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Observatorio Astronómico (Universidad Nacional de Córdoba, Argentina)
Tirada aparte N° 91

IC 2082 and the Radiosource in Doradus*

By

J. L. Sérsic**

With 2 Figures in the Text

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The radiosource in Doradus is associated with the double galaxy IC 2082 which is located in the center of the cluster 0428—5358. Its appearance as well as its absolute and radio magnitudes give support to this identification.

1. In 1935 Shapley studied the spatial distribution of 7900 galaxies in the Horologius-Doradus-Reticulum region, finding a large metagalactic cloud with at least five clusters and more than ten thousand galaxies members (Shapley, 1935; 1957).

A few years ago Mills reobserved the same area with the Sydney Cross radio interferometer, searching for radioemission associated with clusters of galaxies. As a result of these investigations (Mills, 1959), a radiosource was discovered in the following coordinates:

$$\text{RA: } 04\text{ h. } 27.8 \pm 0.2\text{ m.} \quad \text{Dec.: } -53^\circ\,59' \pm 3' \qquad (1950)$$

and with a flux density $5.8 \times 10^{-25}\ W m^{-2}(c/s)^{-1}$ at 3.5 meter. The center of one of the clusters coincident with IC 2082, as we shall see in Secc. 3, falls on the coordinates

$$\text{RA: } 04\text{ h. } 28.0\text{ m.} \quad \text{Dec.: } -53^\circ\,58' \qquad (1950)\,.$$

From the large diameter of the cluster as compared with the small angular extent of the radiosource, Mills concluded that the radioemission comes from some discrete source and not from the cluster as a whole.

After Shapley (quoted by Mills) IC 2082 may be an identification of the radiosource. Moreover, Basinski, Bok and Gottlieb (1959), believed that a nebulous object — probably, they say, an irregular galaxy — located some minutes north of IC 2082, has something to do with the radiosource.

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According to new measurements by MILLS (private communication, 1961), the location of the radiosource would be at

$$\text{RA: } 04\text{ h. } 28.1 \pm 0.2\text{ m.} \quad \text{Dec.: } 53^\circ\ 59' \pm 3' \qquad (1950)$$

with a 3.5 meter flux density of $5.0 \times 10^{-25}\ W m^{-2}(c/s)^{-1}$. This new observation, although a catalogue position, puts the radiosource nearer to IC 2082 but still south of it.

The preceding problems suggested the possibility of a study with the 60-inch reflecting telescope at Bosque Alegre (Astrophysical Branch of Cordoba Observatory), the present note being the result of it.

2. IC 2082 is the following and brighter member of a pair of galaxies with magnitudes 16.1 and 16.7 (pg.) and 30″ and 24″ diameter respectively (SHAPLEY, 1959). The angular distance between the nuclei of both galaxies is 12″ according to our measurements on a short exposure plate. The nuclear dimensions of both members of the pair are 8″ and 6″ respectively, but the faint extensions spread considerably, overcoming the distance between the nuclei. SHAPLEY termed IC 2082 as "irregular" in the 1935 catalogue but we should prefer to call it "peculiar".

In fact, as can be seen in Fig. 1, IC 2082 and its partner are surrounded by an extended halo, elongated in the direction defined by the two nuclei. An elliptical object of the same brightness as IC 2082 and following it 2′ does not show large faint extensions as described. The same is true for the remaining members of the cluster.

Although BASINSKI, BOK and GOTTLIEB have observed the cluster area, they have not reported the peculiar character of IC 2082, possibly because they worked with the 74-inch Mount Stromlo telescope stopped to $f/8$.

We have analysed the plates with the Hilger microphotometer at Cordoba Observatory in order to trace the faintest extension of the double nebula. A rectangular 5″ × 10″ analyser spot was employed for reducing the plate graininess. During the tracing we took account of faint stars that could disturb the profiles. In Fig. 2 we have drawn the isophotes corresponding to intensities 1.02, 1.05 and 1.15, the sky background being taken as unity. The plates were standardized with a step sensitometer, the marks being impressed on the free areas.

The striking facts in Figure 2 are the large extension of the common envelope of the pair, reaching to 3′.5 by 1′.5 and its contrast with the definite borders of the normal objects in the cluster.

From the south following end of the system a "tail" 1′ long comes out while on the other side the isophotes are curved, tending to point to the irregular system of BASINSKI, BOK and GOTTLIEB, 4′3 north of IC 2082.

3. From counts of galaxies based on Shapley's catalogue of the Horologium-Doradus-Reticulum area, we deduced that the center of the

cluster practically coincides with IC 2082. By counting galaxies on successive rings centered on it, a diameter of 66′ and a population of

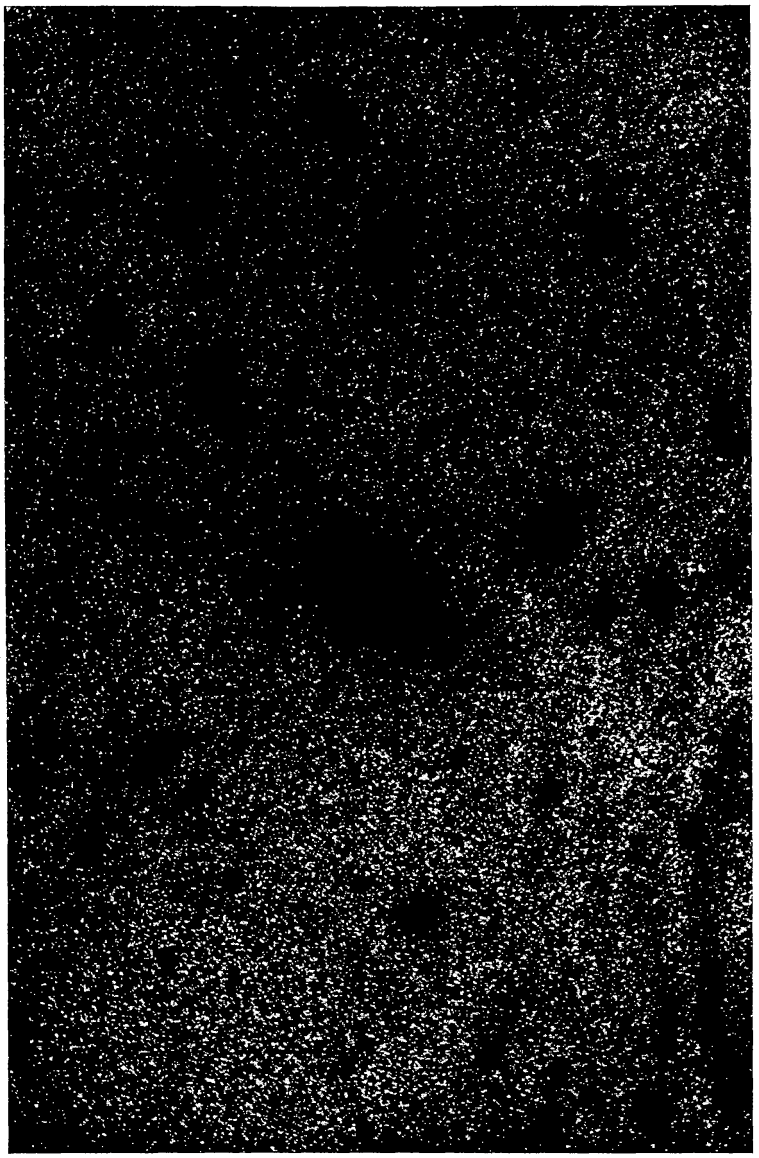

Fig. 1. Negative reproduction of a IIa—O plate taken with the 60-inch telescope at Bosque Alegre. North is at the top, east to the right. The scale is the same as in Fig. 2

82 galaxies just to the limiting catalogue magnitude ($m = 17.5$), was found. (See Table.)

The degree of concentration of the cluster, defined according to WALLENQUIST (1957) results relatively low and equal to 1.7. Adopting also Wallenquist's definition of the reduced angular diameter — as the diameter of the circle containing half of the cluster population — we find a value of 22′.

We can make now some estimate of distance. The mean diameter for distant clusters (which appear to be also of a low concentration index), is 2.64 ± 0.55 Mpc. in a distance scale defined by $H = 125$ km./sec.Mpc. (See for example, VAN DEN BERGH, 1960; SÉRSIC, 1960a). From that one obtains a distance of 140 ± 30 Mpc. or a true modulus of 35.7 ± 0.4 magnitudes. Using the mean reduced diameter for the same clusters,

Table. *Density of galaxies per sq. degree as a function of radius in (0428—5358) cluster. Field density is* N_f

r'	N_r	$N_r - N_f$
0	1169	1044
5	546	421
10	452	327
15	345	220
20	164	39
25	177	52
30	114	...
40	132	7
50	128	3
60		

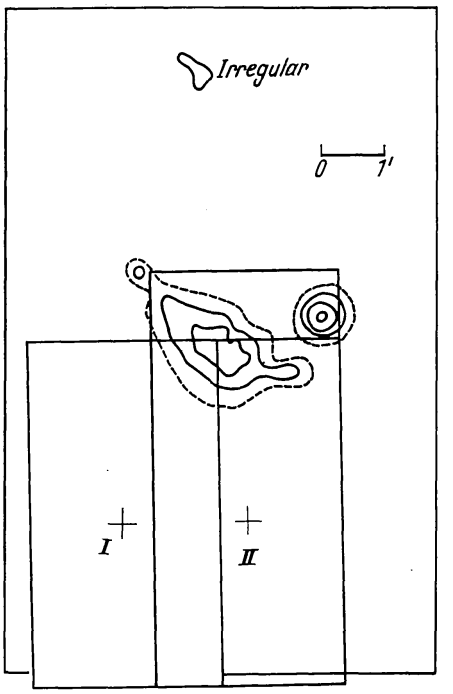

Fig. 2. Outer isophotes of IC 2082 system. The corresponding intensities are 1.02; 1,05 and 1.15 of sky background. Orientation and scale are the same as in Fig. 1. The crosses marked *(I)* and *(II)* are the radio positions as given by MILLS. The rectangles give the probable errors in the coordinates

equal to 1.24 ± 0.36 Mpc., the corresponding estimate of distance will be 210 ± 60 Mpc. and the true modulus 36.4 ± 0.6.

On the other hand, the apparent magnitudes of the galaxies ranking 1st, 3rd, 5th, and 10th in the cluster are 15.9, 16.0, 16.0 and 16.1 respectively. The corresponding absolute magnitudes for cluster galaxies of the same rank as given by HUMASON, MAYALL and SANDAGE (1956), corrected for the same distance scale as above, when combined with the foregoing values give an apparent modulus of 35.9 ± 0.4 magnitudes. From the galactic absorption in the region, which is of the order of 0.3 magnitudes, follows a third estimate of the true modulus: 35.6 ± 0.4.

Taking now the mean, we get a value of 35.9 ± 0.4, a distance of 150 ± 30 Mpc. and an apparent modulus of 36.2.

4. Although the cluster distance determined as above is very uncertain, it gives an order of magnitude for the dimensions of the IC 2082 system.

The separation between nuclei is 9 Kpc., of the same order as in the Hydra — A radiosource, while the largest observed dimension of the halo reaches to 160 Kpc. If we disregard the projection shortening, the

irregular system of BASINSKI, BOK and GOTTLIEB would be 190 Kpc. from IC 2082, a distance that does not let us discard a connection with it. In fact, if the irregular system had been in contact with IC 2082 4×10^8 years ago, a velocity of 500 km/sec. would have been sufficient to take it out that distance, which is possible, the speed being of the order of the velocity dispersion of galaxies in clusters.

If a connection between both objects really had existed, the difficulty of a second collision suffered by IC 2082 in such a short time as 4×10^8 years arises. We shall see that this is improbable. If R is the radius of the cluster and N its total population to the 17.5 magnitude, the density of galaxies is $g = 3N/4\pi R^3$ or 9 galaxies per cubic megaparsec. Accepting a cross section (very exaggerated), $\pi s^2 = \pi(0.05 \text{ Mpc.})^2$, for the galaxies, the number of them swept out by a central passage of the cluster is $2\pi s^2 Rg = 0.18$. The time of passage is $2R/v$ or 5×10^9 years, if $v = 500$ km/sec. At this velocity there would be a collision between two galaxies every 3×10^{10} years. As the calculations have been based only on the brighter members of the cluster, the figures apply to our objects directly, and we might conclude that either IC 2082 has nothing to do with the irregular system, or the processes taking place in IC 2082 are not collisions, but disruptions as suggested by AMARTSUMIAN (1958).

From the distance modulus given in the foregoing section and the magnitude given by SHAPLEY for the irregular galaxy ($m = 16.8$ pg.), there follows an absolute magnitude of -19.4. According to ours plates, the colour of this object is certainly blue, suggesting a Magellanic type. Its age must be less than 3×10^{10} years because if it were longer it would have been swept out by some collision.

The origin of this irregular galaxy appears to be the problem now. If it has been formed from the intracluster gas, it would be worth while knowing about other similar objects inside other clusters of galaxies without a radiosource associated to peculiar systems such as NGC 1275, NGC 4486, NGC 6166, etc. Dwarf systems such as these discovered by HODGE (1959) in the Fornax Cluster are too faint as to be compared to our case.

Coming back to IC 2082 and its companion, their absolute magnitudes are respectively -20.1 and -19.5, while the absolute magnitude of the pair reaches to -20.6.

Somewhere else (SÉRSIC, 1960b), we have confirmed Ambartsumian's conclusion about the high intrinsic luminosity of radiogalaxies, corresponding in mean to -20.7 ± 0.2. Moreover, the 3.5 m. flux of the Doradus radiosource gives a $m_{1.9}$ magnitude equal to 8.1 after taking in account the corrections given by MILLS (1959) for reducing to the Hanbury Brown $m_{1.9}$ system. The difference $m_{1.9} - m_p = -7.5$ is typical of radiosources associated to pairs of galaxies (DEWHIRST, 1959).

5. In conclusion, the radiosource in Doradus is associated to a pair of galaxies of peculiar structure, one member being IC 2082. If the irregular galaxy had had some connection with the IC 2082 system, it could have been a genetic one, and not too long ago. Lastly, the cluster (0428—5358) to which these galaxies belong is approximately 150 Mpc. far away.

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Dr. J. L. Sérsic, Observatorio Astronómico, Universidad Nacional de Córdoba, Córdoba (Argentina)