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LIGHT VARIATIONS OF THE SEYFERT GALAXY NGC 4151

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The discovery of strong infrared radiation from the nucleus of the Seyfert galaxy NGC 1068 (Pacholczyk and Wisniewski, 1967) strengthened the evidence for a possible relationship between Seyfert galaxies and quasi-stellar sources, discussed some time ago by Burbidge, Burbidge and Sandage (1965) and by Shklovskii (1965). A few other Seyfert galaxies (among them NGC 4151) have since been detected in the infrared (Pacholczyk and Weymann, 1967).

The similarity of the radio, infrared and ultraviolet continua between some of the nuclei of Seyfert galaxies and some of the quasistellar sources led to the suggestion that Seyfert nuclei might show light variations. Since the quasar-like excess radiation in the Seyfert nuclei is the largest in the ultraviolet and in the far infrared, larger light variations were to be expected in these spectral regions (Pacholczyk and Wisniewski, 1967).

In the spring of 1967 the Seyfert galaxy NGC 4151 was measured photo-electrically in the U, B, V, and K passbands. The UBV measurements were carried out with the 36-inch reflector of the Steward Observatory at Kitt Peak using a standard single channel photometer and reduced using a computer program developed by one of us (W.S.F.). The infrared K measures were made with Johnson's JKL photometer (Johnson and Mitchell, 1962) attached to the 60-inch reflector of the Lunar and Planetary Laboratory at Mt. Lemmon.

The UBV measures were made with a 36" diaphragm on J.D. 2439599, 2439601, and with a 32" diaphragm thereafter, and the K measures utilized a 15" diaphragm. Observations on JD 2439648 were made with both a 32" and 44" diaphragm. Note however that an <u>increase</u> in brightness was observed despite the switch to a smaller diaphragm.

In Table 1 are listed individual UBV measures on NGC 4151 and a comparison star situated 5' from the nucleus at P.A. 150°, and it may be seen from these measures, tied directly to the standard system each night, that there are no significant variations in the comparison star during the observing season and that the mean error of a single observation is 0.04, 0.02, and 0.02 mag in V, B, and U, respectively.

In Table 2 we give the average magnitude of NGC 4151 on each night, where the UBV measures have been corrected differentially with respect to the comparison star. On JD 2439631 only the U magnitude is given, because a bright moon made the B and V measures uncertain whereas the mean error in U appears to be 0.03 mag on this night.

We believe that real changes in brightness occur during the course of one night, with an observed range of about 1 mag in K, 0.15 mag in U, and 0.09 mag in B. In Table 2 it is seen that over the period of the observations the galaxy increased in brightness by about 0.45 mag in U, 0.25 mag in B, and 0.20 mag in V. The last three K measures utilized a comparison star of K = 8.5 mag, 7' distant at P.A. 280°, as a check. At maximum light the probable error of a flux measure in K is about 25%, however on JD 39619 the galaxy was just at the limit of detectability, so we cannot make a good error estimate for that measure but we are convinced that NGC 4151 was significantly fainter then.

The suspicion that the amplitude of the variations of flux depends upon the spectral region and ought to be larger in the region where the quasar-like component makes the largest contribution seems to be confirmed.

We are aware of only two other UBV measures of NGC 4151. The first is by de Vaucouleurs (1959) whose value, measured in the 1957-58 season with a 24" diaphragm is V = 11.78, B-V = 0.66, U-B = -0.31 (U = 12.13). The 2nd set was obtained on JD 2439505.0 and JD 2439509.0 by W. Z. Wisniewski with the L.P.L. 28" reflector using a 27" diaphragm. His values are, for the first night V = 11.46, B-V = 0.59, U-B = -0.50 (U = 11.55) and on the second night V = 11.42, B-V = 0.57, U-B = -0.60 (U = 11.39). These observations support the reality of the variations.

In connection with the apparent variability of the nonstellar component of the nucleus we note that two trailed spectra of the nucleus of NGC 4151 which we have inspected (Morgan 1967, Sargent 1967) show apparent differences in the strength of the underlying stellar absorption lines. Since the plates were taken with different instruments one cannot be certain how much of these apparent differences are real, but a reasonable interpretation is that the stellar component is drowned out as the nonstellar component increases.

The Seyfert galaxy 1068 is being currently observed for variability in the U, B, V, K and millimeter spectral regions.

We wish to thank Dr. H. L. Johnson for permission to use his instrumentation. The kind assistance of Dr. W. Z. Wisniewski in observing, of Messrs. R. I. Mitchell and J. C. Geary in reducing the data and Mr. W. Fogarty in preparing the diagram is gratefully acknowledged.

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TABLE 1

INDIVIDUAL UBV MAGNITUDES OF NGC 4151

Comparison Star				NGC 4151				
Hel. J.D. 2439000+	V	B	U	Hel. J.D. 2439000+	V	B	U	Diaphragm Size (seconds of arc)
599.737	9.758	10.445	10.343	599.755	11.335	11.958	11.480	36
				599.760	11.353	11.968	11.435	36
599.778	9.803	10.359	10.414	599.764	11.332	11.967	11.424	36
601.760	9.854	10.423	10.409	601.769	11.332	11.907	11.310	36
				601.772	11.341	11.896	11.279	36
601.784	9.848	10.431	10.399	601.776	11.367	11.899	11.286	36
601.833	9.852	10.429	10.425	601.842	11.309	11.865	11.263	36
				601.845	11.306	11.874	11.294	36
601.857	9.687	10.435	10.360	601.850	11.319	11.877	11.279	36
648.678	9.849	10.432	10.387	648.703	11.209	11.713	10.945	32
648.700	9.842	10.422	10.404	648.717	11.213	11.720	10.963	32
648.714	9.830	10.423	10.401	648.758	11.280	11.725	11.022	32
648.737	9.832	10.424	10.393	648.768	11.270	11.733	11.040	32
648.762	9.830	10.409	10.393	648.778	11.293	11.804	11.089	32
648.774	9.826	10.430	10.424	648.706	11.033	11.573	10.844	44
648.785	9.799	10.393	10.406	648.722	11.035	11.586	10.851	44
				648.782	11.048	11.587	10.914	44
655.675	9.829	10.411	10.401	655.684	11.203	11.691	11.009	32
655.692	9.831	10.373	10.402	655.687	11.187	11.695	10.991	32
Mean	9.818	10.416	10.397					
	±.011	±.006	±.006	m.e.				

TABLE 2

MEAN UBVK MAGNITUDES OF NGC 4151

J.D. 2439000+	U	B	V	K
530.0				8.4
598.9				9.4
599.8	11.46	11.98	11.38	
601.8	11.28	11.87	11.34	
619.9				10.2
623.7	11.20	11.86	11.26	
631.8	11.14			
642.7	10.89	11.63	11.13	
648.7	11.01	11.74	11.24	
655.7	11.00	11.72	11.18	8.7
656.7				8.5
657.7				8.5

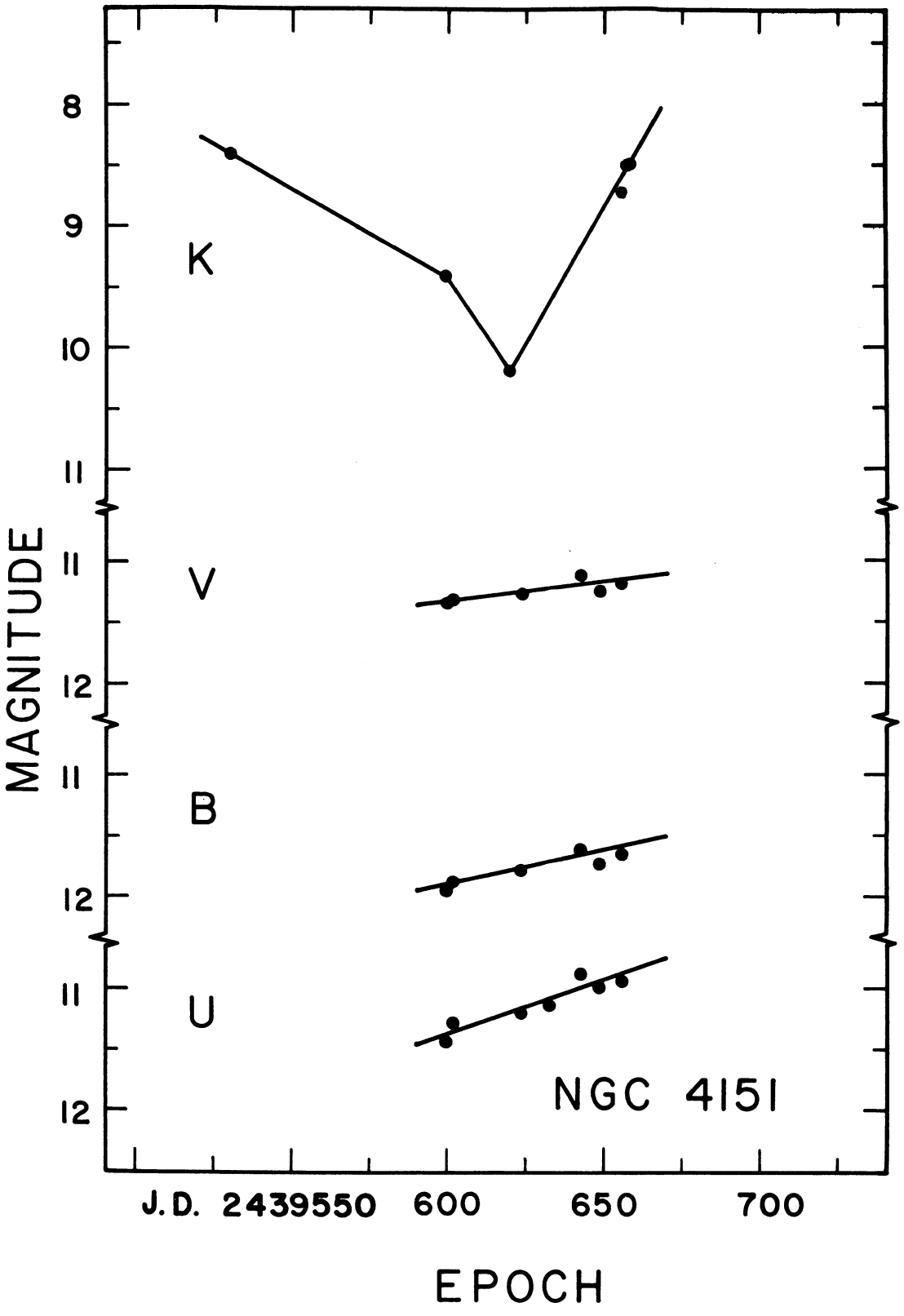

Fig. 1. Light variations of the Seyfert Galaxy NGC 4151 in the U, B, V and K spectral regions.