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A VARIABLE RADIO-QUIET COMPACT GALAXY I Zw 1727+50

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ABSTRACT

The continuous energy distributions of two Zwicky compact galaxies, I Zw 1727+50 and 3C 120, have been measured. The first of these is variable both in brightness and color. In I Zw 1727+50 non-thermal radiation probably contributes to the visual radiation, but the flux does not continue to increase in the infrared. Reasons for this behavior are discussed.

I. INTRODUCTION

A general program is now in progress to investigate peculiar galaxies which may be related to quasi-stellar objects. The objects being studied include Seyfert and N-type galaxies and the compact galaxies discovered by Zwicky. They are being investigated by photographic low-dispersion spectroscopy, photoelectric spectrophotometry, and infrared photometry. The recent discovery by Oke (1967) of large changes in brightness of the nucleus of the N-type galaxy 3C 371 suggested that brightness changes might occur in these other galaxies.

The purpose of this Letter is to report that variability has been discovered in the radio-quiet compact galaxy I Zw 1727+50, of visual magnitude 15.8, which has been described by Zwicky (1966). Results for this object are described and a comparison is made with another Zwicky compact galaxy, 3C 120, which has *not* yet been shown to be variable.

II. OBSERVATIONS OF I Zw 1727+50

Visual inspection of I Zw 1727+50 at the prime focus of the 200-inch telescope indicates that it has a diameter of 3″ and a pronounced central concentration. Zwicky (1966) obtained low-dispersion spectra and found no emission or absorption lines out to λ6800. Additional slit spectra were obtained in the blue at a higher dipsersion of 190 Å/mm, but still no clear evidence for spectral features was found. Consequently, the redshift cannot be determined. It is surmised, however, that if I Zw 1727+50 is like objects of similar appearance of known redshift, the value of z is unlikely to be more than 0.05–0.07.

Photoelectric spectrophotometric observations of this object were made with the prime-focus spectrum scanner of the 200-inch telescope on four nights. One set of blue measures from 0.33 to 0.60 μ was obtained on July 24–25, 1966, and another on October 2–3, 1967. A few near-infrared measures from 0.584 to 0.995 μ were obtained on August 10–11 and September 29–30, 1967. All measurements were reduced to absolute fluxes outside Earth's atmosphere by standard techniques (Oke 1965); the absolute fluxes are based on the absolute calibration of α Lyr give by Oke (1964) except that all points below the Balmer jump are made fainter by 6 per cent. Absolute fluxes have been measured at effective wavelengths of 1.65 and 2.2 μ using an infrared photometer at the Cassegrain focus of the 200-inch telescope. The techniques and calibrations are described by Neugebauer and Becklin (1968). The point at 2.2 μ is the mean of measurements made on

June 28–29, 1967, and September 26–27, 1967. The separate measurements are in agreement. The 1.65-μ measurement was made on the night of September 26–27, 1967.

All results are shown in Figure 1 where $\log f_\nu$ is plotted versus $1/\lambda$; f_ν is the absolute flux in ergs sec^{-1} cm^{-2} Hz^{-1} and the wavelength λ is in microns. Standard deviations are plotted for the points in the infrared. Errors for the remaining points are all less than 0.02 in $\log f_\nu$. It is clear that I Zw 1727+50 is variable with a range in the blue of 0.2 in

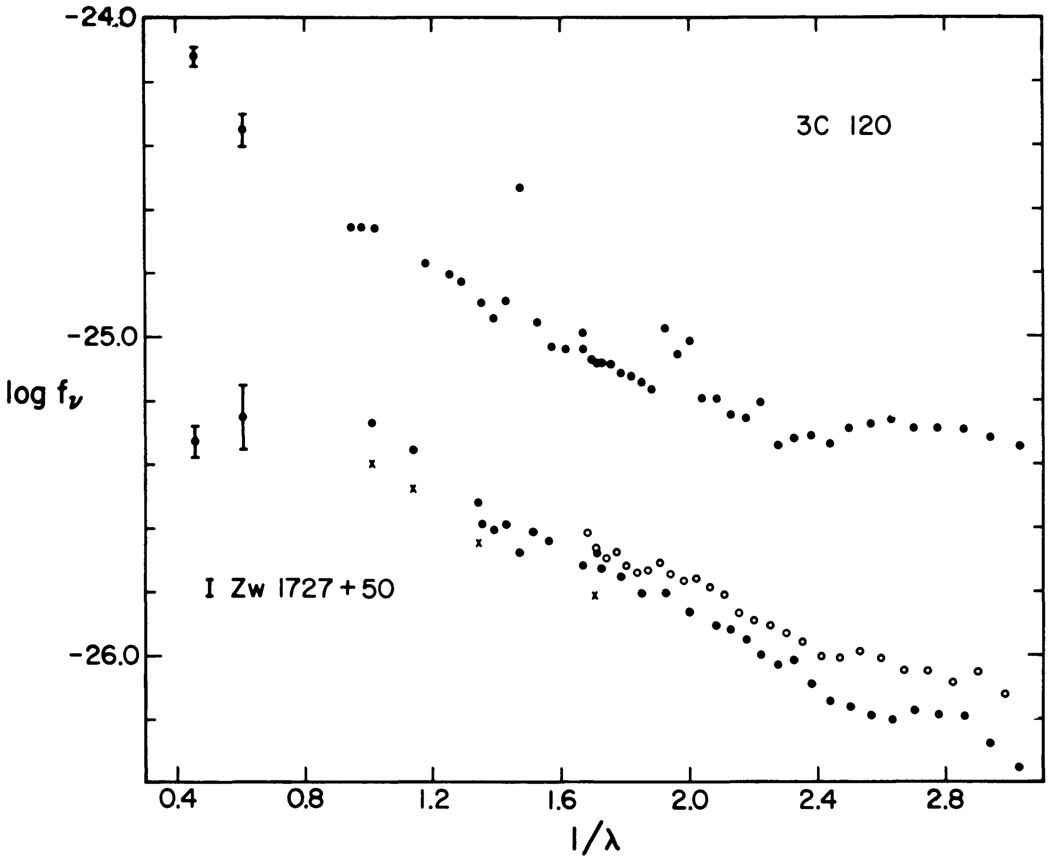

FIG. 1.—Absolute fluxes $\log f_\nu$, where f_ν is the flux in ergs sec^{-1} cm^{-2} Hz^{-1}, are plotted against $1/\lambda(\mu)$ for 3C 120 and I Zw 1727+50. In the lower plot, open circles are measurements made on July 24–25, 1966, and solid dots are fluxes obtained on September 28–29 and October 2–3, 1967. The points marked by × were obtained with an entrance aperture of 7″ and are too low by approximately 0.06 in $\log f_\nu$ (Sandage 1967). The 1.65- and 2.2-μ measurements were also made with 7″ entrance apertures and should be corrected upward, presumably by the same amount. Dates for all observations are listed in the text. The bars denote the standard deviations for the infrared points. For all other points the standard deviations are less than 0.02 in $\log f_\nu$.

$\log f_\nu$ or 0.5 mag. Changes occur in times of the order of 50 days; over an interval of 3 days no change has been observed.

A comparison of the detailed flux measurements in the blue shows that the color has changed appreciably. Sandage (1967) has independently found changes in the brightness and color using *UBV* photometry. The change is similar to that observed in 3C 371 (Oke 1967) and can possibly be interpreted in the same way, namely, that there are contributions from a constant background galaxy and a less-red non-thermal source which is variable. Since no well-defined spectral features are observed, it is not possible at present to verify this hypothesis or to separate the components.

III. OBSERVATIONS OF 3C 120

The radio object 3C 120, also identified as PKS 0430+05, is a Zwicky compact galaxy with a visual magnitude of 14.25 (Sargent 1967). The visible light does not appear to be polarized (Kinman 1967). Its spectrum has been obtained by Sargent (1967) and by Burbidge (1967). It differs from I Zw 1727+50 in having strong broad emission lines which give $z = 0.0323$. Photoelectric spectrophotometric measures from 0.33 to 0.60 μ were obtained on January 18–19, 1967, and from 0.33 to 1.06 μ near October 1, 1967. Infrared fluxes were measured at 1.65 μ on September 25–26, 1967, and at 2.2 μ on September 13–14 and September 25–26, 1967. The visual results obtained near October 1, 1967, and the infrared fluxes are plotted in Figure 1. The relative energy distribution on January 18–19, 1967, agrees with that shown and an indirect calibration of these measures on an absolute scale shows that 3C 120 had the same brightness within 10 per cent.

IV. DISCUSSION

There are now a number of peculiar galaxies with measured continuum fluxes where it is suspected that non-thermal radiation contributes to, or even dominates, the continuum in the wavelength region from 0.33 to 1.10 μ. Such objects are Seyfert galaxies such as NGC 4151 (Oke and Sargent 1968), 3C 371 (Oke 1967), and the two objects described here. Infrared measurements of the Seyfert galaxy NGC 1068 by Pacholczyk and Wisniewski (1967) show that the continuum flux continues to increase with a slope similar to that observed below 1 μ. In the case of 3C 371, Neugebauer and Becklin (private communication) find that the 2.2-μ flux is compatible with a linear extrapolation of the visual continuum. A similar result is found here for 3C 120. In contrast, I Zw 1727+50 is an object in which a non-thermal contribution to the visual continuum is suspected and in which the flux does not increase and may in fact begin to decrease in the infrared. There are two possible explanations of this behavior.

a) The non-thermal radiation may be self-absorbed up to very high frequencies ($\sim 10^{14}$ Hz). Self-absorption has been proposed to explain why the Seyfert galaxy NGC 4151 and Ton 1542 have non-thermal optical continua and yet are not radio sources (Wampler 1967; Oke and Sargent 1968). However, in no previous case has the spectrum been observed to turn over at such high frequencies.

b) It is possible that the infrared radiation from I Zw 1727+50 is mostly thermal and that a relatively flat non-thermal contribution dominates in the blue. Combination of a galactic energy distribution (Johnson 1966) and an energy distribution such as the non-thermal portion of 3C 371 shows that this is indeed possible.

If the energy distribution for $1/\lambda < 2.2$ is extrapolated linearly into the violet, both I Zw 1727+50 and 3C 120 have excess ultraviolet radiation. In the case of 3C 120, this excess could be Balmer continuum emission since the Balmer lines are strong. However, in I Zw 1727+50 this is not likely to be the explanation since no Balmer lines are seen. Wampler (1967) has measured the spectral energy distribution of Ton 1542. For $1/\lambda < 2.2$ he finds virtually the same slope obtained here for 3C 120 and also a strong ultraviolet excess which he concludes is not Balmer emission. Since he has pointed out that Ton 1542 may be non-stellar in appearance and is possibly variable, it may be similar to the objects described in this paper.

It is clear that a search in the red spectral region for stellar absorption features coming from an underlying normal galaxy may be critical in understanding I Zw 1727+50 and these other objects. In addition, polarization measurements at several wavelengths and investigations of the light variations from the infrared to the ultraviolet may provide insight into the problems of the nature of the continuum.

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