

COMPARISON OF DESCRIPTIONS OF GALAXIES IN THE MORPHOLOGICAL CATALOG OF GALAXIES WITH THEIR CLASSIFICATIONS

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Translated from *Astronomicheskii Zhurnal*, Vol. 45, No. 1,

pp. 141-145, January-February, 1968

Original article submitted January 18, 1967

The descriptions of galaxies in the Morphological Catalog of Galaxies (MCG) are compared with de Vaucouleurs' and Hubble's classification systems. Of the galaxies described in the MCG as E objects, N or N;H objects, and (N) or (N);H objects, de Vaucouleurs classifies 95%, 90%, and 55% respectively as E or S0 objects. Most of the galaxies seen edgewise and described in the MCG as L or L;H also belong to type S0. Of the galaxies classified by de Vaucouleurs as SAB and SB, only 20% and 46% respectively are noted in the MCG as possessing a bar. Among the SAB and SB galaxies, spiral arms are not recorded in the MCG for 13% and 20% respectively, nor for 15% of the SA galaxies. Edgewise and overexposed systems predominate among these in the MCG. Since the structural character of each feature in a galaxy is recorded individually in the MCG, no opportunity is afforded for a comparison with subtypes such as Sa, Sb, or SBa. About 70% of the galaxies described in the MCG as Fa are classified by de Vaucouleurs as S0 - Sa. De Vaucouleurs regards almost all the objects described as Fb as spirals; he classifies about 70% of them as later than Sa. According to de Vaucouleurs nearly all the Fcd - Fi are late-type spirals, while those described as F are either S0, Sc, or irregular.

Up to now the most popular classification of galaxies has been Hubble's second classification in the form of a succession of types E, S0, Sa and SBa, Sb and SBb and SBc, and I.

In the Morphological Catalog of Galaxies (MCG) [1] it was explained that its authors had to devise a system of describing galaxies by special symbols, and did not make use of a limited number of classification types. The reason for this was the overexposure of many images in the Palomar Atlas and the existence of a great many galaxies that in no way fit into Hubble's classification or specifications and are classified under the same type arbitrarily. In particular this concerns galaxies seen edge-on.

Many are interested, however, in the interrelation of the MCG descriptions and the usual classification of galaxies. For their comparison we find that de Vaucouleurs' catalog [2] contains the largest number (1660) of objects in common with the MCG. Basically, de Vaucouleurs' classification

differs from Hubble's by the introduction of the family SAB, intermediate between SA (corresponding to Hubble's S) and SB (corresponding to Hubble's SB). De Vaucouleurs also continues the sequence of subtypes a, b, and c by the introduction of subtypes d and m.

The collection of all varieties of the S0 under one type, the addition of one half of the SAB family to type S and the other half to type SB, and the collection of all of de Vaucouleurs' subtypes c, d, and m under the subtype c is statistically equivalent to Hubble's second classification. It is well known that there exist differences in the classifications of individual objects by different persons using the same classification system. These differences are no less than the differences between the indicated simplification of de Vaucouleurs' system and Hubble's system. Therefore our comparison here is simultaneously a comparison of the MCG descriptions with the classification systems of both de Vaucouleurs and Hubble.

TABLE 1

| MCG \ Vauc | N | N;H | N and N; H | (N) | (N);H | N and (N); H | Total, % |
|------------|----|-----|------------|-----|-------|--------------|----------|
| E | 7 | 19 | 44% | 6 | 12 | 26% | 35 |
| S0 | 5 | 22 | 46 | 5 | 15 | 29 | 37 |
| S | 1 | 5 | 10 | 15 | 12 | 40 | 26 |
| I | 0 | 0 | 0 | 1 | 2 | 5 | 2 |
| | 13 | 46 | | 27 | 41 | | |

E galaxies according to MCG. These 270 objects comprise 16.6% of the total number of objects in common with [2]. De Vaucouleurs' type are distributed among them as follows.

E: 62.5%; S0: 32.8%; S: 3.6%; and I: 1.1%. (In particular, SA0: 12.2%; SAB0: 4.1%; SB0: 6.3%; and S0 without indication of family: 10%.) S0 differs from E by the presence of a nucleus that because of overexposure in the Palomar Atlas does not stand out. For the same reason van den Bergh [3] could not differentiate between E and S0.

Comment. Group I consists of three galaxies: 1) NGC 4753, a very peculiar object that is described in the MCG as E, Ap!, that is, strictly not an E; 2) NGC 5363, classified by certain authors as Ep; and 3) NGC 5253, an Apo that is very overexposed in the center in the Palomar Atlas. In group S the following are included from [2]: two mentioned simply as S; three mentioned as SAa; two mentioned as SBa; one mentioned as SABb; and one mentioned as SBp (the interacting galaxy NGC 5218); but three of these are alternatively described in the MCG as flat with suspected arms.

N and (N) galaxies according to the MCG. These are very luminous, compact galaxies with very clearly defined edges. N and (N) are equally luminous and identical in all respects except that (N) has suspected structure in the image. If a very faint haze is observed around such a galaxy it is described as N;H and (N);H. There are 127 such objects in common with [2]. They are distributed according to type as shown in Table 1.

Thus 90% of the N objects and 55% of the (N) objects according to the MCG are elliptical or S0 or E galaxies, but are more compact than the latter, such as, for example, M32. Among (N) galaxies the percentage of overexposed spirals having clearly defined edges proved to be less than we supposed, i.e., 40%. Why the large percentage of E galaxies, according to [2], on the Palomar Atlas produce an impression of (N), that is, of overexposed and clearly defined spirals, is difficult to understand. It is possible that part of them, as for example NGC 194 (E according to de Vaucouleurs), are not really ellipticals. This is clearly apparent from the following comparison.

TABLE 2

| MCG \ Vauc | SA0 | SAB0 | SB0 | S0 | All S0 |
|------------|-------|------|-------|-----|--------|
| E | 42.5% | 35% | 18.5% | 20% | 26% |
| (S0) | 40 | 50% | 71.5% | 50 | 61 |
| (S and F) | 17.5 | 15 | 10 | 30 | 13 |

E galaxies according to de Vaucouleurs. Of these objects, 248 are in common with the MCG. According to the descriptions in the MCG, they are distributed by type as follows:

E 68.0% L 0.8%
 N; H and N; L 10.1 F 6.5
 N 2.8 N;... and L; ... 2.8
 (N) 8.9

Objects of low surface brightness, which are apparently rarefied dwarf ellipticals, are here described as lenticular or L galaxies. A large, gradually fading halo can produce the impression of an L galaxy with a nucleus immersed in the center. Objects with a central nucleus or lens whose descriptions are incompatible with the appearance of an E or S0 galaxy here are indicated by N;... and L;... Among the 16 galaxies described as F (flat), six are observed to have spiral arms and dark matter, and four are described as Fa and may be late subtypes of S0. Thus galaxies of type E according to de Vaucouleurs are undoubtedly not all the same. Three objects are described in the MCG [1] as F?;H, but 5-33-6 according to de Vaucouleurs [2] is a peculiar E.

S0 galaxies according to de Vaucouleurs. There are 345 of these objects in common with MCG, distributed according to subtype as follows: 80 SA0, 37 SAB0, 92 SB0, and 136 simple S0. They are distributed according to the MCG description in the following manner (Table 2).

In the first column (S0) designates the different descriptions in the MCG that do not contradict the appearance of galaxies usually attributed to class S0, and (S and F) designates objects with detailed structure of subtype b, or of a more strongly pronounced kind. Objects in the last line are undoubtedly spirals and not S0 galaxies.

The bar in group SAB0 generally stands out poorly, especially because of overexposure, and in the MCG is only observed in two objects that have type b structure. They are in reality not SAB0 galaxies but are of the later type SB. Of the objects in group SB0, 22% have a short or suspected bar.

Galaxies later than S0 according to de Vaucouleurs. There are 1039 of these objects in common with the MCG. Their distribu-

TABLE 3

| Family | SB | SAB | Sb | S |
|---|-----|-----|-------|-----|
| Number | 248 | 237 | 290 | 264 |
| Percentage with a noticeable bar | 3% | 20% | 45.5% | 15% |
| Percentage without noticeable spiral arms | 15% | 13% | 20% | 40% |

tion by family and whether or not they are observed to have a bar is given by the following percentages (Table 3).

According to de Vaucouleurs [2], 11 SA galaxies in the MCG have a questionable bar. Spiral arms are not noticed for galaxies that are very overexposed and sharp-edged or that are very strongly inclined. The latter are usually assumed to be spirals. The former are usually described in the MCG as (N) or F and the latter as F. From 4 to 9% of the objects in each group of the table undoubtedly do not have spiral arms; these are usually purely disk-shaped or annular galaxies with varying degrees of structure. Most of these are probably in group S. In the MCG it is noted that the spiral NGC 278 looks like a typical E because of overexposure in the Palomar Atlas. There are discrepancies of description with classification because of the confusion that arises, for example, in deciding which of two galaxies is NGC 5216 and which is NGC 5218. Owing to lack of space we cannot specify each incident and reason for clear-cut discrepancy between the classification and the description. Straightforward mistakes, independent of the quality of photographs used, occur in classification and description. It should be further noted that de Vaucouleurs frequently and incorrectly classifies as SB galaxies objects that are seen edge-on and that in reality may be SA; in contrast the MCG describes the actual appearance of the image.

Comparison of the estimates of structure: a, b, etc. This is difficult because of the MCG, insofar as possible, describes each detail separately. There are objects with several different or with two extreme degrees of structure, for example, one arm described as a and the other as i, such as when a strong condensation against the amorphous background of an a arm would correspond to structure i. The latter case is described as ai. The objects with indications of structure common to [2] and [1] number 660. The complexity of the true structure of galaxies, resulting in an enormous variety of descriptions, allows us to say only the following. The percentage of objects in the MCG coinciding and contiguous

with the analogous subclasses of de Vaucouleurs for the same objects diminishes with the degree of structure. For example, the structure described as b in the MCG is most frequently encountered among de Vaucouleurs' Sab, Sb, and Sbc galaxies.

Irregular galaxies according to de Vaucouleurs. There are 23 irregular galaxies of type Im or IO according to de Vaucouleurs (Holmberg's Ir II) in common with the MCG. Sixteen of them are described in the MCG as flat, i.e., F in nine cases with mention of the degree of structure; and four are described as lenticular or bar with haze H of structure c or i. The galaxy -5-32-60 is described as E in the MCG because of over exposure. Three of the IO galaxies in the MCG have spiral arms and one is described as E. For statistical purposes this material is poor, especially since "irregular" galaxies themselves are diverse.

F (flat) galaxies according to the MCG. There are 173 of these in common with [2]. Of these, among 28 Fa (amorphous) galaxies there are five E galaxies according to de Vaucouleurs [2], 11 S0 galaxies, three Sa galaxies, four Sb galaxies, and five S galaxies.

Out of 34 Fb galaxies we have three E galaxies, but two of them obviously have spiral arms (these are 5-31-58 and -2-33-96), two are S0 galaxies, three Sa, two Sb, ten Sc and later, and four are simple S galaxies.

Out of 34 Fc galaxies, one is an E5, but has a dark band (5-3-49) and -2-6-33 is an Ep (but has no spiral arms). Eighteen objects are Sc and later, and 14 are simple S. Seventeen objects from Fcd to Ff are classified in [2] as late S types, from c to m. The galaxy 8-15-52 is classified as S0.

Out of 59 F and F;H galaxies, six are called E, 12 are called S0, nine are called Sc, 12 are called irregular, and 12 are called S. The rest of the objects making up the total number in each class are scattered among the various subclasses of S.

In total, about 70% of the Fa objects are classified as early S galaxies (S0 - Sa). The Fb galaxies are almost all spirals, but 70% of them are classified in [2] as later objects. Out of the Fc objects, which are always spirals, more than 1/2 are classified Sbc - Scd. Practically all galaxies from Fcd to Ff are classified in [2] as spirals of type Sc - Sm. Among simple F galaxies either S0, Sc, or irregular galaxies predominate.

L and L;H objects according to the MCG. These objects according to the MCG are not accompanied by descriptions of external arms, rings, or disks. There are not many of them, but

all are classified in [2] as spirals of various types. But the group is distinguished from the 25 objects of types L and L;H that, according to the MCG, are seen edge-on. They are all called S0 in [2].

Out of 16 La objects, nine with dark equatorial bands are classified in [2] as Sa, four as S0, and three as S. Out of the Lb objects, three are S0, two are S, one is Sb, one is Sd, and one is E. Thus among the L, L;H, and La objects of greatest inclination, the majority belong to the types S0-Sa.

By using the resultant comparison one may obtain a more distinct idea of the interrelation between the types of Hubble and de Vaucouleurs and the descriptions of galaxies in the MCG. The majority of sharply differing cases are caused either by over-

exposed images on the Palomar Atlas, or by the arbitrary classification of objects seen edge-on, or by the inclusion in the usual types of morphological forms virtually unspecified by the classification.

LITERATURE CITED

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