A Preliminary Photometric Study of NGC6946

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Abstract

We present UBVR stellar photometry in the spiral galaxy NGC6946. Two colour-magnitude (V,B-V),(V,V-R) and one colour-colour (U-B,B-V) diagrams were built. The internal and foreground reddening was determined. Using the method of the three brightest blue stars we made an estimation of the distance to the object, that appeared to be approximately 6 Mpc. These preliminary results may change a little during the further work.

Introduction

NGC6946 is a bright spiral galaxy with coordinates

$$\alpha_{2000} = 20^{\mathrm{h}}35^{\mathrm{m}} \qquad \delta_{2000} = 60^{\circ}10'.$$

It it visible almost onface. According to van der Bergh(1960) this galaxy belongs to the nearest giant spirals of ScI type as M101, IC342 and NGC628. In the PGC catalogue (Paturel et.al. 1992) the following characteristics were found: $\mathrm{B_T} = 9.67\mathrm{m}$ (total magnitude in B band), $\mathrm{a}_{25} = 11.4$ arcmin (diameter to 25 isophote) and $\mathrm{V_h} = +51 \pm 4$ km/sec (heliocentric radial velocity). The Galactic Latitude of NGC6946 is 11.7° that makes its study more difficult due to the higher interstellar extinction and the field contamination with stars from our Galaxy. Hubble (1936) considered that it is a member of the Local Group. In the following years a lot of different authors made distance estimations that vary between 3 and 10 Mpc. The precise determination of the distance to NGC6946 is a question of present interest, because that galaxy and its irregular dwarf companion UGC11583 are located in the middle of so called "Tully's Local Void" ang the system is free from perturbations caused from other massive stellar systems. That gives an excelent opportunity to determine the local value of the Hubble's constant.

1 Observations

The observational matherials used in that work include 12 CCD frames of the eastern field of NGC6946 and 16 frames of the photoelectric standart in the globular cluster M92. They were obtained on the 2m RCC (Ritchey-Chretien-coude) telescope of the Bulgarian National Astronomical Observatory "Rozhen". The CCD camera Photometrics, including 1024x1024 px. array was mounted in the Cassegrain focus of the instrument. In that case the scale of the optical system was 0.33 arcsec/px, that gives us an observable area 5.6x5.6 arcmin. That is why we were forced to split the object in two fields. The "eastern" field was observed during the night of 15/16 August 1998 under very good and stable photometric conditions. The seeing was about 1 arcsec. and the galaxy was resolved into stars on the 12 frames achieved during that observational run. Three frames were taken in each band. Their total duration was 3600 sec. in U and 2700 sec. in B,V,R. The standart fields were observed twice (on a different zenith distances) in order to take into account the air mass dependency. Twenty-one frames required for the flat fields were ochieved on sunset before the observations.

Figure 1: The observed field of NGC6946

2 Data reduction

For the basic reductions and the stellar photometry we used IRAF (Image Reduction and Analysis Facility). The frames taken in each band were transformed in an equal coordinate system and combined using median combination. In order to transform the instrumental magnitudes into a standart system the following equations were used:

$$V = 0.985v + 0.046(b-v) - 0.3378X - 1.565$$
$$(B-V) = 1.043(b-v) - 0.1816X - 0.376$$
$$(U-B) = 1.0066(u-b) - 0.1823X - 2.787$$
$$(v-R) = 1.1135(v-r) - 0.0916X + 0.243$$

These dependencies were obtained from the photometry of the standart fields. Some information about the stellar photometry in NGC6946 is given in Table1.

Frame	Objects	m_{lim}
U	627	21.5
B	2259	23.7
V	2646	23.8
R	4333	23.0

Table1. Photometry

All the objects that are taken into account have photometric errors smaller than 0.15m (see Figure2). That is the reason why the limiting stellar magnitude is only 23.0 in R.

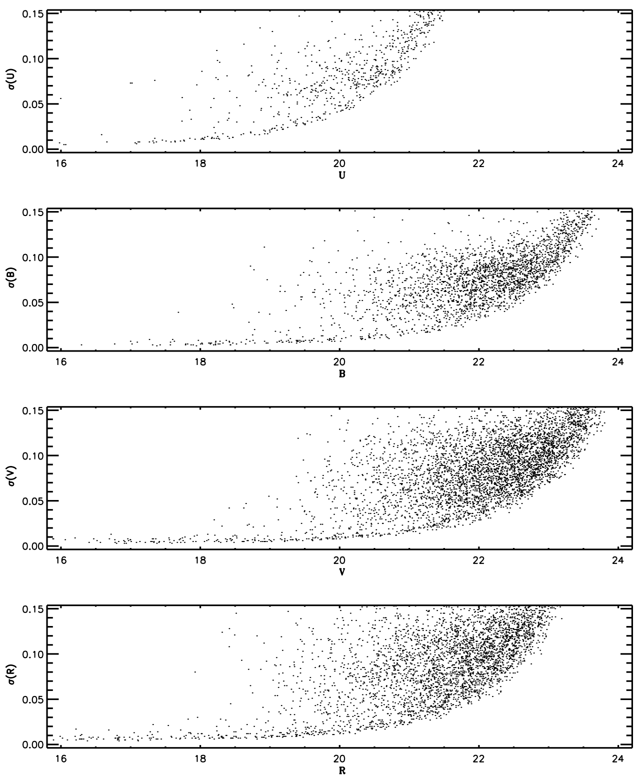

Figure 2: Internal errors of the photometry

The unusual shape of the error dependencies is due to the unsteady background in the spiral arms of the galaxy.

3 Results

On the two colour diagram (U-B,B-V) are drawn 627 objects with common photometry in U,B and V. On that diagram is visible the upper part of the Main Sequence (MS) for NGC6949 and a number of stars from the field of our Galaxy, that are grouped in the region with approximate boundaries $0 < (U-B) < 1.3$ and $0.7 < (B-V) < 1.2$.

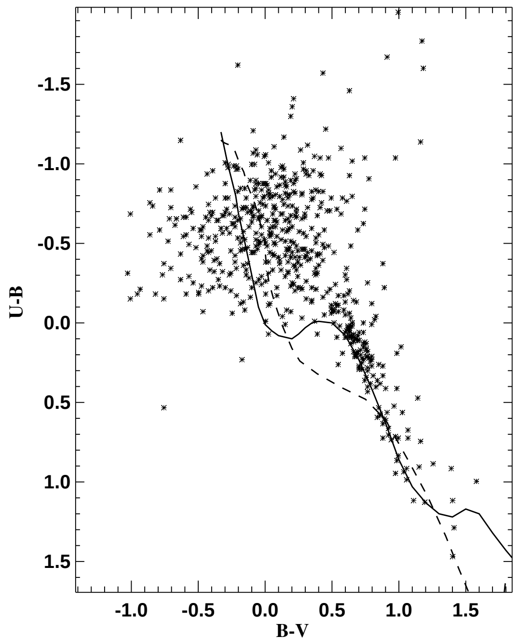

Figure 3: (U-B,B-V) two colour diagram for the objects in the observed field

The fiducial locus for the stars ot luminocity class V is drown with a solid line, while the same locus for the supergiants I_{ab} is presented with a dashed line. Using the stars from the Galaxy and the locus for luminocity class V we obtained the minimal value of the colour excess in the direction of the object

$$E_{(B-V)} = 0.19.$$

To determine the excess for the stars on the MS of NGC6946 we used the following dependence (Massey et al. 1995):

$$E_{(B-V)} = 0.332Q + 0.009,$$

where Q is the Jonson's parameter, equal to:

$$Q = (U-B) - 0.72(B-V)$$

We ochieve

$$E_{(B-V)} = 0.21.$$

And from the relation:

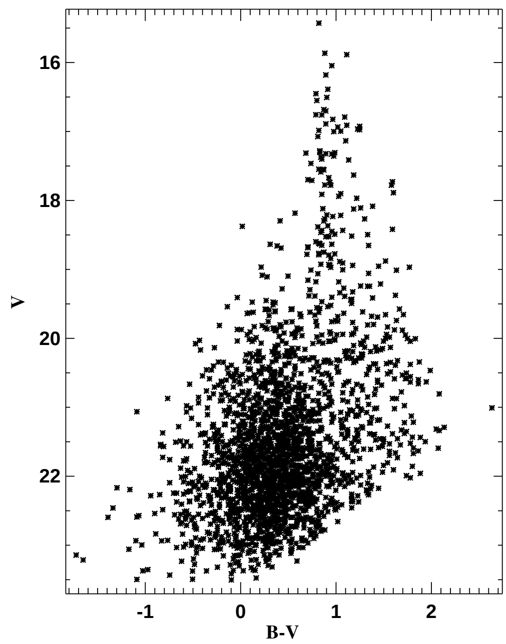

Figure 4: $(V, B-V)$ two colour diagram

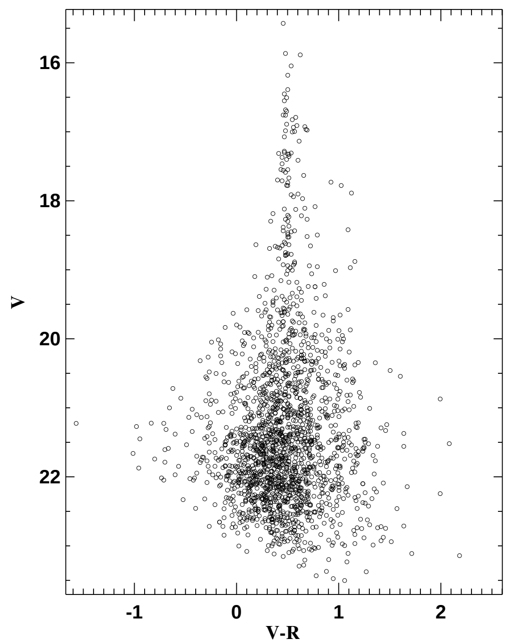

Figure 5: $(V, V-R)$ two colour diagram

$$A_B = 4.2E(B-V),$$

follows that A_B is equal to 0.93m.

On the two CM (colour-magnitude) diagrams are drawn 2259 objects for

(V,B-V) and 2846 objects for (V,V-R).

All the objects on the $(V, B-V)$ diagram have a common photometry in B and V band. The stars from NGC6946 are situated in the region with approximate boundaries $V > 20^m$ and $-0.3 < (B-V) < 1$. In that means we are able to observe about 3 stellar magnitudes from the upper part of the Main Sequence of the galaxy. The mean magnitude of the three brightest blue stars, taking into account the reddening is $20.^{\mathrm{m}}3$. The method of Karachentsev and Tikhonov (1994) gives us an opportunity to estimate the distance to the object. It connects the mean stellar magnitude of the brightest blue stars, the total magnitude of the parrent galaxy in B band and the distance modulus. The following relation is derived from a set of galaxies with distances, determined with high precision using the cepheid method:

$$(m-M)_0 = \langle B(3B)\rangle - A_B + 0.51[\langle B(3B)\rangle - B_T] + 4.14.$$

That gives a distance modulus 28.93 which corresponds to a distance of approximately 6Mpc.

Our distance estimations are in a good correspondence with the results of Sharina et. al (1997), also achieved using the method of the three brightest blue stars.

References

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