Semi-dark dwarf galaxy Coma P on the periphery of the Virgo cluster

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INTRODUCTION

After the observations on the Arecibo radio telescope (ALFALFA review) Haynes et al. (2011) compiled a catalog of nearly 16,000 objects. Radio sources were identified with optical objects according to the SDSS survey. Some potential galaxies were absent in the optical survey, so it was assumed that those are the so-called “dark” galaxies, where star formation has not yet begun, or is extremely slow.

Among the “dark” objects of the review ALFALFA, Janowiecki et al. (2015) found a system of three objects that had approximately equal speeds. In the images from the 3.5m telescope, the AGC229385 looked like an irregular galaxy with a low surface brightness. Based on radial velocity, Janowiecki et al. (2015) estimated the distance to this galaxy as D = 25 Mpc. Ball et al. (2018) conducted a study of the kinematics and dynamics of AGC229385, called Coma P. Based on photometry of the HST images according to Brunker et al. (2017), they indicated the distance to this galaxy as D = 5.5 Mpc. Short distance and high radial velocity (v_h = 1348 ± 1 km/s) made this galaxy unique, therefore, Anand et al. (2018) carried out photometry of archival images of the HST and obtained the distance of 10.9 Mpc. After the publication of this result, Brunker et al. (2019) again indicated the value of the distance as D = 5.5 Mpc. A conrtroversial situation has arisen.

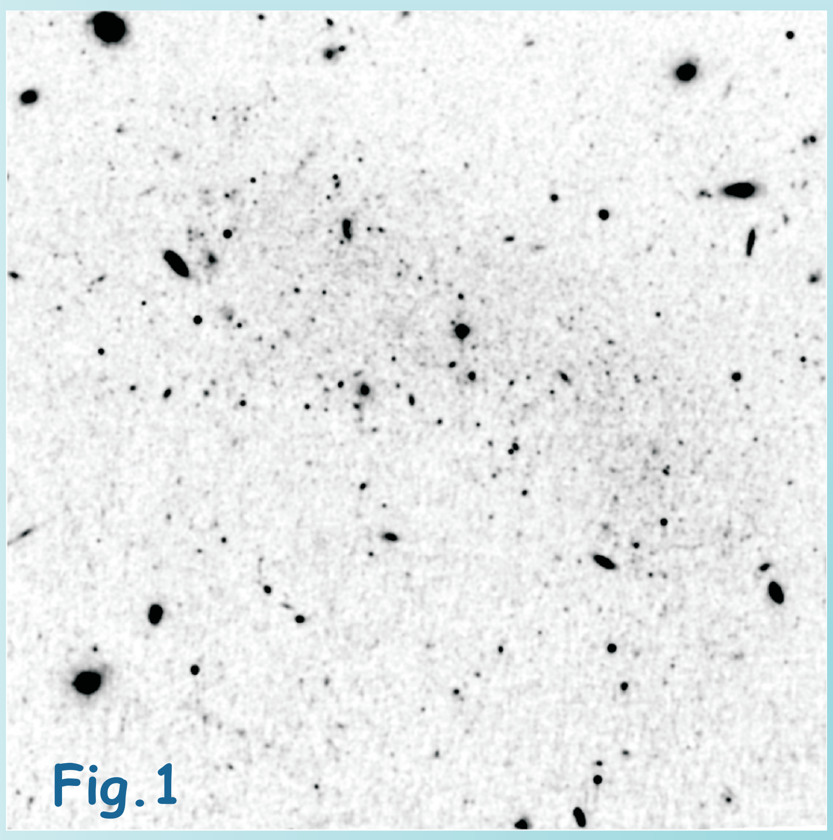

Fig.1

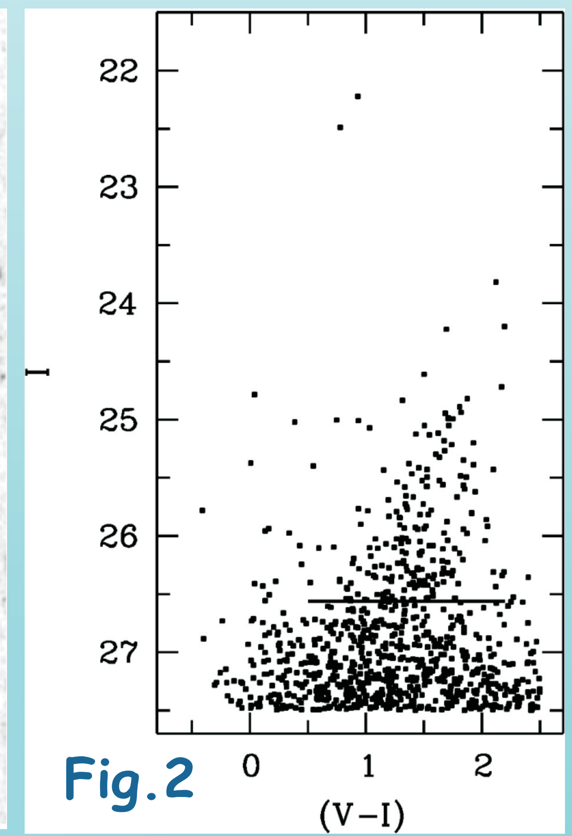

Fig.2

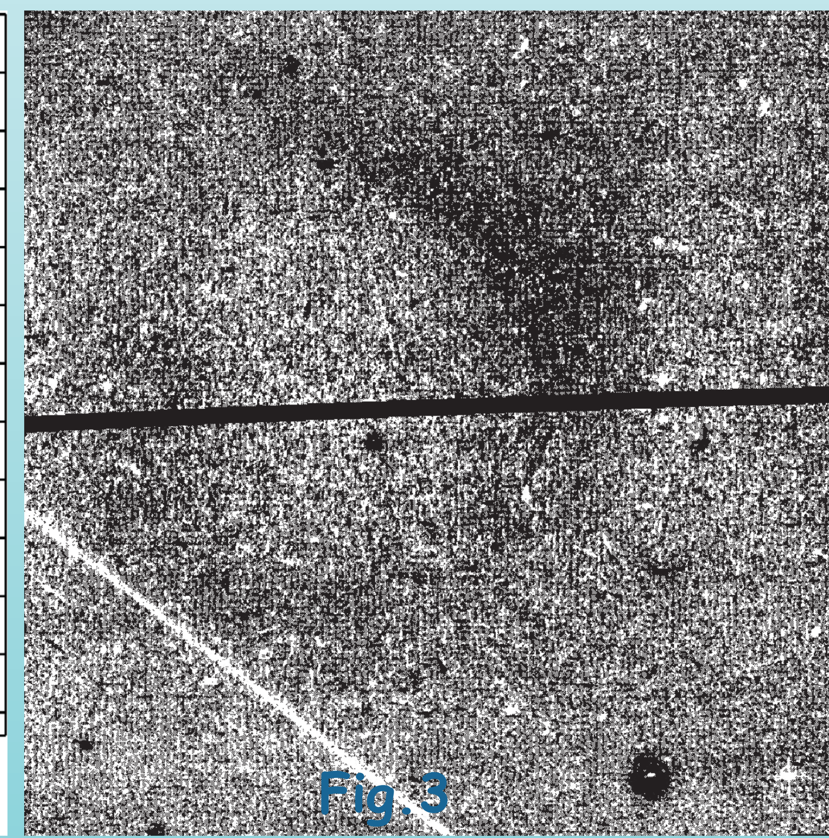

Fig.3

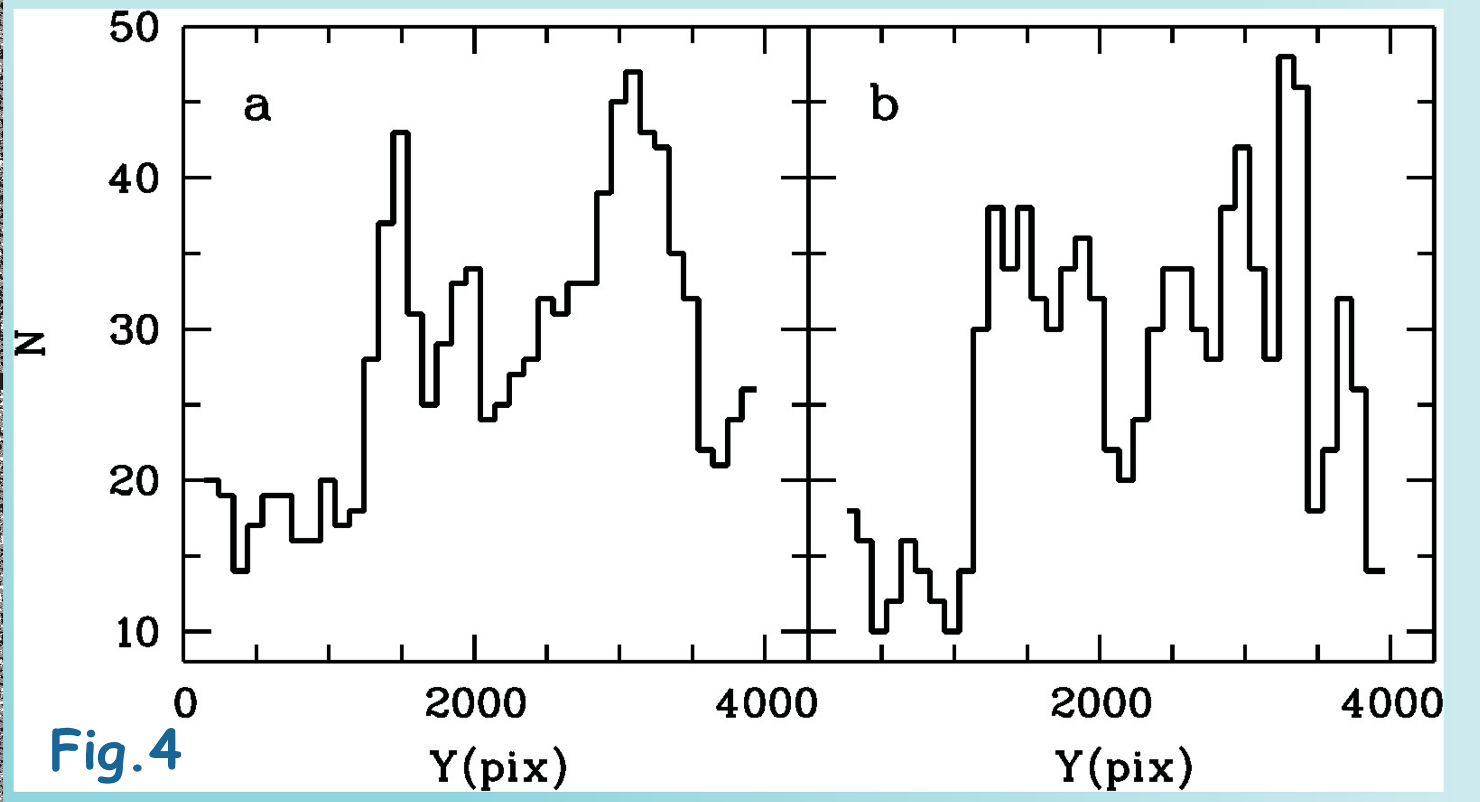

Fig.4

PHOTOMETRY

Fig.1 presents an image of the Coma P galaxy taken at the HST, where it can be seen as an irregular galaxy without active star formation regions. Stellar photometry was conducted in the standard way with the following programs: DAOPHOT II (Stetson, 1994) and DOLPHOT 2.0 (Dolphin, 2016). The results of photometry are presented in Fig.2 as a Hertzsprung-Ressel diagram (CM diagram), in where the star branch, which Brunker et al. (2017) Ball et al. (2018), Brunker et al. (2019) designated as a branch of red giants, is distinguished. This assumption is contradicted by the very large color index of these stars (V-I) = 1.8, and their ragged distribution over the body of the galaxy.

To identify the areas of star formation, we divided the image of F814W into F606W and increased the contrast (Fig.3). Darker areas in Fig.3 correspond to more bluer of the galaxy. It can be seen that the galaxy has a blue color, and its shape – closed ring – has manifested itself.

Selecting the region of weak blue stars on the CM diagram (-0.5 < (V-I) < 0.4), we constructed the distribution of their numerical density along the Y-axis (Fig.4a). The resulting diagram shows the shape of the distribution with two maxima, characteristic to shells or rings. AGB stars and red giants show a similar distribution at 1.1<(V-I)<1.5 (Fig.4b). The obtained distributions of blue and red stars prove that the ring structure of the galaxy is an actual formation. It is possible that the interaction of two dwarf galaxies is observed here.

Studying the structure and kinematics of Coma P, Ball et al. (2018) indicated that a simple model of a rotating disk does not explain the observation and a two-disk model fits better. This conclusion confirms our assumption about two interacting galaxies. The fact that the second galaxy is not visible on the radio telescope and optical images, can be explained by the insufficient sensitivity of these observations.

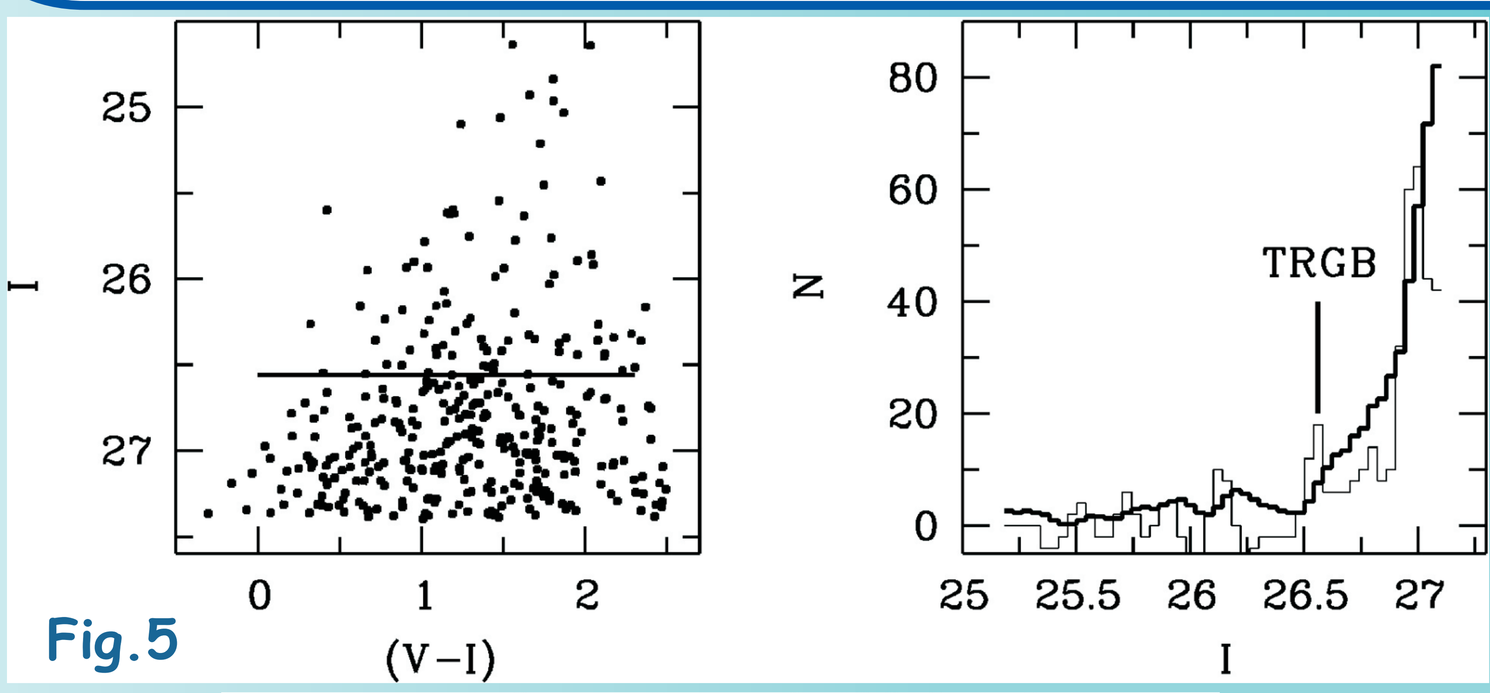

Fig.5

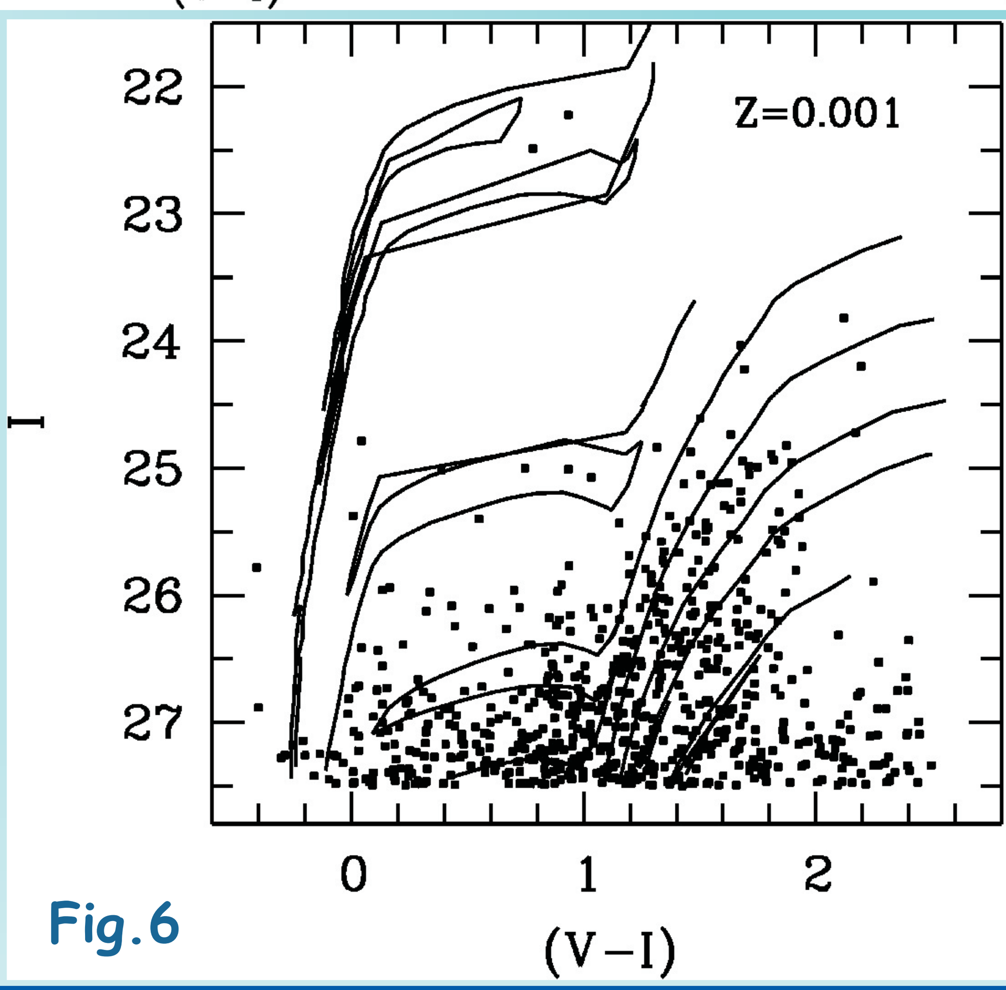

Fig.6

DETERMINATION of DISTANCE

Brunker et al. (2017), Ball et al. (2018), Brunker et al. (2019) determined the branch of stars with the border at I = 24.^{m}5 visible on the CM diagram as a branch of red giants and obtained the distance of D = 5.5 Mpc. Anand et al. (2018) believed that it was a branch of AGB stars, not red giants. Pointing at the concentration of stars at I_{F814W} = 26.^{m}12 as a TRGB jump, they obtained D = 10.9 Mpc. However, in their work there is no luminosity function, where the position of the TRGB-jump would confirm the correctness of the distance measurement.

To reduce the effect of AGB stars on the luminosity function, we used a selection of stars on the periphery of the galaxy, where the number of AGB stars is insignificant. Fig.5 shows the CM-diagram of stars on the periphery of the Coma P galaxy and the luminosity function of these stars. The thin line shows the Sobel function, the maxima of which correspond to abrupt changes in the number of stars, which is observed on the border of the red giants branch. In Fig.5, the peak of the Sobel function is visible at I = 26.^{m}56 ± 0.^{m}05. The diagram also shows that only this value indicates the increase in the number of stars, and there's a reduction in other areas. One of these local jumps at I = 26.^{m}12 Anand et al. (2018) was taken as a real TRGB jump and the distance D of 10.9 Mpc was obtained.

Using the work of Lee et al. (1993) and measuring the color indices of the branch of red giants, we determined that (m-M) = 30.^{m}51, D = 12.65 ± 0.90 and the metallicity of the red giants [Fe/H] = -1.9 for the galaxy Coma P. Absorption of light in the direction of Coma P A_V = 0.^{m}086 was taken from Schlafly & Finkbeiner (2011). Measuring the distance, we inscribed the isochron system of Bertelli et al. (1994) with metallicity Z = 0.001 into the CM diagram of the main body of the galaxy (Fig.6). Isochrons with even lower metallicity (Z = 0.0004) do not describe the positions of the most red stars on the CM diagram. Two bright stars on the CM diagram can also be described by isochrons of 12 Myr old, but there's a doubt about their belonging to the Coma P galaxy.

CONCLUSIONS

The study of morphology of the galaxy Coma P has shown that there are two interacting galaxies, instead of a single galaxy. A brighter galaxy has a low surface brightness, and the second galaxy is not visible on the radio survey maps or in the 3.5m telescope image, i.e. its surface brightness is much weaker. There are no bright stars in this galaxy and it can be called a “dark” galaxy, and the term “semi-dark” galaxy can be applied to the Coma P system.

The distance to the Coma P galaxy (D = 12.7 Mpc) puts this galaxy close to the Virgo galaxy cluster, which has no clear boundaries and consists of several groups of galaxies. The nearest edge of the M87 group is at a distance of 14.5 Mpc (Tikhonov, 2017), i.e. Coma P is located on the periphery of the Virgo cluster. There are no bright galaxies near the Coma P galaxy, so the observed weak star formation is probably caused by the interaction of two dwarf galaxies, one of which is a “dark” galaxy.

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