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MORPHOLOGY OF OPTICAL FORMS OF N GALAXIES

W. W. MORGAN
AND
RICHARD D. DREISER
Yerkes Observatory, University of Chicago
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ABSTRACT

We follow Weedman's suggestion of a spectroscopic definition for Seyfert galaxies, to present a simple four-box classification of the forms of N galaxies. The complete types for these galaxies must include a spectroscopic parameter that would show which of the Ns are also Seyferts—and the type of the Seyfert spectra in each case.

Subject headings: galaxies: structure — galaxies: Seyfert

I. INTRODUCTION

There is a degree of imprecision in a statement in the classical paper by Seyfert (1943) concerning the members of a class of galaxies that now bear his name. He states: "Most of them are intermediate-type spirals with ill-defined amorphous arms, their most consistent characteristic being an exceedingly luminous stellar or semistellar nucleus which contains a relatively large percentage of the total light of the system." The majority of the 12 galaxies listed by Seyfert do show this effect on exposures of 1–3 minutes on plates obtained with telescopes of moderate size; however, on full exposures, the statement appears to be true for only two or three of the 12.

Seyfert's statement does not differ greatly from that defining N galaxies by Matthews, Morgan, and Schmidt (1964), who state: "These are galaxies having brilliant, starlike nuclei containing most of the luminosity of the system. A faint, nebulous envelope of small visible extent is observed." An ambiguous situation has resulted; an example of this is given by G. R. Burbidge (1970) who states: "It is therefore clear, that, as far as form is concerned, 'N galaxy' and 'Seyfert galaxy' are equivalent descriptions."

It is the purpose of the present paper to develop a frame of reference for N galaxies that will be free from the above ambiguity between Seyfert and N galaxies.

II. SEYFERT GALAXIES AND N GALAXIES

The problem of ambiguity in form has been resolved for Seyfert galaxies by Weedman (1977), who adopts a spectroscopic criterion for the latter: "a Seyfert galaxy is considered to be any object appearing nonstellar (nebulous) in photographs and having broad emission lines in its spectrum. This can include N galaxies as well as objects called QSOs, if they are accompanied by surrounding nebulosity." When we add to this a parameter that discriminates the degree of contrast between the starlike nucleus and its background galaxy (and when we accept the fact that many galaxies will thus have two complementary types, Seyfert and N, representing both spectrum and optical form), we have resolved the ambiguity. The spectral classification of Seyfert galaxies is not discussed further here.

We consider that the contrast of the starlike nucleus against its underlying galaxy is the single most important characteristic of the optical forms of N galaxies. Some of the form types used for normal galaxies can be distinguished for the nearer members of the N class; in general, however, in the more distant objects a limited amount of detail in the underlying galaxy is observed.

A one-dimensional classification sequence of four "boxes" is illustrated in Figure 1 (Plate 11). A somewhat similar notation was used in a publication by Morgan (1971); this latter was based on a magnificent series of 200 inch (5.08 m) telescope plates of Zwicky compact galaxies obtained by Dr. W. L. W. Sargent (1970), who offered their use to Morgan on a visit to Pasadena in 1970. Morgan's paper disregards the problem of ambiguity in classification between Seyfert and N galaxies —and for this reason leaves something to be desired in discrimination.

The sketches shown in Figure 1 illustrate the growth in relative luminosity of the starlike nucleus with respect to its underlying galaxy; they were made from the following: (1) NGC 4151 was prepared from Yerkes 41 inch (1.04 m) reflector negatives obtained by N. Walborn. (2) The sketch for II Zw 1 was prepared from published illustrations of a 200 inch plate obtained by Sargent, illustrated in Sargent (1970) and Morgan (1971). (3) The sketch for I Zw 1 was prepared from the illustration from a 200 inch negative by Sargent (1970). (4) 3C 48 was prepared from the illustration from a 200

inch plate by Sandage and Miller (1966). It should be emphasized that these sketches are only for the purpose of illustrating the growth of the starlike nucleus and to show the approximate relative sizes of the brighter parts of the galaxies. Because of the earlier use of the labels N−, N, and N+, we denote their present usage by an asterisk prefix.

In addition to the three boxes for N galaxies, we introduce three other boxes for quasars: (1) *Qn for quasars superposed on faint nebulosity (3C 48); (2) *Qs for quasars consisting of a simple star image; (3) *Qj for quasars accompanied by a jet. The type *Qn illustrated in Figure 1 is one of the original quasars; its nebulosity has been shown recently to be a galaxy (Boroson and Oke 1982).

Comments on the boxes are given below:

*N−. NGC 4151. Adams states (1977): "The bright inner region (diameter about 2.6 kpc) containing the nucleus lies in a faint oval envelope with dimensions 8.8 kpc × 12.4 kpc."

*N. II Zw 1. Adams states (1977): "In Sargent's plate (1970), the length of the bar is 14 kpc, and the diameter of the poorly resolved spiral or annular structure is 21 kpc."

*N+. I Zw 1. Adams states (1977): "The diameter of the 'spiral' pattern is approximately 36 kpc."

III. THE NATURE OF THE *N...*Qn SEQUENCE

The box *N− can be considered as a wall—or divider—separating the *N galaxies from the not *N galaxies. In the prototype for *N−, NGC 4151, the starlike component of the nucleus is not cleanly separated from its immediate surroundings, because of its relatively low luminosity, as compared to its situation in *N, *N+, and *Qn. This characteristic can be considered common to most galaxies assigned to the *N− box.

We therefore omit from the general category of *N galaxies the subgroup in the *N− box—and combine into a general N category the members classified as *N and *N+. In addition, for reasons of continuity, we include the *Qn box in the *N sequence. In doing so, we realize that we are moving into the quasar area; but because of the continuity of behavior of the ratio of sharp nucleus to background galaxy, we seem to be observing a continuous phenomenon.

IV. THE EFFECT OF DISTANCE ON THE CLASSIFICATION OF N GALAXIES

Serious problems can be encountered when we attempt to identify and classify N galaxies at progressively greater distances. As the scale decreases with increasing distance, light from the central part of the galaxy can become united with the "starlike" nucleus and enhance the brightness of the latter. Roger Lynds has emphasized (1968) the importance of utilizing the highest possible resolution for isolating N galaxies; he accepted only surveys based on original negatives obtained with the 200 inch reflector and the 48 inch Schmidt telescope.

A detailed investigation of systematic errors in classification as a function of distance will be necessary when a sufficient body of N galaxies has accumulated.

V. THE PROBLEM OF NUCLEAR VARIABILITY

Variations in the light of the starlike nuclei are observed frequently. In one instance, Zw 0039.5+4003 (Zwicky *et al.* 1970), the sharp nucleus was found to vary irregularly by more than 2 mag; this resulted in the near disappearance of the sharp nucleus on some occasions—and therefore the disappearance of the galaxy itself from the N category. Because of such variations in light, it will be necessary to have a minimum of 3–5 standards in each of the boxes *N, *N+, and *Qn to serve as a completely satisfactory frame of reference.

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RICHARD D. DREISER and W. W. MORGAN: Yerkes Observatory, Williams Bay, WI 53191

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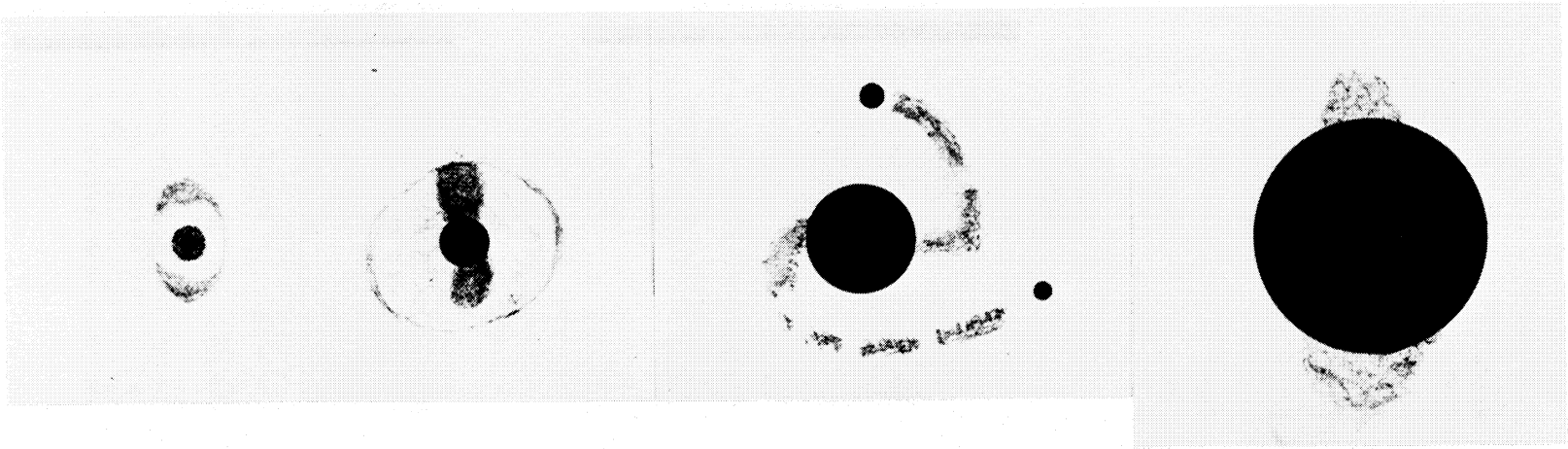

FIG. 1.—Sketches of the brighter parts of the four galaxies defining the boxes *N−, *N, *N+, and *Qn. The scales of the galaxies shown are roughly comparable for the first three; the scale for 3C 48 is approximately half that of the others. The starlike nucleus increases in luminosity by the order of 6 mag on passing from NGC 4151 to 3C 48. The starlike nucleus in NGC 4151 is immersed in the bright, inner part of the galaxy. These sketches are intended only to show gross shapes—not details.

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