latter source prevented observations below 0.1 flux unit with longer integration times on PHL 938.

There is a wide range in the ratio of radio to optical fluxes in QSO's (Bolton, Clarke, Sandage, and Véron 1965), and it is possible therefore that objects such as BSO 1 (Sandage 1965) and PHL 938 are objects for which this ratio is particularly low rather than that they are a distinct class of object. Following Schmidt (1965), intrinsic radio (10^9 c/s) and optical (10^{15} c/s) fluxes may be computed for QSO's with known z assuming a Hubble constant of 100 km/sec per Mpc and a cosmology with zero cosmological constant and $q_0 = +1$. The upper limit to the radio flux of PHL 938 appears to be somewhat lower than the flux from the weak radio emitter 1252 + 11 for which log F (10^9 c/s) = 26.6 (in W [c/s]$^{-1}$) if $z = 0.87$ (Bolton *et al.* 1965) and if the radio spectra of these objects are similar. The intrinsic optical flux of PHL 938 (log F [10^{15} c/s]) = 24.0 (in W[c/s]$^{-1}$) is greater than for any of the nine QSO's given by Schmidt. Also, BSO 1 and 1252+11 are among the (optically) brightest of these QSO's. It will be of interest to see whether or not all QSO's that are weak radio emitters are optically bright or whether the present result is due to some kind of observational selection.

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REFERENCES

Bahcall, J. N. 1966, *Ap. J.* (in press).
Bahcall, J. N., and Salpeter, E. E. 1965, *Ap. J.*, **142**, 1677.
Beals, C. S. 1950, *Pub. Dom. Ap. Obs.*, Vol. **9**, No. 2.
Bolton, J. G., Clarke, M. E., Sandage, A., and Véron, P. 1965, *Ap. J.*, **142**, 1289.
Chandrasekhar, S. 1945, *Ap. J.*, **102**, 402.
Gunn, J. E., and Peterson, B. A. 1965, *Ap. J.*, **142**, 1633.
Haro, G., and Luyten, W. J. 1962, *Bol. Tonantzintla y Tacubaya Obs.*, No. 22, p. 37.
House, L. L. 1964, *Ap. J. Suppl.*, **8**, 307.
Oke, J. B. 1965, *Ap. J.*, **141**, 6.
Osterbrock, D. E., and Parker, R. A. R. 1965, *Ap. J.*, **141**, 892.
———. 1966, *ibid.*, **143**, 268.
Rottenberg, J. A. 1952, *M.N.*, **122**, 125.
Ryle, M., and Sandage, A. 1964, *Ap. J.*, **139**, 419.
Sandage, A. 1965, *Ap. J.*, **141**, 1560.
Schmidt, M. 1965, *Ap. J.*, **141**, 1295.
———. 1966, *ibid*, **144**, 443.
Thomas, R. N. 1957, *Ap. J.*, **125**, 260.

INTENSITY VARIATIONS OF QUASI-STELLAR SOURCES IN OPTICAL WAVELENGTHS

Routine photoelectric photometry of quasi-stellar sources (QSS's) has been in progress with the 200-inch reflector since 1963. The principal emphasis has been the confirmation of peculiar colors as an aid to positive optical identification of radio sources. However, as time permits, repeated observations of previously identified sources have been made to monitor optical variations. We report here observations of those QSS's where more than one observation exists. The QSS's which have been followed most extensively are 3C 48, 3C 196, and 3C 273. The new data extend the time coverage for these three sources to January, 1966, two years beyond that reported previously (Sandage 1964). In addition

to these three objects, data for 3C 9, 3C 43, 3C 47, 3C 216, 3C 245, 3C 286, 3C 287, and 3C 454.3 are given. The QSS's for which the evidence for intensity fluctuations is beyond doubt are listed in Table 1. Three sources with more than one measurement but where variations have not yet been detected with certainty are listed in Table 2.

The magnitudes and colors are on the UBV system as measured with a conventional 1P21 refrigerated photomultiplier relative to Johnson-Morgan standards. The mean error of the magnitudes is of the order of ± 0.03 mag., although occasional values can be in error by more than this value would imply because of the fairly rapid techniques of survey photometry which were employed. Differences between various readings of up to 0.10 mag. are therefore not necessarily proof of real variation of these faint objects.

The observations are spaced rather widely in time and no positive statement can yet be made about the existence of very short-term variations of the order of hours or a few days. But, as previously reported (Sandage 1964), several runs of 3 hours' duration were made on 3C 48 with no evidence of variations on this time scale.

Remarks on the individual objects follow.

3C 47: Although observed only twice, the variation of $\Delta B = 0.21$ mag. is beyond doubt because all three independently measured magnitudes show the same variation; i.e., $B - V$ and $U - B$ remain nearly constant.

3C 48: Remained relatively quiescent during the 16-month period, hovering near $V = 16.29$. The light-curve from 1960 through January, 1966, is shown in Figure 1.

3C 196: The reality of the variation is beyond doubt. The source has gradually brightened in all three wavelengths. An apparent sudden burst in December, 1963, appears to be real, as two independent concordant observations were made on December 12, 1963.

3C 216: The observation of May 10, 1964, appears to be correct. The measurement is of high accuracy with mean errors of $\epsilon_V = \pm 0.022$ mag., $\epsilon_B = \pm 0.018$ mag., and $\epsilon_U = \pm 0.034$ mag., which are small compared with the amplitude of the change between December 12, 1963, and January 10, 1965.

3C 245: The variation is not beyond doubt because of its smallness.

3C 273: This source has remained remarkably constant over the 2-year interval of these new observations. Since photoelectric observations began on February, 1963, the variation has only been $\Delta B = 0.38$ mag., gradually decreasing during the first year, and remaining steady thereafter. This is in contrast to the large variations observed in earlier years by Smith and Hoffleit (1963*a*, *b*) and by Smith (1964), but, of course, these earlier variations are on a considerably longer time scale.

In addition to these photoelectric measurements which indicate variation in at least five sources and probably six, photographic evidence exists for intensity changes in at least four other QSS's.

1. Variations in 3C 345 have been especially well followed by Goldsmith and Kinman (1965). Here the blue magnitude changed by 0.4 mag. in an interval of 18 days. This is the best documented case of a rapid variation on a short-time scale.

2. 3C 2 changed by $\Delta B \simeq 1.5$ mag. between September 27/28, 1954, and August 20/21, 1963, as discussed elsewhere (Sandage, Véron, and Wyndham 1965).

3. 3C 43, also described in this reference, changed in blue magnitudes by 0.9 mag. between September 27/28, 1954, and September 28/29, 1964. An illustration of the change is shown in Figure 2 (*bottom*). 3C 43 is the object at the tip of the arrow. The left picture is copied with 25× enlargement from the original Sky Survey blue paper print; the right print is copied from a new plate taken September 28/29, 1964. The image quality of the left and right prints is not the same because one was made from a paper print and the other from a plate, but the large change of magnitude of 3C 43 is evident by differential comparison of the images on both prints with stars A, B, and C.

4. An equally striking case is 3C 454.3, identified in Figure 2 (*top*). Again, there is a decrease in brightness between the Sky Survey plate of August 1/2, 1954, and a new Schmidt plate of September 24/25, 1965. Photoelectric photometry of stars 1, 2, and 4

TABLE 1

PHOTOELECTRIC DATA FOR

3C47, 3C48, 3C196, 3C216, 3C245, and 3C273

Date	JD 2437+	V	B	U	B−V	U−B	Remarks
			3C47				
Dec. 12, 1963	1375.8	18.12	18.15	17.51	0.03	−0.64	
Oct. 5, 1964	1673.8	18.32	18.36	17.69	0.04	−0.67	
			3C48				
Oct. 3, 1964	1671.8	16.27	16.76	16.21	0.49	−0.55	
Oct. 5, 1964	1673.8	16.28	16.75	16.20	0.47	−0.55	
Jan. 8, 1965	1768.8	16.23	16.66	16.12	0.43	−0.54	
Jan. 9, 1965	1769.8	16.28	16.68	16.14	0.40	−0.54	
Jan. 10, 1965	1770.8	16.30	16.70	16.17	0.40	−0.53	
Feb. 15, 1965	1806.8	16.27	16.61	16.03	0.34	−0.58	
Oct. 19, 1965	2052.8	16.30	16.70	16.17	0.40	−0.53	
Oct. 20, 1965	2053.8	16.33	16.74	16.22	0.41	−0.52	
Jan. 13, 1966	2138.8	16.29	16.73	16.21	0.44	−0.52	
Jan. 14, 1966	2139.8	16.32	16.74	16.21	0.42	−0.53	
Jan. 15, 1966	2140.8	16.33	16.73	16.18	0.40	−0.55	
			3C196				
Apr. 1, 1962	755.8	17.72	18.38	17.94	0.66	−0.44	
May 16, 1963	1165.8	17.69	18.31	17.99	0.62	−0.32	
Dec. 12, 1963	1375.8	17.45	18.05	17.56	0.60	−0.49	Mean of 2
Feb. 14, 1964	1439.8	17.60	18.09	17.64	0.49	−0.45	
Mar. 9, 1964	1524.8	17.54	18.12	17.63	0.58	−0.49	
May 10, 1964	1525.8	17.50	18.02	17.57	0.52	−0.45	
Jan. 10, 1965	1770.8	17.42	18.00	17.53	0.58	−0.47	
Jan. 13, 1966	2138.8	17.40	17.90	17.44	0.50	−0.46	
Jan. 14, 1966	2139.8	17.37	17.96	17.37	0.59	−0.59	
			3C216				
Dec. 12, 1963	1375.8	18.48	18.97	18.37	0.49	−0.60	Mean of 2
$\varepsilon_U = \pm 0.$ May 10, 1964	1525.8	18.75	19.34	18.95	0.59	−0.39	$\varepsilon_V = \pm 0.022; \varepsilon_B = \pm 0.018;$
Jan. 10, 1965	1770.8	18.28	18.78	18.19	0.50	−0.59	
			3C245				
Dec. 12, 1963	1375.8	17.29	17.75	16.93	0.46	−0.82	
Feb. 14, 1964	1439.8	17.25	17.67	16.81	0.42	−0.86	
Jan. 14, 1966	2139.8	17.20	17.63	16.81	0.43	−0.82	
			3C273				
Jan. 20, 1964	1414.8	12.90	13.11	12.26	0.21	−0.85	
Feb. 14, 1964	1439.8	12.90	13.11	12.22	0.21	−0.89	
Mar. 9, 1964	1463.8	12.90	13.11	12.21	0.21	−0.90	Mean of 2
May 9, 1964	1524.8	12.88	13.09	12.20	0.21	−0.89	Mean of 2
June 7, 1964	1553.8	12.94	13.13	12.25	0.19	−0.88	Mean of 2 100"
Jan. 10, 1965	1770.8	12.94	13.12	12.26	0.18	−0.86	
Jan. 27, 1965	1787.8	12.92	13.10	12.16	0.18	−0.94	60"
Jan. 29, 1965	1789.8	12.93	13.07	12.11	0.14	−0.96	60"
Mar. 27, 1965	1846.8	12.87	13.06	12.19	0.19	−0.87	
Jan. 13, 1966	2138.8	12.90	13.09	12.18	0.19	−0.91	
Jan. 14, 1966	2139.8	12.90	13.10	12.19	0.20	−0.91	
Jan. 15, 1966	2140.8	12.92	13.11	12.20	0.19	−0.91	

TABLE 2

PHOTOELECTRIC DATA FOR NON-VARIABLE QSS'S
3C 9, 3C 286, AND 3C 287

Date	JD 2437+	V	B	U	$B-V$	$U-B$	Remarks
			3C 9				
Dec. 12, 1963 ..	1375 8	18 21	18 44	17 70	0 23	−0 74	
Oct. 5, 1964. .	1673 8	18 22	18 48	17 69	0 26	−0 79	
			3C 286				
May 15, 1963 ..	164 8	17 30	17 54	16 76	0 24	−0 78	
Feb. 14, 1964 .	1439 8	17 29	17 47	16 61	18	− 86	
May 10, 1964 ..	1525 8	17 31	17 52	17 14:	21	− 38:	
Jan. 15, 1966 ..	2140 8	17 29	17 56	16 71	0 27	−0 85	
			3C 287				
Feb. 14, 1964 .	1439 8	17 67	18 22	17 53	0 55	−0 69	Color change suspicious
May 10, 1964 .	1525 8	17 68	18 40	17 79	0 72	−0 61	Does it vary?

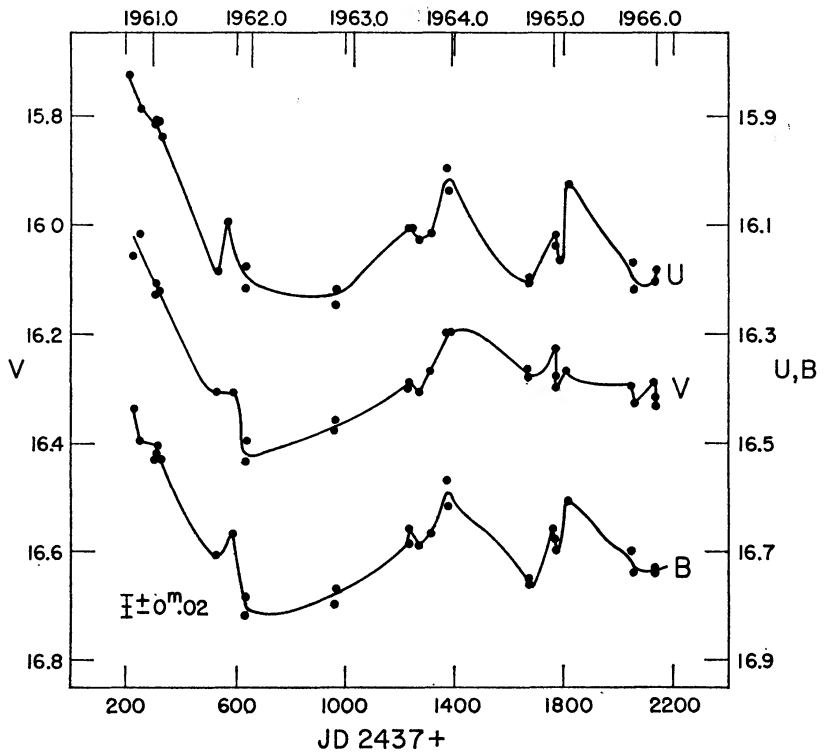

FIG. 1.—Variation of the U, B, and V magnitudes of 3C 48 from October 1960 to January 1966