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A Connection Between the Spiral Galaxy NGC 4319 and the Quasi-Stellar Object Markarian 205

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A luminous filament connects the quasi-stellar object Makarian 205 whose redshift is 0.070 with the nucleus of the spiral galaxy NGC 4319 whose redshift is 0.006.

Markarian (1967, 1969a, b) has published lists of objects with strong ultraviolet continua. Some of the objects on these lists are stellar in appearance and Markarian has classified them as quasi-stellar objects. One of the latter, number 205, falls within the projected boundaries of a large spiral galaxy, NGC 4319. Weedman (1970) showed that Markarian 205 has a Seyfert-type spectrum with a redshift of 0.070, a value about ten times greater than the presumed redshift of the spiral galaxy.

If Markarian 205 is not an accidentally projected background object and is in fact at the same distance as the spiral galaxy, the possibility arises that there is some interaction between the two systems. If this interaction could be observed, it would furnish proof that the two systems were at the same distance. A photographic study of these objects was therefore initiated with the 200-in telescope at Mt. Palomar. On 29 June 1970, normal limiting exposures were made (20 min on 103a-J plates and 30 min on 103a-O plates, both without filter). These photographs showed no connection or interaction between Markarian 205 and the spiral galaxy. They did confirm, however, the Markarian and Weedman description of number 205 as completely stellar in appearance (see Figure 1).

With limited observing time available, not even acceptable seeing was obtained again until 28 March 1971. At that time a 4-hr exposure was made on baked IIIa-J photographic plates. This plate reached more than one magnitude fainter than the standard ones and revealed a luminous, linear feature originating at the Markarian object and running north into the over-exposed central portion of NGC 4319. The relevant portion of this plate is reproduced in Figure 2.

On the nights of 16 and 17 May 1971 (when observing time was kindly made available to me by W. L. M. Sargent), plates were obtained in the ultraviolet (103a-O + Corning 5970), in [O II], and in Hα (with roughly 100 A band-pass interference filters). Both direct photographs and plates using an image intensifying tube were obtained. Signs of partial connection were observed on the ultraviolet and [O II] plates. But on the Hα plates, a narrow, luminous connection could be seen linearly traversing the whole distance between Markarian 205 and the nucleus of NGC 4319. This plate is reproduced in Figure 3.

THE CONNECTION

The discovery of the connection in the present paper follows stages similar to those in the discovery of the counter jet in M87 (Arp 1967). In the earlier case, a faint feature was first noticed on a deep continuum plate. Later plates in Hα showed the counter jet better, and spectra showed it to be weak but, as far as could be ascertained, pure emission. From the preliminary information available at this time, we conclude that the luminous tube from the nucleus of NGC 4319 to Markarian 205 is glowing weakly in Hα. Possibly the passage of the Markarian 205 object from the nucleus of NGC 4319 out through the disk has caused the hydrogen in the disk of the spiral to become excited and to radiate hydrogen emission lines.

It should be noted that the Hα interference filter used here is about 80 A wide at half-transmission wavelengths. It is centered at a wavelength of maximum transmission of 6585 A. After allowing for detuning of about 15 A, because of the convergent *f*/3.67 beam of the Ross correcting lens, we find the half-transmission points of the filter to be close to a redshift of 2100 km/sec. Since this is close to the redshift of NGC 4319, it is clear that an

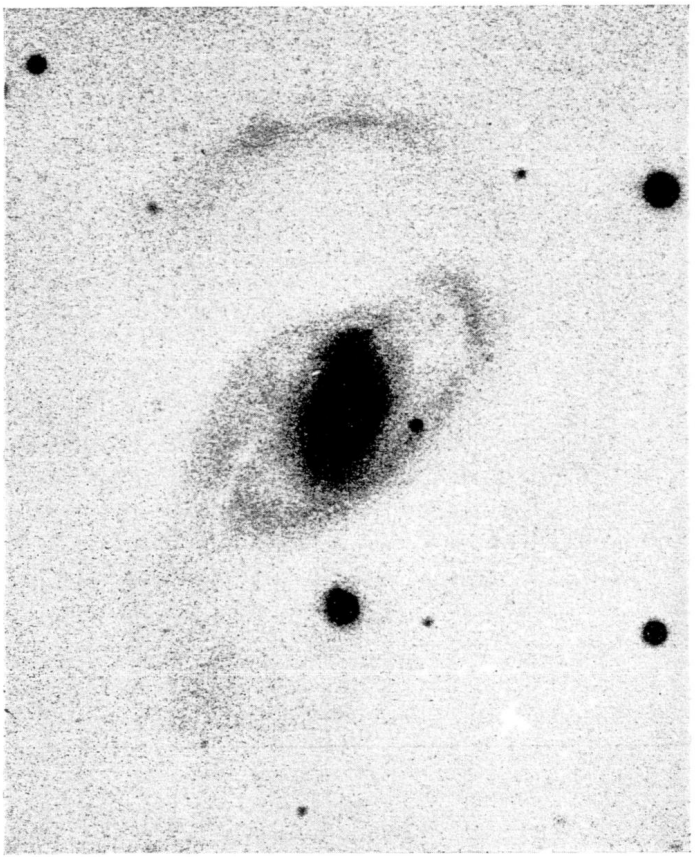

FIG. 1. Twenty-minute exposure on 103a-J plates. This plate and the plates of Figures 2 and 3 were taken with the 200-in telescope, $f/3.67$ corrector. North is at top, East at left. Markarian 205 is the bright object located 40 arc sec south of the nucleus of the spiral galaxy. There is a faint, apparently stellar image just on the north–northeast edge of the Markarian 205 image.

FIG. 2. Four-hour exposure on baked IIIa-J plates.

interference filter shifted more to the red, and possibly narrower, would give a picture of the connection in better contrast. Observations with such filters are planned for the next observing season, and with better seeing and longer exposures a good deal more information about the form and structure of the connection is expected. Spectra with the slit along the connection should also show emission lines, if present, and give some information about its radiation mechanism.

THE GALAXY NGC 4319

Because of the apparent size and magnitude of the spiral galaxy NGC 4319, its redshift had been assumed to be approximately the same as the 1800 km/sec redshift of the nearby companion galaxy, NGC 4291. But until now, no redshift of NGC 4319 itself has been published. Again because of the shortage of observing time, Maarten Schmidt kindly obtained two spectra of NGC 4319 for me. It is now possible, therefore, to report that the actual measured heliocentric redshift of NGC 4319 itself is $c\Delta\lambda/\lambda = 1700 \pm 100$ km/sec (the quoted error is the difference between measures on the two plates). No emission lines are visible on these spectra of NGC 4319, and the redshift refers to only K, H, and the G band observed in the disk and nuclear regions of NGC 4319.

The deep IIIa-J plate (Figure 2) shows NGC 4319 to be disturbed in its outer parts with a long straight outer spiral arm proceeding several diameters away into space. The inner regions are also very disturbed, with one arm appearing to pull away from the disk of NGC 4319 at its root. However,

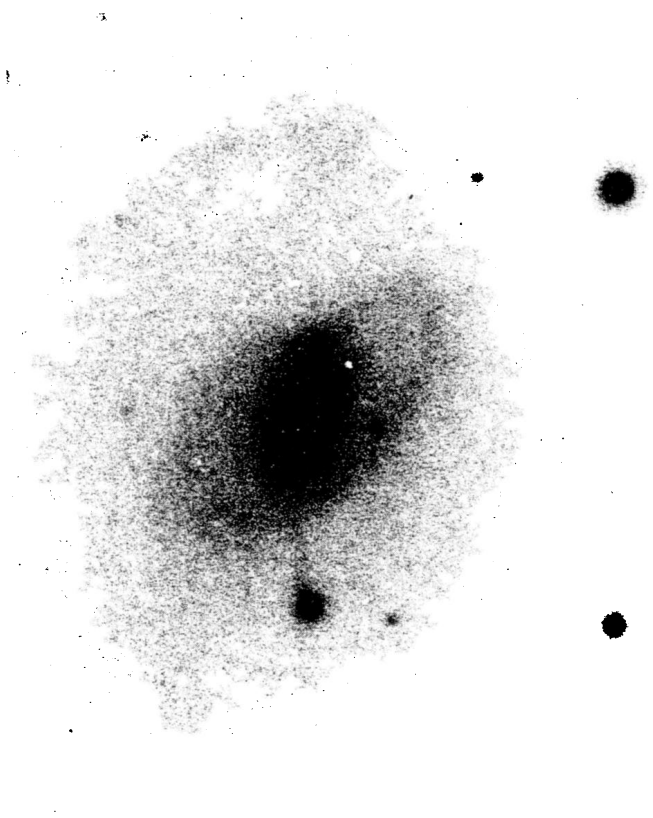

FIG. 3. Thirty-minute exposure with Hα interference filter as recorded by ITT 7151 image intensifier.

because of the proximity of the companion galaxy NGC 4291, we can not judge at this time whether the disturbances in NGC 4391 are caused by its interaction with NGC 4291 or by a disturbance accompanying the ejection of Markarian 205.

THE QUASI-STELLAR OBJECT MARKARIAN 205

It has already been mentioned that normal photographs show that Markarian 205 is stellar. Since its redshift is in the intergalactic range, it fits the definition of a quasi-stellar object (Schmidt 1969, Arp 1970b). On the longest exposure plate (Figure 2) and the Hα plate (Figure 3) a narrow, irregular halo of fuzzy, luminous material barely registers around the object. Since this luminous material has about the same surface brightness as the connection back to the nucleus of NGC 4319, a first hypothesis would be that it represents material in the disk of the spiral that is excited by the presence of the Markarian object.

The spectrum of Markarian 205 is like that of low-redshift quasars. Its redshift is 0.070. This value is rather low among the range of quasar redshifts, which reach as high as 2.877. Burbidge and Burbidge (1969) list quasi-stellar objects with redshifts as low as 0.060 and 0.064. We do not know whether close inspection of normal photographs would show that these QSOs appear truly stellar. The source 3C273 is the best known quasi-stellar radio source, however, and its redshift of 0.158 is not very much higher, in terms of the range of quasar redshifts, than the redshift of Markarian 205.

The place of Markarian 205 in the redshift-apparent magnitude diagram is also of considerable importance. Markarian estimated its photographic magnitude to be $m_{pg} = 14.5$ mag. At its galactic latitude of $b = 42°$, the photographic absorption given by the cosecant extinction law is $A_B = 0.36$ mag. Not enough is known of the energy envelope of the object to say whether K corrections, such as are given galaxies when plotted in the redshift-apparent magnitude diagram, should be applied. (The galaxy K-correction at that redshift would make Markarian 205 about 0.3 mag brighter.) Without applying the K correction, Markarian 205 is about 1.5 mag brighter than would be predicted from the redshift-apparent magnitude relation for the brightest galaxies in rich clusters of galaxies. Another way of measuring this deviation from the line for the most luminous galaxies is to note that Markarian 205 has an excess redshift of about 11,000 km/sec from that line. The important point, of course, is that Markarian 205 falls above the line of brightest galaxies in the redshift-apparent magnitude relation, as do quasars in general, including those with very high redshifts.

In summary, Markarian 205 appears to be a bonafide quasi-stellar object, which is connected to the nucleus of a larger, lower-redshift galaxy. Evidence that compact objects with intrinsic, non-velocity redshifts are ejected from galaxies has been presented elsewhere (Arp 1970a). The present case fits well with the previous examples, except that in the present case the ejected object fits the extreme compactness characteristics of the class and is a quasi-stellar object.

REFERENCES

Arp, H., 1967, *Astrophys. Letters*, **1,** 1.
Arp, H., 1970a, *Nature*, **225,** 1033.
Arp, H., 1970b, *Astrophys. J.*, **162,** 811.
Burbidge, G. R., and Burbidge, E. M., 1969, *Nature*, **222,** 735.
Markarian, B. E., 1967, *Astrofizika*, **3,** 55.
Markarian, B. E., 1969a, *Astrofizika*, **5,** 443.
Markarian, B. E., 1969b, *Astrofizika*, **5,** 581.
Schmidt, M., 1969, *Annu. Rev. Astron. Astrophys.*, **7,** 527.
Weedman, D. W., 1970, *Astrophys. J.*, **161,** L113.

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