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AN ERUPTIVE BL LACERTAE OBJECT WITH A HIGH REDSHIFT, 0846+51W1

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ABSTRACT

The optical counterpart of the radio source 0846+51W1 was observed to brighten from $V \sim 19.5$ mag to $V = 15.7$ mag in less than one month. Additional optical and radio observations are now reported. They show: (1) At maximum light outburst, the continuum is featureless and the object has all the radio and optical characteristics of a BL Lacertae object (except polarization, which is unknown). (2) The normal light level V is between 19 and 21 mag. (3) Throughout its phases, the optical $B-V$ and $U-B$ colors are appreciably redder than any quasar. (4) The spectrum at minimum light has emission lines that yield a redshift of $z = 1.860$. This is the highest redshift so far found for a BL Lacertae object. (5) The BL Lacertae object lies only 12″ south of the southern member of a pair of interacting spirals. (6) One possible emission line is not identified in the $z = 1.86$ redshift system. This could be part of a second emission-line redshift system. The latter would require confirmation by additional observation.

Subject headings: BL Lacertae objects — galaxies: redshifts

I. INTRODUCTION

The radio source 0846+51W1 was identified with a 19.5 mag star on a plate taken on 1975 January 14. Surprisingly, however, the object was 15.7 mag only a month later, when Arp observed it with the 5 m telescope at Palomar on February 15.

Observations were carried out by Arp and Sargent as often as possible for the remainder of that year in order to follow the behavior of the light curve. When its brightness dropped below 19.0 mag, a shallow emission line became visible in the spectrum. Longer-exposure spectrograms were obtained in order to try to detect more lines and determine a redshift. For these spectra, Arp observed principally with apertures, and Sargent observed with a slit.

Additional radio observations of 0846+51W1 were made with the Westerbork Synthesis Radio Telescope. Willis and Oosterbaan report these observations, and in the final sections we discuss what the observations at all wavelengths tell us about this object and its relation to other types of extragalactic objects.

II. OPTICAL IDENTIFICATION OF THE RADIO SOURCE

In a previous paper in this series (Willis, Oosterbaan, and de Ruiter 1976, hereafter Paper I), a catalog of 1075 radio sources detected in 96 fields was published. The accuracy of these radio positions was generally a few arcsec. For those areas near bright or peculiar galaxies, deep photographic plates by Arp were used to measure accurate positions of candidates for optical identification (de Ruiter, Willis, and Arp 1977, hereafter Paper II). One of the radio sources so identified on a 1.2 m Palomar Schmidt IIIa-J Plate was 0846+51W1. It lies 35′ from the bright spiral NGC 2681 ($m_v = 11.2$ mag). The optical position of 0846+51W1 (Paper II) is R.A. = $08^h46^m22^s.51$, decl. = $51°19′39″.9$ (epoch 1950.0) with an uncertainty of $\pm$ 0″.5 in each coordinate. The radio position agrees to within 0″.5 with the optical position in each coordinate.

The optical and radio objects are obviously the same, and when the optical object was first observed to have brightened by almost 4 mag in less than a month, it was clear that it was an unusually interesting object. Figure 1 shows the eruptive object marked by an arrow as it appeared on 1975 March 10. It appears to have been slightly fainter than $V = 17$ mag at this date, as indicated by the light curve of Figure 3. Figure 2 (Plate 2) shows the object about one year later, on 1976 January 31. Around this date, the object appears to have been fainter than $V = 20$ mag. Both photographs were obtained with the 4 m KPNO telescope on IIIa-J plates, but Figure 2 is taken with the best seeing and shows a faint nebulosity 2″ southeast of 0846+51W1, as well as the best detail in the interesting pair of spirals just to the north of 0846+51W1.

Figures 1 and 2 also conspicuously show that the eruptive object 0846+51W1 is extremely close to one of a pair of interacting spiral galaxies (12″ south of the southernmost of the pair). Actually, the configuration north of 0846+51W1 is even rarer than an interacting pair. The five brightest galaxies in this general area form a chain stretching north and slightly west with

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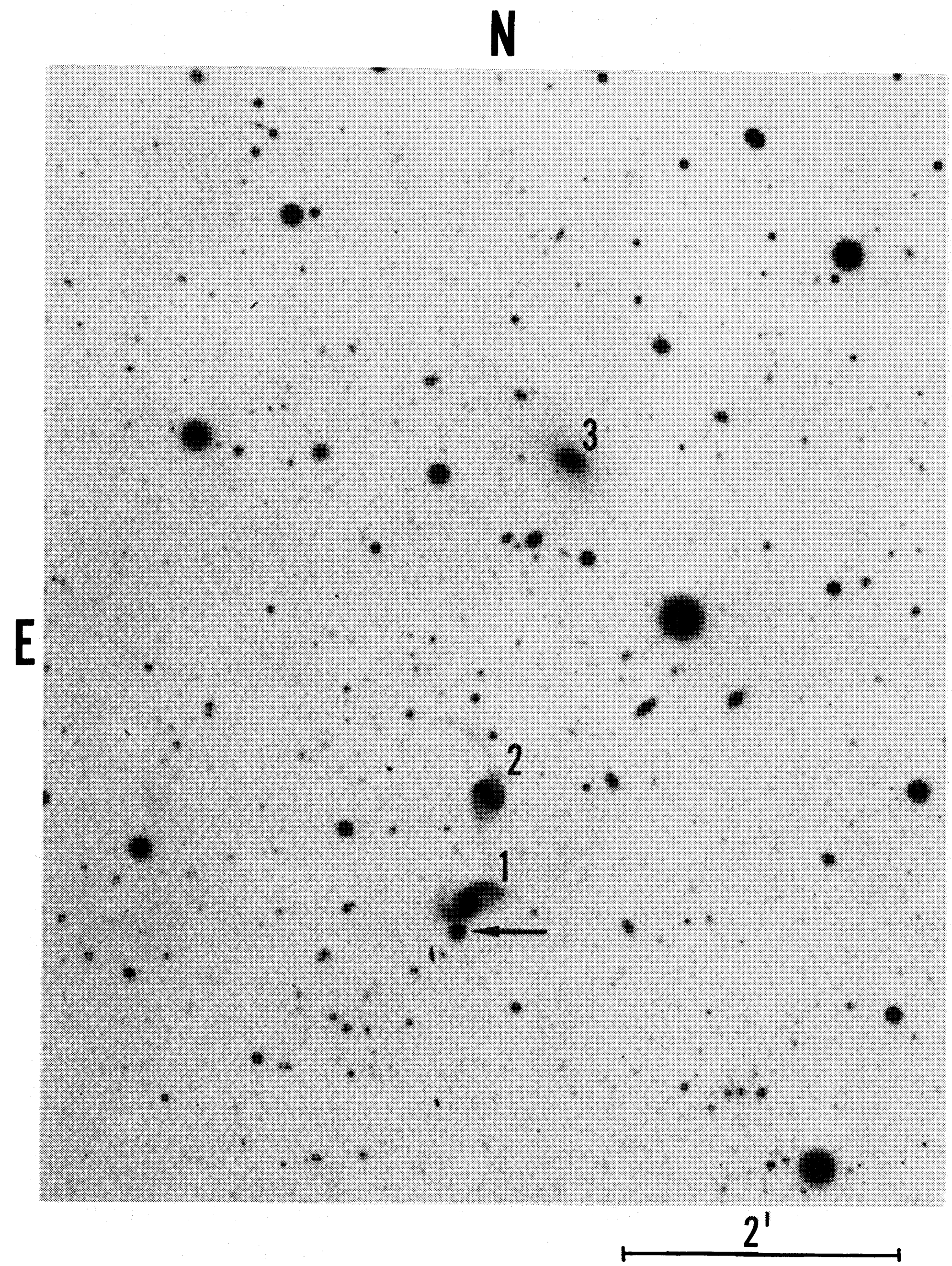

FIG. 1.—Eruptive radio source 0846+51W1 marked by arrow. Photograph is with 4 m KPNO telescope, 45 minute exposure on IIIa-J emulsion behind GG 385 filter. Magnitude is slightly fainter than $V = 17$ on 1975 March 10. Galaxies to north marked 1, 2, and 3. The radio source is 12″ south of galaxy 1. Note interactive distortion in arms of galaxy 2.

TABLE 1

REDSHIFTS OF GALAXIES NORTH OF 0864+51W1

Line	z
Galaxy North 1	
[O] II em	0.072
H9	0.070
H8	0.072
K	0.073
H	0.073
Hδ	0.072
Hβ em	0.071
Average	0.072
Galaxy North 2	
H8	0.074
K	0.073
H	0.071
Hγ	0.068
Hβ	0.067
Mg I	0.073
Average	0.071
Galaxy North 3	
K	0.056
H	0.056
G-band	0.057
Mg I	0.057
Mg H	0.058
Average	0.057

NOTE.—No heliocentric correction.

TABLE 2

MAGNITUDES, COLORS, AND OBSERVING DATES FOR 0846+51W1

Date	V_{5000}	V*	$B-V$*	$U-B$*
1954 Feb 23	~19.5†	...	...	...
1975 Jan 14	~19.5‡	...	...	...
1975 Feb 15	15.9§‖	15.72	0.56	−0.37
	15.9§	15.75	0.56	−0.38
	15.8§	15.64	0.55	−0.38
1975 Feb 17	17.0§	...	...	...
1975 Feb 18	16.9§	...	...	...
1975 May 2	18.4§	18.10	0.88	−0.19
1975 May 3	17.7§	17.50	0.66	−0.23
	17.5§	17.32	0.69	−0.32
1975 Oct 5	18.1§	17.86	0.71	−0.14
1975 Dec 26	slit‖	...	...	...
1976 Jan 1	19.6‖	...	...	...
1976 Feb 27	20.5§	20.03	1.04	−0.38
	20.5§	19.97	0.94	−0.24
	20.2§	19.85	0.82	−0.57
1976 Apr 29	19.9‖	...	...	...
1977 Mar 11	21.0‖	...	...	...
1978 Mar 9	20.3‖	...	...	...

* To correct for galactic csc reddening, use $E_{B-V} = 0.10$, $E_{U-B} = 0.07$.

† *Palomar Sky Survey.*

‡ 1.2 m Schmidt.

§ 5 m MCSP.

‖ 5 m DSP.

0846+51W1 being a sixth object aligned closely in this same direction. The configuration is similar to another chain of galaxies found by Bolton and Peterson (1974) in which the quasar, as in the present case, fell almost tangent to the arm of one of the spirals. Table 1 presents the redshifts measured with the 5 m SIT spectrograph of three of the brightest members of this apparent chain (numbered as in Fig. 2). Other cases of interactive galaxy chains apparently falling close to large spirals (like NGC 2681, which is 35′ NE of 0846+51W1) are discussed in Arp (1972). Another example of alignment of quasars and interacting galaxies is with NGC 7714/15 (Stocke and Arp 1978).

III. LIGHT CURVE OF THE OUTBURST

Table 2 gathers together all the data available on the brightness of 0846+51W1. The first two magnitudes are eye estimates from 1.2 m Schmidt plates, one taken in 1954 (*Palomar-National Geographic Survey*) and the other a special deep IIIa-J plate taken for purposes of radio-source identification by Arp in 1975. On February 15, and later, the measures were made with the multichannel spectrophotometer on the 5 m telescope on Palomar, and then after a transition period in 1976, with the SIT digital spectograph.

A wavelength of 5000 Å has been adopted, and all magnitude measures have been made on this standard system. The reason for adopting 5000 Å is threefold: (1) This wavelength is near the effective wavelength $\lambda_e \sim 5500$ for the Johnson-Morgan V magnitudes. Therefore, we call our magnitudes V_{5000}. (2) The effective magnitude for IIIa-J plates plus a Wr 4 filter is just about $\lambda_e \sim 5000$ Å (J. Kormendy, private communication). (3) The color equation from V_{5000} (or m_J) to IIIa-J plates taken behind a Wr 2C filter is very small (see Arp 1973, p. 427). Therefore, photographic magnitudes from 11a-J plates can most easily be all put on the same system at V_{5000}. Figure 3 plots V_{5000} versus the dates on which 0846+51W1 was observed.

The most interesting part of the light curve is in the month between the observations of 1975 January 14 and those of February 15. Because there are three separate measures on February 15, as well as polaroid photographs of the Quantex viewing screen, there can be no doubt that the object was near $V_{5000} = 15.8$ mag on that date. But two days later it had dropped more than a magnitude to near $V_{5000} = 17.0$ mag. With such a sharp drop, it is possible that prior to February 15 it was even brighter than 15.8 mag. Similarly, the likelihood that the object began its abrupt rise exactly on January 14 is small. In all probability, this abrupt rise started somewhere *between* January 14 and February 15. Therefore, it is most probable that 0846+51W1 brightened by more than 4 mag in fewer than 30 days.

How rapid the true rate of brightening actually was is impossible to say, of course. We have established a lower limit for the rate of 4 mag in 30 days. This is comparable to the brightening observed in 3C 279 of 3.5 mag in 40 days in one of its outbursts (Eachus and Liller 1975). Some more rapid brightening and fading rates have been observed (Liller and Liller 1975) but

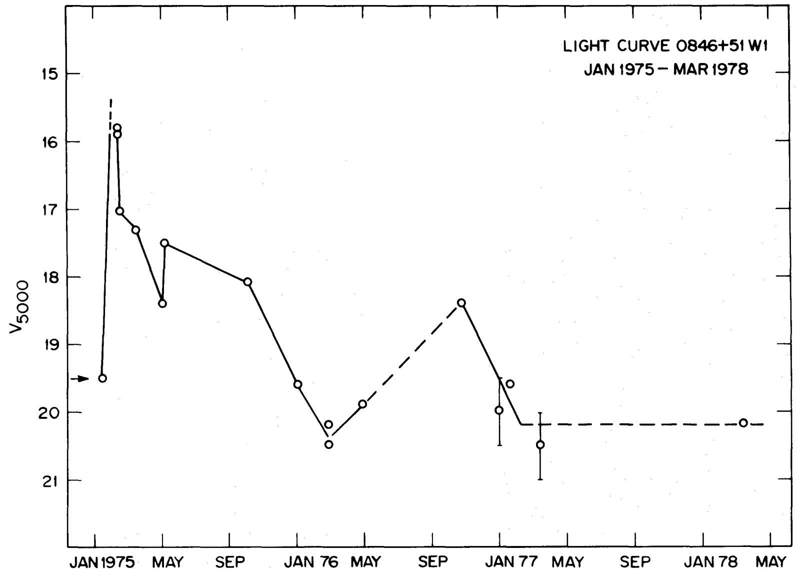

FIG. 3.—Light curve of 0846+51W1 from 1975 January to 1978 March. Values plotted are as summarized in Table 1. *Arrow*, magnitude on 1954 Palomar Sky Survey plate; *dashed lines*, unobserved portions during which behavior is inferred.

only over smaller amplitudes. In the discussion at the end of this paper, 0846+51W1 will be further compared to other quasars.

Continuing the discussion of the light curve in Figure 3, we note that 0846+51W1 fell to fainter than 20th magnitude after about one year. It appears to have had some kind of recovery during the following year, but could not have undergone an outburst which was of similar amplitude and shape to the first one within the unobserved period between 1976 May and October. Recent observations have been made less frequently, but the last one showed $V_{5000} = 20.3$ mag, and the object seems to have settled down around 20th magnitude. The first third of the light curve of 0846+51W1 somewhat resembles a Type I supernova, but the later decline is slower than a typical supernova, and it eventually appears to level out. A supernova, of course, would continue to decline unless it were peculiar like the one in NGC 1058 (Bertola and Arp 1970), which may be associated with a knot in a spiral arm.

IV. CONTINUUM COLORS OF 0846+51W1

Measures are available with the multichannel spectrophotometer (MCSP) over the first year of the outburst from the brightest level observed through the faintest level that the object has reached. Wherever a MCSP scan was available, it was possible to derive U, B, and V magnitudes by integrating under each photometric response curve, as described by Arp *et al.* (1976) and Arp, Willis, and de Ruiter (1979).

The derived magnitudes and colors on the Johnson-Morgan V, $B-V$, $U-B$ system are listed in Table 2. After correction for $E_{B-V} = 0.10$ mag galactic reddening, they are plotted in Figure 4. In Table 2, it is seen from multiple measurements on the same night that when the object is bright, the magnitude and color measures repeat well. When the object is faint, there is more scatter in individual measures. The mean color on each night on which 0846+51W1 was observed is plotted in Figure 4.

It is clear that 0846+51W1 is much redder than normal quasars. It is known that BL Lacertae objects tend to be redder than quasars (for a review, see Stein, O'Dell, and Strittmatter 1976). But 0846+51W1 at minimum is redder than most BL Lacertae objects. At minimum light, 0846+51W1 is about as red as BL Lac, or AO 0235+164 (Burbidge, Caldwell, and Smith 1976). More will be said about the comparison with these last two objects in a later section.

V. VARIATIONS IN CONTINUUM SLOPE

For each of the four different dates on which 0846+51W1 was measured by Arp, the best energy curve has been plotted in Figure 5 on a log F_ν versus ν plot. It is seen that the continuum can be reasonably represented as a straight line from $\log \nu = 14.5$–14.9. In its brightest phase, 0846+51W1 shows a slight bulge above the straight-line fit between $\log \nu = 14.7$ and 14.87. The remainder of the plots do not deviate significantly from a straight line.

If the continuum of 0851+46W1 is represented by a power law $F_\nu \sim \nu^{-\alpha}$, then we find values in the range of $\alpha = 1.63$–2.83. There is a clear progression from the shallowest slope at the brightest phase of the eruption to the steepest slope at the faintest phase. At maximum light, 0846+51W1 has a value for α much like those of the variable quasars 3C 345 and 3C 454.3 (Visvanathan 1973*a*, *b*). However, the slope quickly becomes steeper as 0846+51W1 gets slightly fainter than maximum. Thereafter, the continuum slope is very steep, like that of BL Lac itself.

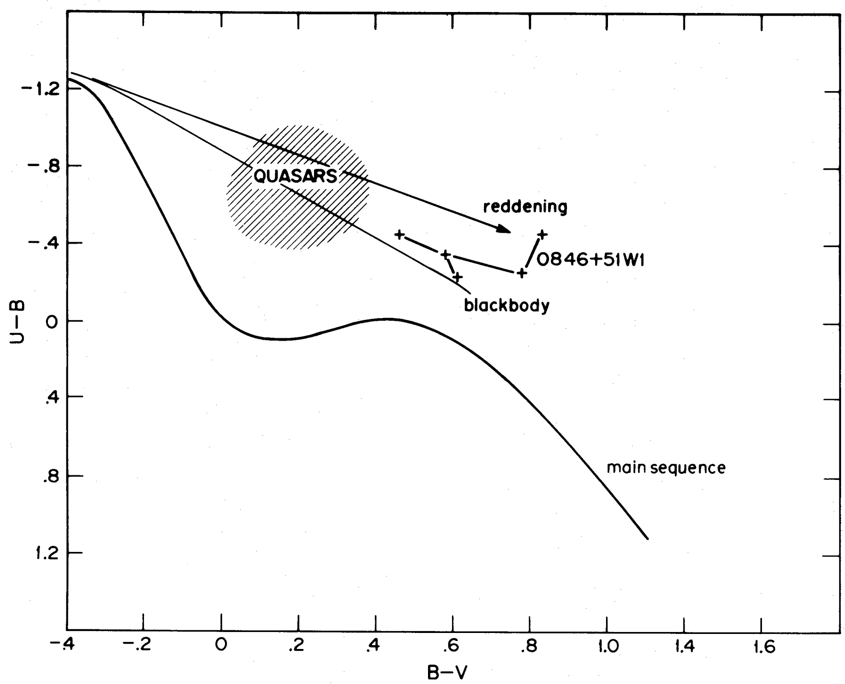

FIG. 4.—Location of 0846+51W1 in the color-color, $U-B$, $B-V$ diagram. The mean positions at five points in the light curve are plotted. Values are from Table 1 corrected for $E_{B-V} = 0.10$ mag cosecant law − galactic reddening. The object is bluest when brightest and reddest when faintest.

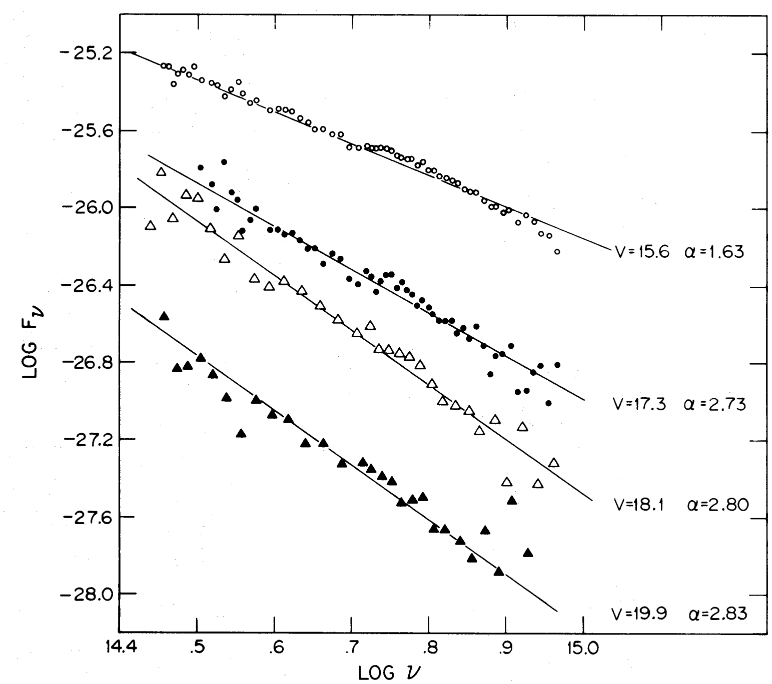

FIG. 5.—Log F_ν versus log ν plots of energy continuum of 0846+51W1. Straight-line slopes are fitted to four different brightness phases (see Table 1 for dates). The power-law coefficient for the nonthermal energy distribution is shown to vary from $\alpha = 1.63$ at brightest to $\alpha = 2.83$ at faintest level.

The observations obtained so far indicate that 0846+51W1 normally resides at some base or minimum magnitude around $V = 20$ mag. At that level, after outburst, it was very red with a steep continuum power law. A major outburst has been observed near its peak, and at that point the energy curve was much bluer. In this respect, it is like the variable quasar 3C 345 (Visvanathan 1973*a*), which becomes bluer at outburst. But other variable quasars like 3C 446 (Sandage, Westphal, and Strittmatter 1966) have gotten both redder and bluer at outburst, so further observations of 0846+51W1 are necessary before drawing general conclusions about its behavior.

VI. RADIO OBSERVATIONS

Radio Observations of 0846+51W1 are summarized in Table 3. The new 610, 1415, and 4995 MHz observations were made with the Westerbork Synthesis Radio Telescope. Those at 2695 and 8085 MHz were kindly made for us with the NRAO 3 element interferometer by Dr. E. B. Fomalont. A spectrum utilizing these data is shown in Figure 6. There is clear evidence that the source is variable at 1415 MHz, having decreased from ~400 mJy in 1970 to 190 mJy in 1975. However, there is no evidence of variability in the 610 and 4995 MHz Westerbork data. Although the present observations are sparse, it is possible that the change in 1415 MHz flux density may be correlated with the optical outburst described earlier, the radio flux density dropping dramatically after the optical flare-up. All the other radio observations were made after the period of most violent optical activity. The dashed line in Figure 6 delineates the radio spectrum in 1975–1976. This spectrum rises at centimeter wavelengths and is similar to those of the four BL Lacertae objects (BL Lac, OJ 287, 0048−09, and W Coma) studied in detail by Altschuler and Wardle (1975). Like the spectra of these four sources, that of 0846+51W1 has a positive spectral index over the whole range of frequencies at which it has been observed. Since there is a good correlation between centimetric excess and variability (Medd *et al.* 1972; Altschuler and Wardle 1975) a more systematic monitoring of 0846+51W1 should reveal that it still exhibits radio variability. The 4995 MHz Westerbork observations showed that the radio source was unresolved, so its angular size is $< \sim 1''$ at this frequency.

VII. SPECTRUM AND REDSHIFT

For about the first eight months, the MCSP scans were very smooth and showed no repeatable spectral features. A year later, however, when 0846+51W1 had fallen to $V_{5000} = 19.6$ mag, the first DSP spectrum taken showed a low contrast emission line at 4430 Å. Later, a DSP spectrum at a brighter phase (1976 October 18, $V_{5000} = 18.4$ mag) showed several more low-contrast emission lines besides the original one at 4430 Å. At that time, Sargent started taking long-exposure slit spectra of the object, and Arp took long-exposure spectra generally through apertures. Figure 7 shows the result of adding together all the aperture spectra (top) and slit spectra (bottom).

All the spectra were carefully calibrated and fluxes added at the same wavelength (±1–2 Å calibration certainty). Averaging the fluxes then reduced the error of measurement enough for each spectrum so that it was possible to plot it on an expanded scale. (On the top spectrum of Figure 7, the scale is 0–8 × 10^{-28} ergs cm^{-2} s^{-1} Hz^{-1}; on the bottom, the full scale is 0–3 × 10^{-28}.) The low-contrast lines are therefore accentuated over that of normal exposure spectra, and the lines may be detected much more easily.

There are only two certain emission lines in the spectrum of 0846+51W1. These are broad features, similar to the emission lines observed in QSO's, at 4430 Å and 5450 Å. They show up particularly well in the bottom part of Figure 7. The only reasonable identification of these lines is that they are C IV λ1549 and C III] λ1909, respectively. The corresponding redshifts are $Z_{cm} = 1.860$ for λ4430 and $Z_{cm} = 1.855$ for λ5450.

A comparison of the two parts of Figure 7 shows that the emission line at 5450 Å is conspicuous on the slit observations and is not conspicuous on the aperture observations. On the other hand, the line at 4430 Å is present on both sets of observations. We do

TABLE 3

RADIO DATA ON 0846+51W1

Frequency (MHz)	Flux Density (mJy)*	Polarization (%)	JD (2,400,000+)	Reference
610.............	204 ± 35	< 4	75,113	1
	166 ± 35	< 4	76,219	1
1400.............	370 ± 35	...	70,085	2
1415.............	360	...	?	3
	420 ± 80	...	70,209	4
	190 ± 15	< 2	75,258	1
2695.............	250	...	75,050	5
4995.............	258 ± 15	< 4	75,103	1
	280 ± 20	< 4	76,178	1
8085.............	400	...	75,050	5

* 1 mJy = 10^{-29} W Hz^{-1} m^{-2}.

REFERENCES.—(1) This paper; (2) Maslowski 1972; (3) Brundage *et al.* 1971; (4) Willis *et al.* 1976; (5) E. B. Fomalont (private communication).

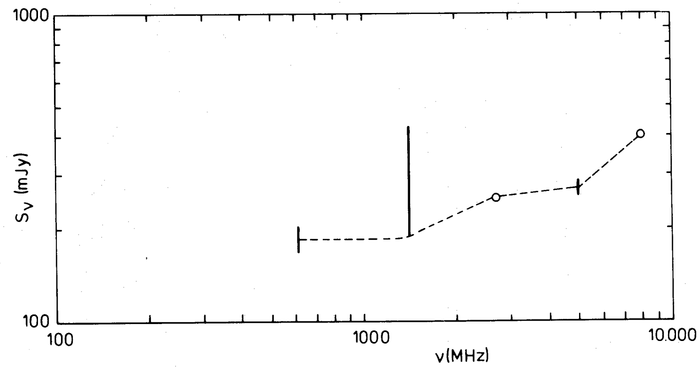

FIG. 6.—Radio spectrum of 0846+51W1. The bars indicate the variations in the measured flux densities at each frequency. At 1415 MHz, the variation is significant; at 610 and 4995 MHz, it is not. *Dashed line*, approximate shape of the spectrum during 1975–1976.

not really understand the reason for this. It is possible that the effect is due to the presence of the Hg I night-sky emission line at 5460 Å. The contribution from the sky is greater through an aperture; consequently, the resulting sky-subtracted signal contains more noise. But the much stronger, adjoining, night-sky line at 5677 Å seems to have relatively little distorting effect on either slit or aperture spectrum.

In order to investigate this effect further, Arp tried both slit and aperture spectra on the same night. The same effect was observed, i.e., the 5450 Å line was strong with the slit and weak or absent with the aperture. On the slit spectra, subtracting sky east or west of the object made no appreciable difference in the result. Arp then tried very small diaphragms (2″ diameter instead of the 3″ and 5″ customarily used). This made no difference in that the small aperture spectra looked the same as the large aperture spectra, i.e., little or no emission line at 5450 Å. Arp measured the small nebulosity 2″ southeast of 0846+51W1 and demonstrated that there was no strong emission or other effect coming from that object (see § IX). Therefore, we must tentatively conclude that the 5450 Å line is larger than it should be relative to 4430, and that, for some reason that we do not understand, it is much more conspicuous in the slit mode than it is in the aperture mode.

It is also puzzling to see the very flat slope of the continuum in the slit observations as opposed to the quite red sloping continuum in the aperture observations. It is true that differential refraction will spill blue and red light outside the 0″9 wide slit, which is oriented in an east-west direction. But the Quantex and Sitex viewers work essentially in the visual wavelengths, so that the image at just about 5500 Å should be the one guided in the center of the slit.

The image of 0846+51W1 appears quite stellar even with $\leq 1''$ seeing on fine-grain IIIa-J and 127-04 plates taken at the prime focus of the KPNO 4 m telescope. It seems unlikely, therefore, that the slit is observing a part of the image different from that observed by the aperture. However, the most attractive among a poor choice of hypotheses may still be that the slit is observing a central blue stellar object embedded in a slightly resolved redder object. This would require that some of the light from the outer ($\sim 1''$ diameter image) included in the apertures would be excluded from the 0″9 slit, and that excluding this light would increase the contrast of the emission line around 5450 Å. At present, this explanation seems to be the best among a poor set of hypotheses, but could be checked by better seeing photographs at perhaps a fainter phase, if such occurs, or possibly by study of the present images with image-processing algorithms.

a) *Emission Line Not Fitted: A Second Redshift?*

There is one strong emission line which appears in Figure 7 that is not fitted by the $z = 1.860$ redshift. There is a divergence of opinion about the reality of that line. Sargent believes that is is due to an ion spot on one of the slit observations and that the corresponding feature in the aperture mode is due to a chance noise fluctuation. Arp believes that the line is real and present in all the slit and aperture observations at 4890 Å. If the line is real, the only reasonable fit would be with the Mg II λ2798 line. This would indicate a redshift of $z = 0.747$ and predict that the O III λ3133 line of that system would fall at 5473 Å. This might be a possible explanation for the large size and breadth of the O III] λ1909 line compared with the C IV λ1549 line in the $z = 1.860$ system. Ruling out or confirming a possible second redshift system would naturally require extensive new observations of 0846+51W1.

VIII. DISCUSSION

The first point that should be established is that 0846+51W1 is clearly a BL Lacertae object, at least at maximum light outburst. Of the five criteria for BL Lacertae objects, 0846+51W1 exhibits (1) absence of, or very shallow emission lines; (2) variability at visual and other wavelengths; (3) a nonthermal continuum; and (4) redder color indices than normal quasars. Only criterion (5), strong and variable polarization, is unknown, as no polarization measures have yet been made on this object.

It is very interesting that as 0846+51W1 fades from

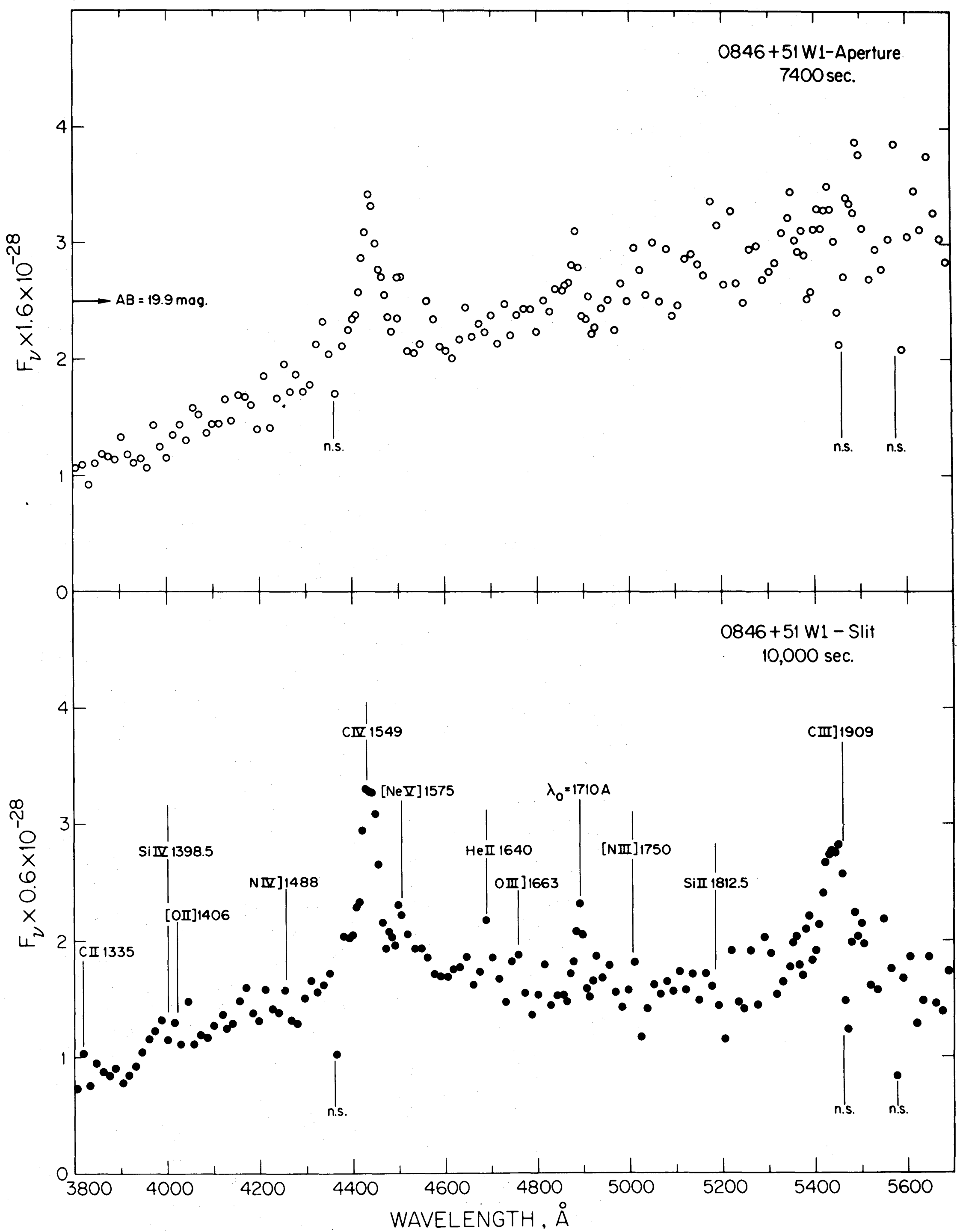

FIG. 7.—Top panel: all spectra taken with apertures 3″ to 5″ on 5 m SIT spectrograph averaged together for total of 7,500 s observation time. Vertical scale in ergs cm^{-2} s^{-1} Hz^{-1}. Bottom panel: all spectra taken with 0″.9 slit on 5 m SIT spectrograph averaged together for a total of 10,000 s observation time. Positions of three major night-sky lines marked in each spectrum. Major emission lines in the $z = 1.860$ redshift system are marked on lower, slit spectrum. The most conspicuous lines are identified with Si IV λ1398.5, C IV λ1549 and C III] λ1909. The position of the possible line at 4890 Å is marked as λ_0 1710 on the bottom plot. The positions of other lines expected in the $z = 1.86$ redshift system are marked. They are not claimed to be present on the basis of these data.

its outburst brightness, emission lines become visible and a very large redshift is derivable. In the sense that it acquires an emission-line redshift, it becomes like a quasar rather than a BL Lacertae object. It might also be that further study will show it to be less variable at its minimum phase. But, surprisingly, at its minimum phase, when it shows quasar emission lines, it is also at its reddest phase, during which it is least like a quasar in color and most like the prototypical BL Lac. Clearly, we have here a specific observational example of a transitional case between a quasar and a BL Lacertae object. It is true that we do not understand in what physical sense this is a transition, but further studies of this object and objects like it could illuminate the nature of the continuity between quasars and BL Lac objects, which most workers in the field have long considered to exist.

The fact that there is a small nebulosity very close to 0846+51W1 is reminiscent of A0235+164 (Burbidge *et al.* 1976) and PHL 1226 (Burbidge *et al.* 1971; Arp, Pratt, and Sulentic 1975). The nebulosity is 2″ southeast of the 0846+51W1 image, and Arp measured it to have $B_{4425} = 22.8$ mag, $V_{5000} = 22.0$ mag. It seems to be a normal red galaxy with no conspicuous emission lines. It may be part of what appears to be a loose cluster of galaxies of about that magnitude situated about 1′ southeast of 0846+51W1, or it may have some physical relationship with the BL Lac object, as is suspected in the first two mentioned cases.

The high redshift of 0846+51W1 makes it unique because when redshifts are found for BL Lacertae objects they usually are in the range $z = 0.05$–0.5. Here we determine a redshift of $z = 1.86$, which is far larger than any recorded before. Perhaps the most promising comparison of 0846+51W1, however, can be made with the quasar 3C 279. As we noted earlier, 3C 279 rose 3.5 mag in 40 days in one outburst. Overall, its amplitude is greater than 6.7 mag, and it generally rises from a baseline of about $B = 17$ mag (Eachus and Liller 1975) to apparent magnitudes as bright as 11th magnitude. Its redshift is $z = 0.54$, and if both this redshift and the 0846+51W1 redshift of $z = 1.86$ are assumed to be distance proportional, then 0846+51W1 would be derived to be 3.47 times farther away, or a factor of 2.7 mag in modulus. We would then expect, on the cosmological assumption, that 3C 279 with a redshift of $z = 1.86$ would outburst from a level near $B = 19.7$ mag up to levels near 13.7 mag, a fairly close match for the behavior of 0846+51W1.

But 3C 279 is blue, like a normal quasar, and not red, like 0846+51W1. To what is the redness of 0846+51W1 due? The normal explanation of the redness of BL Lacertae objects involves an underlying galaxy. But at a redshift of $z = 1.86$ for the object 0846+51W1, any normal galaxy would be much too faint in apparent magnitude to make any contribution to the observed light. So the nature of this high-redshift, BL Lacertae object–Quasar remains a mystery.

It is, of course, important to investigate the possibility that the BL Lacertae object is associated with the galaxy directly to the north. A statistical claim for the association is unfortunately affected by the usual *a priori–a posteriori* statistics controversy. Here we simply present two arguments, one of which would indicate that such a close radio source–galaxy coincidence would be expected in the de Ruiter *et al.* (1977) identification program; the second, that the coincidence is rare and unusual.

First, let us test the *a priori* assertion that any "bright" galaxy found near a stellar identification is a significant and unusual event. On the IIIa-J plates used for the de Ruiter *et al.* identifications, any galaxy brighter than $m \sim 19$ would be quite visible, and, if one were found close to a stellar identification, the grouping would certainly be considered interesting. Now, the average density of galaxies brighter than $m_{pg} \sim 19$ is $\sim 2.6 \times 10^{-5}$ arcsec^{-2} (using the relation given by McEwan, Browne, and Crowthers 1975). If we assume that these galaxies are randomly distributed, then the probability of finding one within a search radius of 12″.1 (the exact separation between the stellar object and the center of the galaxy to the north) is, from Poisson statistics, $\sim 12.1^2 \times \pi \times 2.6 \times 10^{-5} = 0.012$. However, in the de Ruiter *et al.* identification program, we identified 64 stellar objects, so that the number of expected galaxy-stellar object associations is $64 \times 0.012 = 0.77$. Thus it is not surprising that we have found at least one such coincidence.

The second alternative possibility is that 0846+51W1 is associated with the interacting galaxy *pair*. Interacting pairs are much rarer than random-field galaxies. Karachentsev (1968) states that 0.075 of all galaxies fall into the category of interacting systems. It is estimated that the interacting galaxies north of 0846+51W1 are about $m_{pg} = 16$ mag. Again using the relation given by McEwan *et al.* (1975) gives an average density of galaxies brighter than $m_{pg} \sim 16$ of 4.1×10^{-7} arcsec^{-2}. Applying the Karachentsev fraction to this yields a density of interacting systems of 3.1×10^{-9} arcsec^{-2}. This checks rather well against the density of interacting systems of 1.5×10^{-9} arcsec^{-2} cataloged by Zwicky brighter than $m_{pg} = 15.7$ mag. (The present interacting pair is not in a region covered by the Zwicky catalogs.)

Now, if we compute the Poisson probability of finding an interacting pair 31″ (distance of 0846+51W1 to the centroid of the interacting pair) from an arbitrary point in the sky, it turns out to be 9.3×10^{-6}. Multiplying by 64 stellar identified objects gives a chance of 6×10^{-4} of accidentally finding an interacting pair this bright this close to a stellar identification (less to a confirmed quasar). Seen in this way, the association must be considered very rare.

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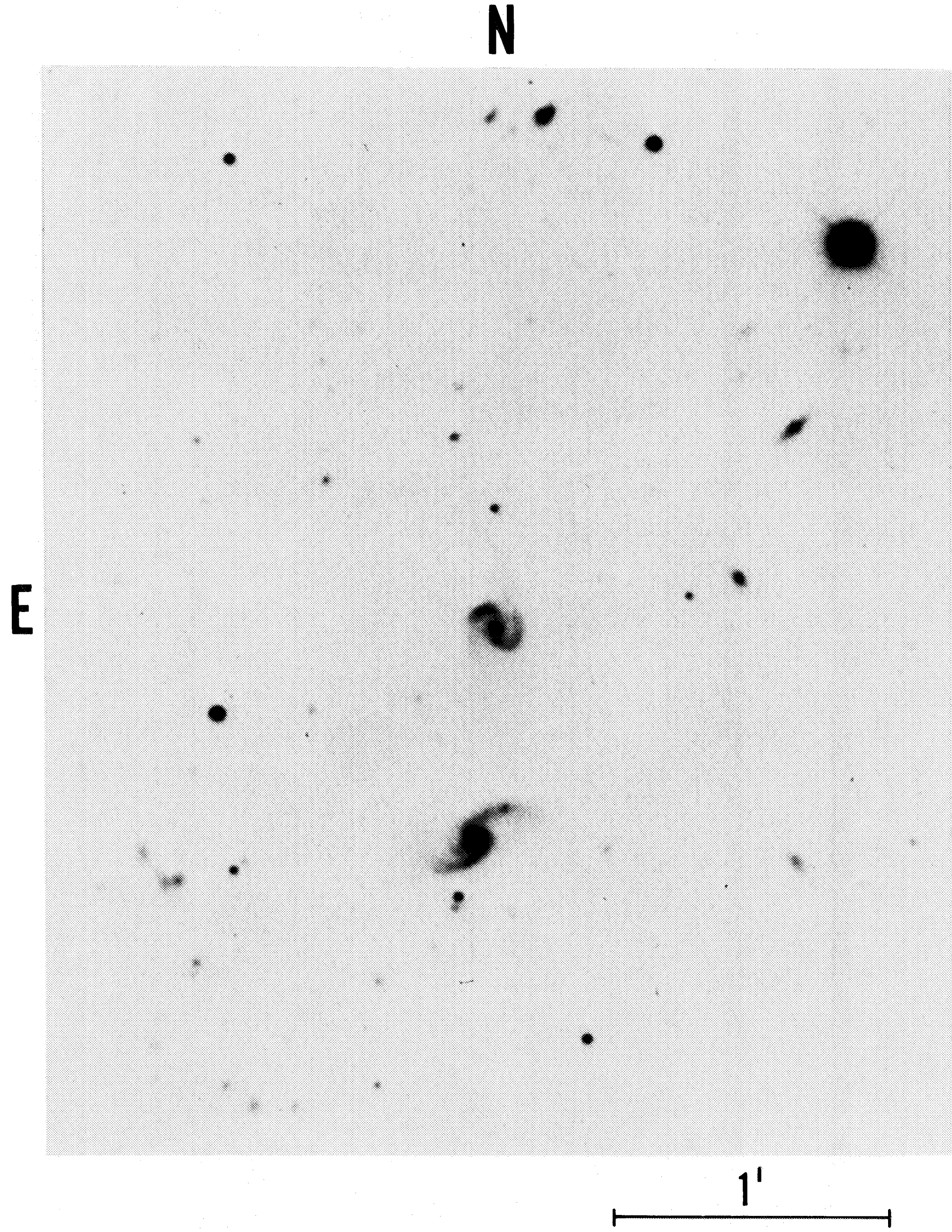

FIG. 2.—Radio source 0846+51W1 on 1976 January 31. See Fig. 1 for identification. Magnitude is slightly fainter than $V = 20$ on this 50 minute exposure with the 4 m KPNO telescope on IIIa-J emulsion behind a GG 385 filter. Seeing is best that was obtained, although, because of the extreme slowness of the emulsion batch, the plate does not reach as deep as Fig. 1. Note faint nebulosity 2″.1 south of the eruptive object. Note resolution of H II regions in arms of interacting spirals, H II regions which are as bright or brighter than those in the large disturbed spiral NGC 2681, which is at the center of this search field, about 35′ east.

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