1 as follows. We sum up luminosities of stars of -3.5<B<0.5 in Cluster 1 and subtract the total luminosity of foreground stars, which is estimated from Field 1-3 in the same manner, and, then, obtain the total magnitude. The total manitude estimated in this way is B=-8.5 mag, though the value gives the lower limit since luminosity of stars fainter than B=0.5 is neglected. The magnitude of B=-8.5 is the lower magnitude limit of dwarf galaxies found in the Local Group (e.g., Draco and Ursa Minor). Hence, Cluster 1 could survive and evolve to a dwarf galaxy.

8. Summary

Extended blue star distribution around NGC6822, which resembles the HI gas distribution, is found. The CMDs of different regions in NGC6822 suggest that large scale star forming activity over NGC6822 had occured a few 100Myr ago. The trigger of this star formation activity is suggested to be an interaction of Cluster 1. The distribution of old stellar population is not disturbed, suggesting that the interaction was a minor event to the main body of NGC6822.
Two globular cluster candidates are found and their properties are examined.

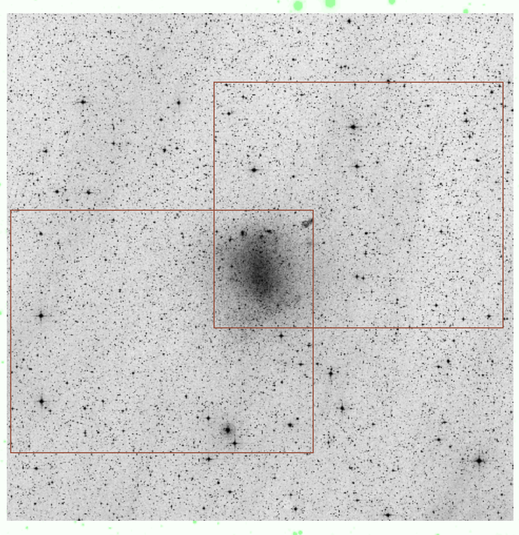

Fig.2 Our survey area overlaid on DSS image (FoV is 1 degree square)

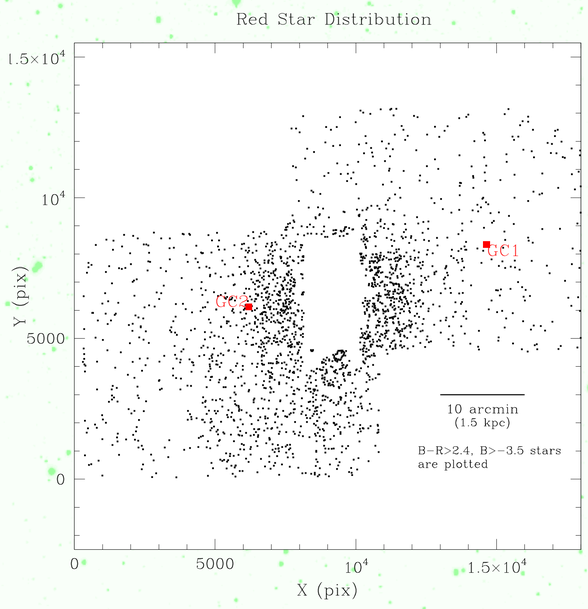

Fig.4 Red star distribution around NGC6822

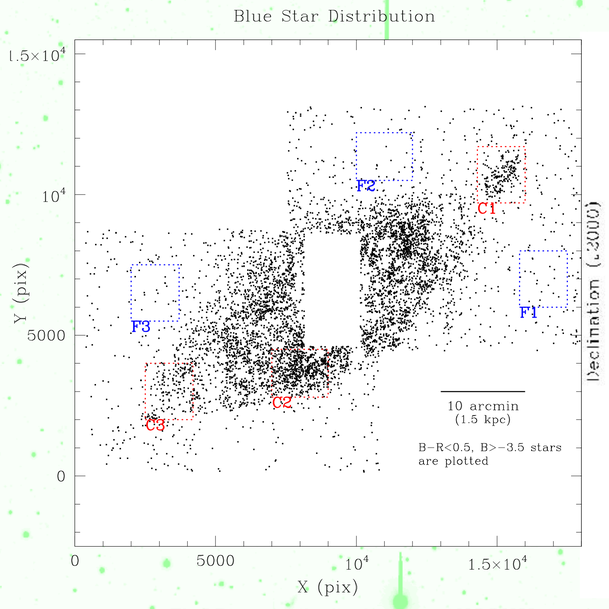

Fig.5 Blue star distribution around NGC6822

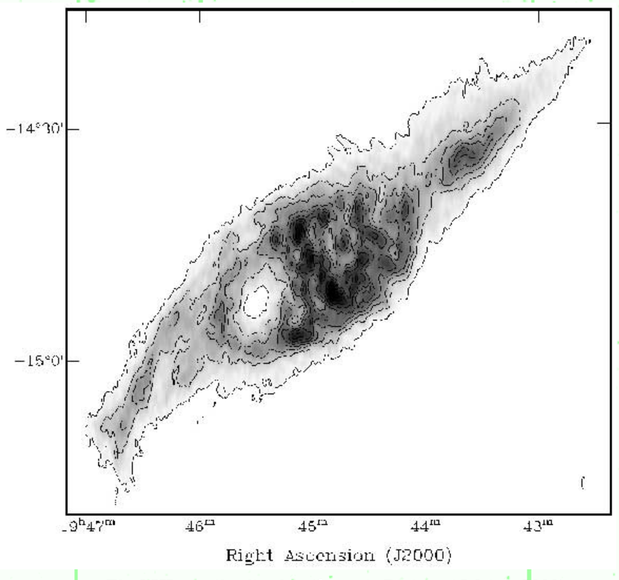

Fig.6 HI gas distribution (from de Blok and Walter 2000)