

OPTICAL SPECTRUM AND REDSHIFTS OF A QUASAR OF EXTREMELY
HIGH INTRINSIC LUMINOSITY: B2 1225+31

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ABSTRACT

The optical spectrum of the 15.8 mag blue stellar object associated with the radio source B2 1225+31 shows two broad emission lines and many absorption lines. Seven absorption lines, identified with transitions common in quasar absorption spectra, give a redshift $z_{\text{abs}} = 1.793$. A strong emission line at 3930 Å and a weaker one near 4950 Å are identified with $\text{L}\alpha$ and $\text{C IV } \lambda 1549$ at a redshift $z_{\text{em}} = 2.2$.

The absolute magnitude of B2 1225+31, calculated with $m_v = 15.8$, $z_{\text{em}} = 2.2$, $H_0 = 100 \text{ km s}^{-1} \text{ Mpc}^{-1}$, and $q_0 = 0$, is $M_v = -29.8$; this quasar, one of the most luminous known, affords an exceptional opportunity for detailed study.

Subject headings: galaxies: redshifts — quasars

I. INTRODUCTION

We report spectroscopic observations of the blue stellar object of magnitude $m_v = 15.8$ associated with the radio source B2 1225+31. This quasar was observed in the course of a spectroscopic study of a sample of 33 radio weak quasars; this sample is formed with the quasi-stellar sources identified by Fanti *et al.* (1975) which have $m_B < 18.6$. The spectrum of B2 1225+31 shows a number of absorption lines and two broad emission lines. We propose identifications giving $z_{\text{abs}} = 1.793$ and $z_{\text{em}} = 2.2$, making this quasar one of the most luminous known.

II. DESCRIPTION OF THE OPTICAL SPECTRUM
AND REDSHIFTS

The spectroscopic observations were made with the 2.7 m telescope at McDonald Observatory on 1976 March 3 and 4. We used a two-stage image intensifier and obtained several spectrograms with dispersions of 235 and 112 Å mm⁻¹ (Fig. 1 [Pl. L6]; Table 1). The lower dispersion spectrograms cover the range 3150–6000 Å.

a) Absorption Lines

The optical spectrum of B2 1225+31 is rich in absorption lines, especially shortward of the strong emission line at 3930 Å. From inspection of the plates, it is clear that some of these lines are single while others are blends. We measured the wavelengths of the absorption lines on the spectra taken with a dispersion of 112 Å mm⁻¹ except for lines No. 1 and 19 in Table 1, column (1), which were measured on the low-dispersion spectra which have an extended wavelength range. The lines which we measured on the 112 Å mm⁻¹ spectra are shown in Figure 1b. The accuracy of the measured wavelengths depends on the strength and width of each line and is typically ± 1.5 Å.

Seven absorption lines, including the three brightest ones, are identified with transitions commonly observed

TABLE 1

WAVELENGTHS OF 19 ABSORPTION LINES

Number (1)	Wavelength (Å) (2)	Identification (3)	z (4)
1.....	3194.5		
2.....	3370	Si III $\lambda 1206.5$	1.7932
3.....	3396.2	H I $\lambda 1215.7$	1.7936
4.....	3429		
5.....	3508.5		
6.....	3520.5	Si II $\lambda 1260.4$	1.7932
7.....	3531.5		
8.....	3604		
9.....	3621.5		
10.....	3675		
11.....	3728.2	C II $\lambda 1334.5$	1.7937
12.....	3744.1		
13.....	3790.5		
14.....	3895	Si IV $\lambda 1393.7$	1.7947
15.....	3922.3	Si IV $\lambda 1402.8?$	
16.....	4069.3		
17.....	4265	Si II $\lambda 1526.7$	1.7936
18.....	4329	C IV $\lambda 1548.2, 1550.8$	1.7938
19.....	4670		
Mean z_{abs}			1.793

in absorption in quasars spectra and give the redshift $z_{\text{abs}} = 1.793$. The identifications are listed in Table 1, column (3). The measured wavelengths, in general, agree within 1 Å with the wavelengths of the proposed identifications redshifted by 1.7935. The only case where the agreement is poor is Si IV, the redshifted wavelengths of the two transitions at $\lambda 1393.7$ and $\lambda 1402.8$ differing by 1.7 and 3.6 Å, respectively from the measured wavelengths; we have to invoke the presence of contributors other than Si IV to explain the poor agreement. Nevertheless, in spite of this discrepancy, we consider the redshift $z_{\text{abs}} = 1.793$ as well established.

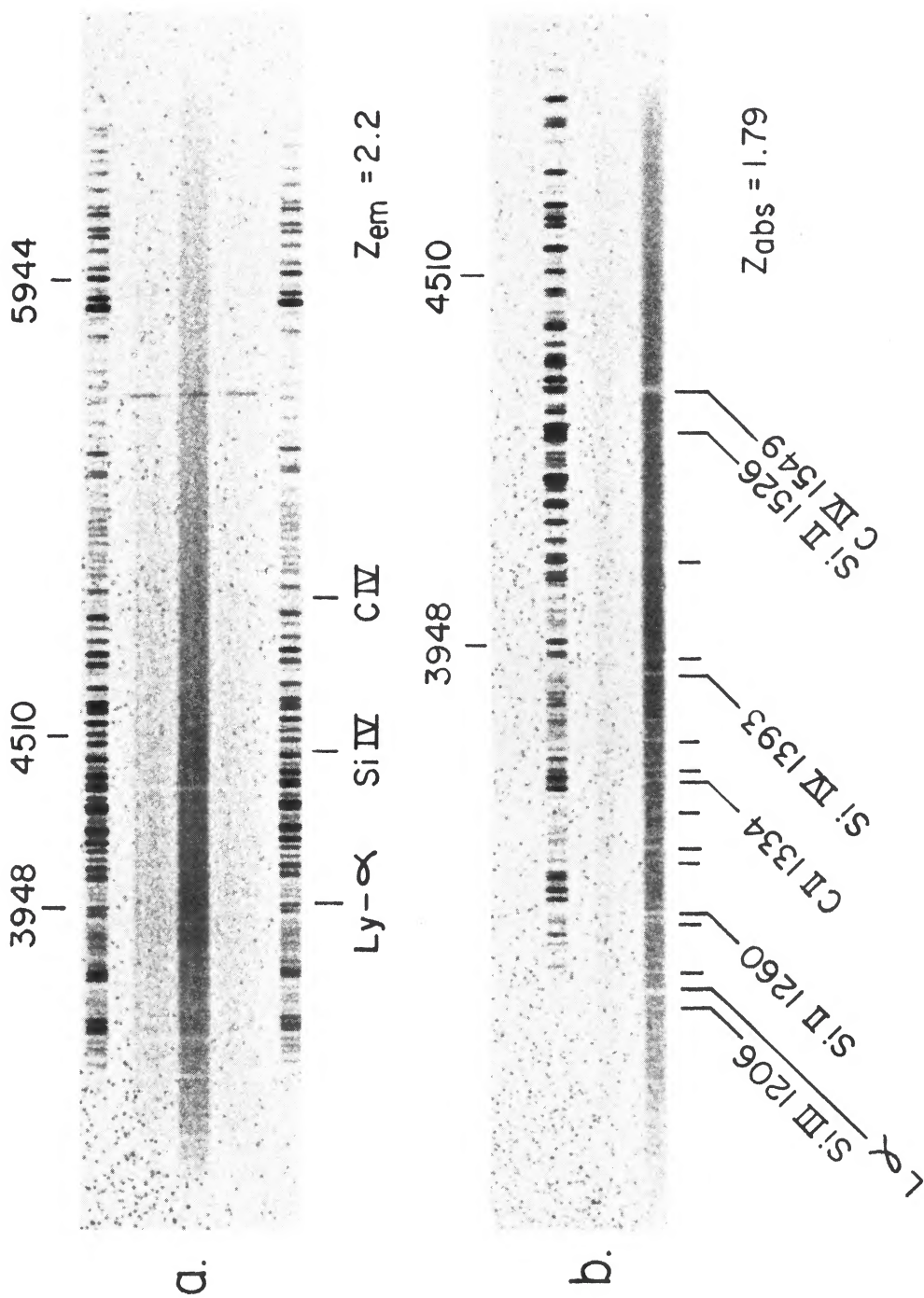


FIG. 1.—Spectrograms of the quasar B2 1225+31. Wavelengths of a few comparison lines are marked on top of each spectrum. (a) (top) 235 Å mm⁻¹ spectrum. The three emission features identified with $L\alpha$, $Si\ IV\ \lambda 1400$, and $C\ IV\ \lambda 1549$ at $z_{em} = 2.2$ are marked. (b) (bottom) 112 Å mm⁻¹ spectrum. The vertical lines mark the absorption features. Seven of the absorption lines are identified with transitions most commonly observed in quasars absorption-line spectra and give the redshift $z_{abs} = 1.793$.
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b) *Emission Lines*

The spectra show an intense emission line peaking near 3930 Å and a much weaker, low-contrast line near 4950 Å. A third broad emission line is suspected to be present near 4420 Å (see Fig. 1a). On our spectra these lines show little contrast against the continuum, partly because they sit in the strong gradient of density, reflecting the spectral response of the image intensifier. The identification of the lines near 3930 and 4950 Å with $L\alpha$ and C iv $\lambda 1549$ at $z_{\text{em}} = 2.2$ is plausible for three reasons: (i) The ratio of the observed wavelengths agrees well with the ratio of the rest wavelengths within the uncertainty $\Delta\lambda = \pm 40$ Å. (ii) The redshift $z_{\text{em}} = 2.2$ explains the line suspected to be present near 4420 Å as a blend of Si iv $\lambda\lambda 1393, 1402$ and O iv] $\lambda 1406$. (iii) Numerous absorption lines shortward of $L\alpha$ are seen in the spectra of other quasars. Identifications of the strong line at 3930 Å with transitions other than $L\alpha$ are unlikely; in particular, if this line were Si iv $\lambda 1393, 1402$, we would expect to find a strong line corresponding to $L\alpha$ at 3400 Å, which is not observed. If the line at 3930 Å were C iv $\lambda 1549$, the emission redshift would be 1.53, which is smaller than the well-established absorption-line redshift of 1.793; for this reason, we eliminate this identification.

III. COMPARISON WITH OTHER BRIGHT QUASARS

The apparent magnitude and colors of B2 1225+31 were measured by Battistini, Braccisi, and Formigini (1974), who found $m_v = 15.87$, $B - V = 0.28$, $U - B = -0.68$; the colors are typical of a quasar.

We calculated the absolute magnitude of B2 1225+31, of three other intrinsically bright quasars, and of 3C 279 at its peak of luminosity in 1937 (Eachus and Liller 1975). We used $q_0 = 0$, $H_0 = 100$, and no K -correction, and assumed that the color of 3C 279 at

its peak was the same as when measured by Sandage (1966). The results are shown in Table 2, column (4). The last column gives the references for the emission-line redshifts and the magnitudes. From Table 2 it appears that B2 1225+31 is one of the most luminous quasars. The only quasar definitely brighter than B2 1225+31 was 3C 279 at its peak of luminosity in 1937. Bright quasars are interesting in several ways which deserve further study: (i) Quasars of very high intrinsic luminosity appear to occur at very different redshifts. (ii) Do the radio properties and the optical properties such as the spectrum or the variability depend on the absolute optical luminosity? (iii) Among the quasars of same redshift, those of highest intrinsic luminosity can be analyzed with the greatest precision.

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TABLE 2
ABSOLUTE MAGNITUDES FOR INTRINSICALLY BRIGHT QUASARS

Name (1)	Redshift (2)	m_v (3)	M_v (4)	References (5)
3C 279 (peak)	0.536	11.0	-30.5	1, 2
PKS 0237-23	2.22	16.6	-29.1	3
PHL 957	2.69	16.5	-29.8	4
OQ 172	3.53	17.9	-29.4	5
B2 1225+31	2.2	15.8	-29.8	6 and this paper

References for the emission line redshifts and m_v : (1) Lynds, Stockton and Livingston 1965. (2) Eachus and Liller 1975. (3) Arp, Bolton, and Kinman 1967. (4) Lowrance *et al.* 1972. (5) Wampler *et al.* 1973. (6) Battistini, Braccisi, and Formigini 1974.

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