

at λ 2855 in Osterbrock's list, which should be blended with λ 2869, but the wavelength of λ 2869 gives much better agreement with the redshift derived from Mg II λ 2798.

The feature at 4484 Å is weak; it may possibly be identified with [Mg v] λ 2928 which is given in the search list for lines published by Schmidt (1965). In view of the rather large difference between the redshift derived from this line and those derived from the other features, it is possible, however, that this is not a real line. The wavelength of the feature at 5976 Å may be affected by the presence of a weak nightglow line of OH (Blackwell, Ingham, and Rundle 1960).

There are, however, enough identifications so that one may have confidence in the derived redshift. Greatest weight should be attached to the strong Mg II line; consequently, we take $z = 0.540$ to be the redshift of 3C 279.

TABLE 1
MEASURED WAVELENGTHS AND IDENTIFICATIONS IN 3C 279

$\lambda_{\text{measured}}$	Ident	λ_0	z
4308	Mg II	2798	0 540
4420	[Ar IV]	2855, 2869	548, 0 541
4484	[Mg V]	2928	.531
5276.	[Ne V]	3426	.540
5736	[O II]	3727	.539
5976	[Ne III]+H γ	3869, 3889	0 544, 0 537

The spectrum of 3C 279 is rather similar to that of 3C 48. There is one further noteworthy fact about 3C 279. When the spectra described above were taken, it was realized that the star was certainly not as bright as it appears on the Palomar Atlas plates (16.8 mag.). Since then, it has been measured photoelectrically and found to have $V = 17.75$ (Sandage 1965). Thus it has undergone a decrease in brightness amounting to 1 mag. in a 9-year interval.

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REDSHIFTS OF THE QUASI-STELLAR RADIO SOURCES 3C 334, 3C 345, 3C 380, AND A DISCUSSION OF THE POSSIBLE REDSHIFT OF 3C 446

The radio sources 3C 334, 3C 345, 3C 380, and 3C 446 have been identified with blue, starlike objects (Sandage and Wyndham 1965; Wyndham 1965). Various spectra of the

first three objects were obtained in wavelength regions between 3600 and 6800 Å with the prime-focus spectrograph on the 120-inch telescope at Lick; the same camera-grating combinations were used as for MSH 14-121 (Burbidge 1965) and 3C 279 (Burbidge and Rosenberg 1965), but in addition one spectrogram of 3C 345 in the region 3600–5000 Å was obtained with the new Schmidt corrector plate on the F/0.5 camera which gives a dispersion of 400 Å/mm in the blue and ultraviolet region. For this latter plate, the new Kodak emulsion 080-01 was used; it is considerably faster than baked Kodak IIa-O. Two spectra of 3C 334 were also obtained at the prime focus of the McDonald 82-inch telescope with the B-spectrograph. For 3C 446, two spectrograms only, in the blue-ultraviolet region with the F/1 camera, were obtained with the Lick prime-focus spectrograph.

The objects 3C 334, 3C 345, and 3C 380 all showed a strong broad emission feature in the blue, which proved in all cases to be due to Mg II λ 2798, and a few other weaker

TABLE 1
MEASURED WAVELENGTHS AND IDENTIFICATIONS

Object and $\lambda_{\text{measured}}$	Ident.	λ_0	z
3C 334:			
4350	Mg II	2798	0 555
4975	He II	3204	0 553
6384	H δ	4102	0 556
6790	H γ , [O III]	4340, 4363	0 564, 0 556
3C 345:			
4465	Mg II	2798	0 596
4577	[Ar IV]	2869	0 595
5458	[Ne V]	3426	0 593
6166	[Ne III]	3869	0 594
3C 380:			
4737	Mg II	2798	0 693
4846	[Ar IV]	2854, 2869	0 693
5788	[Ne V]	3426	0 689
3C 446:			
3727	Ly- α or C IV	1216 or 1550	2 065 or 1 404*
4580	N IV or C III	1488 or 1909	2 078 or 1 399

* Two possible identifications: see discussion in text

emission lines as well. The [Ar IV] lines at 2854, 2869 Å, first identified in 3C 279 (Burbidge and Rosenberg 1965) and by Lynds (1965) in these same radio sources, appeared in 3C 345 and 3C 380. Identifications and redshifts are given in Table 1.

The object 3C 334 was not well exposed in the green-yellow spectral region, so we could not search for lines there, and the two features in the red were weak; consequently, the redshift of this object is less well established than that of 3C 279 determined earlier.

In 3C 345, there is a suspicion that the wavelength of the very strong Mg II λ 2798 line may not be the same on all the plates. Some structure in this line may be present on one of the plates; during the period over which the plates were obtained (July–September, 1965), the object varied in brightness (Goldsmith and Kinman 1965), and it is being followed closely at Lick Observatory by several workers. The wavelengths given in Table 1 are from the plates obtained closest together in time. T. Gold (private communication) has suggested that wavelength variations in the center of gravity of emission lines in quasi-stellar radio sources might occur if the objects are condensed galaxies in which star collisions take place on an enormous scale in the center. Dent (1965) has also reported that 3C 345 possibly is variable in radio output.

In 3C 380 the feature at 4846 Å appears to be best represented by a blend of the two

[Ar iv] lines, while in 3C 345 and 3C 279 the longer wavelength of the pair gave the better fit with the other lines.

Giving most weight to the measures of the strong line of Mg II λ 2798, we adopt the following values for the redshifts: 3C 334, 0.555; 3C 345, 0.595; and 3C 380, 0.693. These have not been corrected for motion of the local standard of rest due to rotation of our Galaxy. They may be compared with those obtained recently by Lynds (1965). There is good agreement; in fact, the biggest difference between the two sets, obtained quite independently with very different spectrographs, occurs for 3C 279, determined previously. Here Lynds's value is $z = 0.536$, and ours is $z = 0.540$.

In Figure 1 the spectrum of 3C 446 in the blue-ultraviolet region is shown with that of 3C 9 for comparison. Both spectra were taken with the F/1 camera at 200 Å/mm. The redshift of 3C 9 was determined by Schmidt (1965) to be 2.012, from two lines at 3666 and 4668 Å, due to Ly- α and C iv λ 1550, which are marked in Figure 1. The rather sharp drop in the intensity of the continuum on the short-wavelength side of Ly- α in 3C 9, discussed by Gunn and Peterson (1965), can be seen. In 3C 446, a line which is almost 50 Å wide can be seen at a slightly greater wavelength than the line at 3666 Å in 3C 9, and the continuum drops rather sharply on the short-wavelength side of this also. The falloff in intensity appears to be more steep than is the case in 3C 9. The wavelength of the feature was measured to be 3727 Å. Three possibilities exist:

a) The line is Ly- α , in which case the redshift of 3C 446 is 2.065. However, no line corresponding to C iv λ 1550 is seen (the position where this should be is shown in Fig. 1). There does, however, appear to be a feature (also marked in Fig. 1) at about 4580 Å, which could, if this were the correct redshift, be identified with N iv λ 1488. 3C 446 has a visual magnitude $V = 18.39$ (Sandage 1965), and is therefore faint so that it might well have a large redshift.

b) The line might be [O II] λ 3727. The object would then be intrinsically very faint with zero redshift; some explanation for the great breadth of the feature and the break to the blue would then have to be found.

c) The line might be redshifted but have some other identification than Ly- α . One possibility is that λ 3727 is C iv λ 1550 and λ 4580 is C III λ 1909. The redshift would then be 1.402. The break in the continuum intensity would have to be explained in some other way. It is hoped to obtain spectra in the visual region to search for other lines; also, direct intensity measures of the continuum on either side of the line are necessary to establish the magnitude of the break in the continuum.

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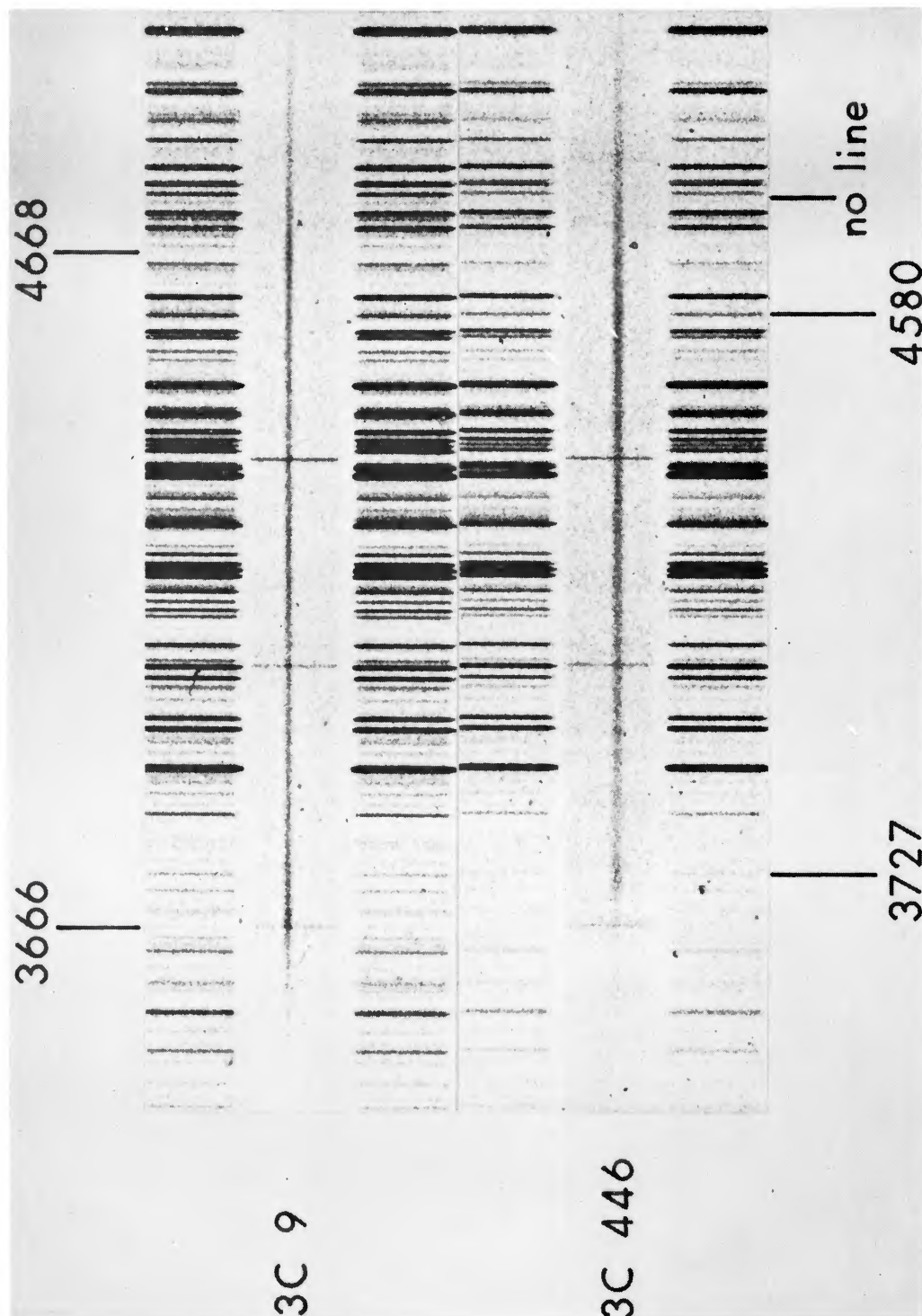


FIG. 1.—Spectra of 3C 9 and 3C 446 taken with the F/1 camera at the prime focus of the 120-inch telescope. The two lines measured and identified by Schmidt in 3C 9 are marked, as are the two features measured in 3C 446. The place where C iv λ 1550 should fall in 3C 446 if λ 3727 is attributed to Ly- α is marked “no line.”