

OPTICAL VARIABILITY OF EXTRAGALACTIC OBJECTS USED TO TIE THE *HIPPARCOS* REFERENCE FRAME TO AN EXTRAGALACTIC SYSTEM USING *HUBBLE SPACE TELESCOPE* OBSERVATIONS

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ABSTRACT

Observations of a set of 89 extragalactic objects (EGOs) will be made with the *Hubble Space Telescope* Fine Guidance Sensors and Planetary Camera in order to link the *HIPPARCOS* Instrumental System to an extragalactic coordinate system. Most of the sources chosen for observation contain compact radio sources and stellarlike nuclei; 65% are optical variables beyond a 0.2 mag limit. To ensure proper exposure times, accurate mean magnitudes are necessary. In many cases, the average magnitudes listed in the literature were not adequate. The literature was searched for all relevant photometric information for the EGOs, and photometric parameters were derived, including mean magnitude, maximum range, and timescale of variability. This paper presents the results of that search and the parameters derived. The results will allow exposure times to be estimated such that an observed magnitude different from the tabular magnitude by 0.5 mag in either direction will not degrade the astrometric centering ability on a Planetary Camera CCD frame.

I. INTRODUCTION

Plans are being made to link the *HIPPARCOS* Instrumental System to a set of Extragalactic Objects (EGOs, mostly QSOs and BL Lac objects, with a few active galactic nuclei AGNs) at the milliarcsecond level; cf. Hemenway and Duncombe (1986 and references therein). The observations involve measuring the relative positions and motions of individual *HIPPARCOS* stars with respect to nearby (in angle) EGOs. The observations will be made with the Fine Guidance Sensors (FGS) and the Planetary Camera (PC) of the *Hubble Space Telescope* (HST). The superset of objects consists of approximately 165 *HIPPARCOS* stars which are within 18 arcmin of 89 EGOs. Most of the measurements are expected to be made with the FGSs directly, but for a subset of the EGOs, observations will be made with the FGSs and the PC in the "Transit Circle Mode."

In order to measure accurately the positions of the objects with the PC CCD detectors, exposures that result in electron levels somewhat below A/D saturation in the central image pixel [30 000 electrons/pixel (Griffiths 1985)] are required (a) to minimize saturation effects and (b) to minimize charge transfer inefficiency effects; cf. Monet and Dahn (1983). Also, the signal in the maximum image pixel must be sufficient to allow an adequate center to be determined (more than 3000 electrons in the central pixel). Therefore, the magnitude of the objects to be observed must be estimated to within one magnitude for accurate astrometry.

This paper presents the photometric data available for the estimation of the magnitudes, colors, and hence the exposure times to be used for tying the *HIPPARCOS* system to EGOs. The compilation should be useful for making other observations.

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II. THE DATA

Global characteristics of the EGOs have been estimated from published data and are presented in two tables: Table I contains the variable EGOs and Table II the nonvariable EGOs, i.e., those not reported as variable.

Table I contains the EGOs that have been monitored for variability. The information is not inclusive; it does not contain all the published variability information on each source. Rather it is designed to provide a realistic estimate of range in magnitude we can expect for each source and the timescale on which this change can be expected. Where overlapping or similar datasets exist, and one was more complete, we give only the more complete reference in Table I. Other references are sometimes indicated in the Notes On Individual Sources. The maximum and minimum values specify the approximate limits, the average values, the most likely observed value, and the rate of change (long and/or short term) of the variation we can expect during an observing period and between observing periods. Where possible the values are taken from published tables; otherwise they are read from published graphs. All the values are actual measured values not theoretical values taken from models. Thus the maximum and minimum values are not the true minimums and maximums, but rather close to those values unless the observing sessions happened to coincide with a source's maximum and/or minimum.

Table I is presented in ten columns; all the columns may contain multiple entries for each source. Column 1 contains as many as four entries in the following order: the source name in IAU format using 1950 coordinates, a second well-known name, the source type in parentheses, and where known, the $B - V$ color taken from Véron-Cetty and Véron (1987, 1989) or Hewitt and Burbidge (1987, 1989). For the source type we use the following classifications: AGN, QSO,

TABLE I. Variable EGOs.

Source Name	Band	Magnitude		Avg. Mag.	Δm	Time Range of Observations	$\Delta m/\Delta T$ long term	$\Delta m/\Delta T$ short term	Reference
		Faint	Bright						
0109+224 (BL Lac) B-V=.34	m _B	17.41	14.34	~15.75	3.07	16.88y 1934.4-51.3	3.07/y		Pica, 1977
	m _B	17.42	15.48	16.41	1.94	11y 11/76-11/87	1.94/4.09y		Pica et al., 1988
	B _C	17.34	16.03		1.31	37.28d 1986.9-87.0		.36/69m	Xie et al., 1988
	V _C	16.78	15.62		1.16	"		.24/74.9m	"
0134+329 3C 48 (QSO) B-V=.42	m _B	16.86	16.17	16.42	0.69	6.25y 9/79-12/85			Pica et al., 1988
	m _B	16.89	16.43	~16.7	0.46	16.4y 6/63-12/79	.46/10.35y	.28/1.01d	Lloyd, 1984
0135-247 (QSO) B-V=.19	m _B	~17.5	~16.8	~17.4	~.76	~1.1y 7/76-8/77	~.76/.97y	~.6/28d	Gilmore, 1980
	m _V	~17.10	~16.28	~17.01	~.82	"	~.82/.97y	~.7/28d	"
0138-097 (BL Lac)	V	18.16	16.64	~17.27 3 obs.	1.52	12d 1/29-2/09/85		1.52/8d	Impey and Tapia, 1988
0150-334 (QSO)	V	18.6				1/76			Wright et al., 1977
	V	≥17.3	~16.5			1/77, 9/76 faint, bright			Adam, 1978
0202-765 (QSO) B-V=.05	V	16.90	16.77			1966, 1/77			Adam, 1978
	m _B	(17.99)	(17.61)	(17.74)	~.38	2.49y 2/75-8/77	.38/300d	.23/37d	Gilmore, 1980
0237-233 (QSO) B-V=.15	m _B	~16.81	~16.04	16.51	0.77	25y 1927-52	.77/20y	.55/33d	Angione, 1973
	V			16.63		10/9/1966			Arp et al., 1967
0241+622 (QSO) B-V=-.04	m _B				0.28	1.73y 3/78-11/79	0.28/1.64y		Lloyd, 1984
	m _V	16.5	15.6		0.9	12/80, 1/81			Hutchings et al., 1982
	V			16.6		11/29/83			Moles et al., 1985
0316+413 NGC 1275 (AGN) B-V=.62	m _B	14.75	13.63	~14.2	1.13	13.3y 9/64-1/78	1.13/3.06y 11/65-9/68	.5/30d	Lloyd, 1984
	V (27")	12.81	12.24	~12.5	0.57	5.0y 1972-76	.57/382d	.22/8d	Lyutyi, 1977

TABLE I. (continued)

Source Name	Band	Magnitude		Avg. Mag.	Δm	Time Range of Observations	$\Delta m/\Delta T$ long term	$\Delta m/\Delta T$ short term	Reference
0336-019 CTA 26 (QSO) B-V=.55	m _B			17.97					Pica and Smith, 1983
	P	18.12	16.66	17.60	1.46	18y 12/69-1/88	1.46/4.3y	0.8/1m	Pica et al., 1988
0405-123 (QSO) B-V=.18	m _B	15.54	15.18		0.36	1966-70	0.36/2.86y	.30/75d	Tritton and Selmes, 1971
	m _B	15.45	15.18	~15.3	0.27	1.9y 3/69-2/71		.27/85d	Lü, 1972
	m _B	15.6	14.5	15.13	1.1	1900-55	1/6.7y		Angione, 1973
	m _B			15.09		1.08y mid1970s			Angione et al., 1981
	m _B			15.35	~0.36				Pica and Smith, 1983
0430+052 3C 120 (AGN) B-V=.67	m _B	16.16	14.72	~15.3	1.44	14.4y 1971-86	1.44/3.97y	.45/54d	Webb et al., 1988
0440-003 NRAO 190 (QSO) B-V=.37	P	19.20	15.61		3.59	17.58y 12/69-12/85	3.59/8.7y	1.4/28d 1.9/34d	Webb et al., 1988
				~18.0		1969-80	2.56/1.7y		
				~16.8		1983-85	2.43/1.2y		
0528-250 (QSO) B-V=.83	V			17.34	few/10	1977-80		few/10/dys	Adam, 1985
	m _V	>19.5	17.5		>2.	7mos 1,2,9/76	>2/.58y		Jauncey et al., 1978
0537-440 (QSO) B-V=.46	m _B	16.6	12.6	~14.8	4.0	1934-52	4.0/2.08y	0.7/days	Liller, 1974
	V	>16.5	13.76		>2.74	9/71-5/72		>2.74/72d	Eggen, 1973
	m _B	17.53	15.53	~16.2	2.0	1.94y	2./1.4y	1.7/66d	Gilmore, 1979
	V	16.40	15.79	~16.1	.61	2/85,3/84		.95/4d	Impey and Tapia, 1988
0607-157 (QSO)	m _V			18.0					Hutchings et al., 1984
	V			~20.2	2.2	1974.2,76.9			Hunstead et al., 1978
0716-714 (BL Lac)	P	15.5	13.2		2.3	PSS,1979-80			Biermann et al., 1981
0736+017 (QSO) B-V=.43	P	16.80	15.45	16.05	1.35	11/70-1/88	1.35/5.9y	.7/22d	Pica et al., 1988

TABLE I. (continued)

Source Name	Band	Magnitude Faint Bright		Avg. Mag.	Δm	Time Range of Observations	$\Delta m/\Delta T$ long term	$\Delta m/\Delta T$ short term	Reference
0743-673 (QSO)	V			16.37		1/77			Adam, 1985
B-V=.24	m _v	16.53	16.17		.36	12/73-5/77	.32/1.03y	.36/28d	Gilmore, 1980
0818-128 OJ-131 (BL Lac)	m _B	18.17	15.77	17.01	2.40	11/80-3/86	2./3y	1.16/24d	Pica et al., 1988
B-V=.3									
0828+493 OJ 448 (BL Lac)	V	18.82				1/15/77			Owen et al., 1978
B-V=.64	m _R	18.9	16.9			PSS,4/81			Walsh et al., 1984
0851+202 OJ 287 (BL Lac)	m _v	16.39	12.22		4.17	15.1y	4.17/4.18y	1.96/42d	Webb et al., 1988
B-V=.48				14.9		1977.0-82.2			"
				16.19		1/1986			"
0912+297 (BL Lac)	P	17.05	14.8		2.25	48.8y 4/12-2/61	2.25/30y		Zekl et al., 1981
B-V=.40	B	16.79				4/72,2/73			Battistini et al., 1974
	B		16.21			1975			Tapia et al., 1976
0923+392 4C 39.25 (QSO)	V	17.86			1.3				Moore and Stockman, 1984
B-V=.06									
0955+326 3C 232 (QSO)	m _B	16.48	15.94	~16.2	.54	10.8y 3/67-1/76	.54/8.87y	.25/23d	Lloyd, 1984
B-V=.10									
1038+064 4C 06.41 (QSO)	m _E				.17	PSS/74-75			Uomoto et al., 1976
B-V=.16	V	16.70	16.40			70/PSS			Wills and Lynds, 1978
1101-325 (QSO)	m _v				~.44	1.1y 4/76-5/77	.44/.55y	.35/10d	Gilmore, 1979
B-V=-.01	V			16.30					Adam, 1978
1127-145 (QSO)	P	16.83	16.58	~16.7	.25	8.8y 5/70-3/79	.25/3.89y		Pica et al., 1980
B-V=.27									

TABLE I. (continued)

Source Name	Band	Magnitude		Avg. Mag.	Δm	Time Range of Observations	$\Delta m/\Delta T$ long term	$\Delta m/\Delta T$ short term	Reference
1144-379 (BL Lac) B-V=.5	V	18.64	16.72	~ 17.7	1.92	3/84-4/85		1.92/68d	Impey and Tapia, 1988
1148-001 4C -00.47 (QSO) B-V=.17	P	17.62	16.54	17.14	1.08	17.9y 4/69-3/87			Pica et al., 1988
	P	17.62	16.98		.64	9.96y 4/69-3/79	.64/4.27y		Pica et al., 1980
1150+497 4C 49.22 (QSO) B-V=.30	m _B	17.75	17.31	17.50	.44	6.2y 2/81-4/87			Pica et al., 1988
	m				.39	.85y 4/67-3/68	.39/.85y		Tritton and Selmes, 1971
1206-399 (QSO) B-V=.36	V	17.01	16.98			1/77			Adam, 1985
	V	17.5							Hewitt and Burbidge, 1989
1215+303 ON 325 (BL Lac) B-V=.46	m _B	16.65	14.65	15.73	2.00	15.9y 2/72-1/88	2.0/10.93y	1.2/120d	Pica et al., 1988
1219+285 ON 231 (BL Lac) B-V=.70	m _B	17.43	15.30	~ 16.3	2.13	14.1y 2/72-4/86	2.13/9.65y		Webb et al., 1988
						1976 1985		1.83/33d .73/26d	" "
1226+023 3C 273 (QSO) B-V=.21	m _B	13.36	13.00	~ 13.2	.36	3/63-8/80	.36/3.07y		Lloyd, 1984
	m _B	13.46	12.59	13.02	.87	1/74-5/87 1979			Pica et al., 1988 Pica et al., 1980
	m _B			13.35 13.20 13.03	.79 .30 .21	1984 1985 1987			Corso et al., 1987 " "
1244-255 (QSO) B-V=.41	m				2.04	4/76-7/77	2.04/100d	.82/14d	Gilmore, 1979
	V			17.41	~ 2	1977-80 6 obs.			Adam, 1985
	V	16.42	15.95		.47	1/26-2/2/85		.47/7d	Impey and Tapia, 1988
1302-102 OP-106 (QSO) B-V=.12	V	16.1	14.92		1.18	6/73,8/75,1/77			Adam, 1978
	V				1.2				Moore and Stockman, 1984

TABLE I. (continued)

Source Name	Band	Magnitude		Avg. Mag.	Δm	Time Range of Observations	$\Delta m/\Delta T$ long term	$\Delta m/\Delta T$ short term	Reference
1404+286 OQ 208 (AGN) B-V=.78	P P	15.91	14.91	~15.4 ~15.2 ~15.6	1.00 .68 .91	4/69-4/75 4/69-5/71 2/74-4/75	1.00/4.05y .68/1.04y .91/59d	 .80/14d	McGimsey et al., 1975 " "
1418+546 OQ 530 (BL Lac) B-V=.52	m _B m _B	16.66	15.12	15.91	1.54 4.8	5/80-4/87 1900-78 1937-38	 4.8/77.2y 3.2/11m	1.1/2m 1.2/2d	Pica et al., 1988 Miller, 1978 "
1510-089 OR-017 (QSO) B-V=.20	P m _B	17.60	15.58	16.74	2.02 5.4	18.2y 6/69-8/87 1933-52	2.02/9.85y 3./1y	~1.5/40d 2.5/30d	Pica et al., 1988 Liller and Liller, 1975
1514-241 AP Lib (BL Lac) B-V=.80	m _B	16.71	14.21	~15.4	2.5	14.2y 1/72-4/86	1.8/4.73y	2.43/27d	Webb et al., 1988
1633+382 4C 38.41 (QSO)	m _B	19.00	15.85	~17.7	3.15	7y 5/69-5/76	3.15/4.02y	1.55/20d	Barbieri et al., 1977
1638+398 NRAO 512 (QSO)	P	19.35	16.32	~18.4	3.03	15.9y 5/70-4/86	2.85/90d	1.47/2d	Webb et al., 1988
1641+399 3C 345 (QSO) B-V=.29	m _B m _B	17.15	15.15	~16.2 ~16.6	2.00 1.98	14.8y 6/71-4/86 13.98y 4/66-4/80	2.00/4.18y 1.98/2.5y	1.17/5d .83/24d	Webb et al., 1988 Lloyd, 1984
1656+053 OS 094 (QSO) B-V=.46	V	16.54	16.41		.13	12-20/8/74		.13/8d	Craine et al., 1975
1727+502 I Zw 187 (BL Lac) B-V=.58	m _B m _B m _B	16.95	16.15	16.70 ~16.5 ~16.7	.80 1.12 .53	11.9y 5/75-4/87 4.43y 5/75-10/79 8.35y 3/68-4/76	 1.12/3.89y .53/4.55y	 .82/22d .44/80d	Pica et al., 1988 Pica et al., 1980 Lloyd, 1984
1749+701 (BL lac) B-V=.45	m _B	18.14	16.74	17.39	1.40	8.4y 3/79-8/87	1.4/1.35y	.63/78d	Pica et al., 1988
1921-293 OV-236 (QSO)	P	18.11	15.47	16.78	2.64	11.2y 6/76-8/87	2.64/.87y	1.4/9d	Pica et al., 1988

TABLE I. (continued)

Source Name	Band	Magnitude Faint Bright		Avg. Mag.	Δm	Time Range of Observations	$\Delta m/\Delta T$ long term	$\Delta m/\Delta T$ short term	Reference
1928+738 4C 73.18 (QSO)	P	16.5	15.5		1.0	PSS-12/79			Biermann et al., 1981
2005-489 (BL Lac)	B	13.89	13.36		.53	9/81,8/82 Faint, bright			Wall et al., 1986
2128-123 PHL 1598 (QSO)	m _B	16.51	15.49	15.89	1.02	17.3y 7/69-11/86			Pica et al., 1988
B-V=.22	m _B	16.25	15.24		1.01	10.23y 7/69-10/79	1.01/3.21y	.71/87d	Pica et al., 1980
2134+004 PHL 61 (QSO)	m _B	17.75	17.13	17.55	.62	13.2y 9/73-11/86			Pica et al., 1988
B-V=.30	m _B	17.73	17.13		.60	8.4y 6/71-11/79	.60/1.2y		Pica et al., 1980
2155-152 OX-192 (BL Lac)	m _B	~19.	12.5		6.5	55y 1885-1950			Willson, 1975
	P	15.1	14.6		.6	2.9y 9/06-8/09			Zekl et al., 1981
	B			18.2		10/75			Craine et al., 1976
2200+420 BL Lac (BL Lac)	m _B	16.75	14.67	~15.7	2.08	11.41y 7/68-12/79	2.08/5.13y	1.2/44d	Lloyd, 1984
B-V=.94	m _B	17.17	14.38	~15.7	2.79	14.4y 6/71-11/85	2.79/7.6y	1.91/169d	Webb et al., 1988
2201+315 4C 31.63 (QSO)	m _B	15.76	15.58		.18	8-12/72		.18/30d	Tritton et al., 1973
B-V=.27	V			15.58		9/23/82			Moles et al., 1985
2251+158 3C 454.3 (QSO)	m _B	17.63	16.12	~16.8	1.51	13.27y 8/66-11/79	1.51/2.9y	1.18/.7y	Lloyd, 1984
B-V=.47	m _B	17.68	16.27	~17.	1.41	14.3y 8/71-12/85	1.46/2.1y	1.28/63d	Webb et al., 1988
2254+074 OY 091 (BL Lac)	m _B	18.02	15.65	17.03	2.37	8.3y 7/79-11/87	2.37/1.93y	1.3/18d	Pica et al., 1988
B-V=.71									
2345-167 OZ-176 (QSO)	P	18.07	15.52		2.55	9.2y 10/69-1/79	2.55/1.39y	1.04/32d	Pollock et al., 1979
				~17.0		1973			"
				~17.7		1978-79			"

TABLE II. Nonvariable EGOs.

Name	Name	Type	V	B-V	Note
0111+021		AGN	16.3		*
0113-118		QSO	18.5		
0133+476	OC 457	QSO	19.0		**
0153+744		QSO	16.0		
0312-770		QSO	16.10	0.16	
0402-362		QSO	17.17	0.15	
0454+844		BL Lac	16.5		
0637-752		QSO	15.75	0.33	
0826-373		QSO	16.		*
0836+710		QSO	16.5		
1020-103	MSH 10-17	QSO	16.11	0.14	
1116-462		QSO	17.00	0.30	
1211+334	ON 319	QSO	17.89	-0.05	
1328+307	3C 286	QSO	17.25	0.26	
1416+067	3C 298.0	QSO	16.79	0.33	
1435+638		QSO	15.0		
1451-374		QSO	16.69	0.09	
1546+027		QSO	17.79	0.17	
1821+107		QSO	17.27	0.39	
1830+285	4C 28.45	QSO	17.16	-0.25	
1912-550		QSO	16.49	0.09	
2007+776		BL Lac	16.7		
2044-168	OW-174	QSO	17.36	0.19	
2227-088	PHL 5225	QSO	17.5		
2232-488		QSO	17.2		
2234+282	CTD 135	QSO	19.		
2245-328		QSO	18.6		
2255-282		QSO	16.77	0.58	
2300-683		QSO	16.38	0.22	
2326-477		QSO	16.79	0.25	
2352+495	DA 611	AGN	19.		*

* magnitude from Argue *et al.*, 1984.** magnitude from Cohen *et al.*, 1977.

and BL Lac. Column 2 is the photometric band of the observations: *m* with subscript designates photographic plate material in the band of the subscript, *P* is the international photographic band, *B* and *V* are the Johnson bands, *m* is where no band has been specified, the subscript *C* designates CCD observations and the subscript *E* the Palomar Sky Survey *E* plates. Columns 3 through 6 summarize the photometric information for the band specified in column 2: column 3 and 4 the faintest and brightest magnitudes observed, column 5 the average magnitude which may or may not be the average of the brightest and faintest magnitudes, and column 6 the magnitude difference. Column 7 is the time range of the observations. When there are two entries, the first is the length of the observations with the following symbols: d for days, mos for months, and y for years. The second entry gives the epochs of the observations. Columns 8 and 9 specify the observed long- and short-term magnitude variations,

respectively; the symbols are the same as those in column 7 with the additional symbol m for minutes. Column 10 contains the reference for the entries in the preceding columns. Entries in columns 3, 4, and 6 preceded by a tilde indicate uncertainties in the tabulated magnitudes and are explained in the notes; parentheses are used to indicate even greater uncertainties in the tabulated magnitudes. Entries in columns 5 and 7 preceded by a tilde indicate that the tabulated entry was estimated by the authors, usually from a published light curve.

Table II is presented in six columns: column 1 is the source name in IAU format using 1950 coordinates, column 2 is a common name, column 3 is the source type (AGN, QSO, or BL Lac), columns 4 and 5 are the *V* magnitude and *B - V* color taken from Véron-Cetty and Véron (1987, 1989) and Hewitt and Burbidge (1987, 1989) (in all cases of overlap the magnitudes from the two references agree), and column 6 contains an entry when the magnitude is from another source.

III. NOTES ON INDIVIDUAL SOURCES IN TABLE I

0109+224 is a well-observed source. The Harvard Observatory plate collection (1934-1951) shows a 3 mag variation occurring in 1 yr (1942-43) (Pica 1977). Recent observations (1976-87) show that the variation has decreased in amplitude and increased in timescale: 1 mag in 4 yr (1978-1982). The average m_B has dropped from approximately 15.9 for 1976-79 to 16.7 for 1980-87 (Pica *et al.* 1988). This source also shows short-term flickering: 0.4 mag in 70 min (Xie *et al.* 1988).

0134+329 (3C 48) has been observed from 1963-1985 by Pica *et al.* (1988). Their χ^2 test indicates a very low confidence level for variability. However, the graph presented by Lloyd (1984) suggests that short outbursts of 0.2-0.3 mag may be occurring.

0135-247 has only been observed for a little more than a year. The magnitude estimates are based on Gilmore's (1980) conversion from iris reading to magnitude. The magnitude variation is based on only one point which is well above the other points which are all within their mutual error bars. The variability of the source needs to be confirmed with more observations.

0138-097. The only variable information on this source are the observations by Impey and Tapia (1988) that span 12 days. During this time the source varied by 1.52 mag in one week. This source is classified as a blazer.

0150-334. Peterson and Bolton (1973) identified the optical counterpart and estimated the blue magnitude as 16.5 from blue and UV plate material. They did not classify the source as an optical variable: the magnitude change between the Palomar Sky Survey and their two color plates was less than two magnitudes. Wright *et al.* (1977), from 3800-8000 Å spectral data, estimated the magnitude in January 1976 as 18.6. Adam (1978) estimated that $V = 16.5$ in September 1976 and $V \geq 17.3$ in January 1977. This source is obviously variable, but the size and timescale of the variability are not known.

0202-765. Gilmore (1980) classifies this source as a low-amplitude short timescale variable: ≤ 0.5 mag in ≤ 30 days. The magnitudes for Gilmore's observations are estimated using his formula for conversion from iris reading to magnitude. These magnitudes are fainter than the range over which he states his formula is valid. The $B - V = 0.05$ color and the January 1977 $V = 16.90$ photoelectric magnitude

measured by Adam (1978) that overlaps the observations of Gilmore suggest that the magnitudes estimated from Gilmore's formula are too faint by about 1 mag.

0237—233. Using historical data Angione (1973) places this QSO in the same class as 3C 273: sources with quasiperiodic or systematic changes in average brightness. From 1927 to 1934 the average magnitude was approximately 16.55. From 1934 to 1941 the source increased in brightness reaching an average magnitude of approximately 16.35 which it maintained from 1941–1952. The short-term deviation from the average magnitude was as great as 0.28 mag with a timescale of less than a month. The 1966 V magnitude measured by Arp, Bolton, and Kinman (1967) suggests that the average magnitude had again decreased in brightness.

0241+622 is at $|b| = 2^\circ$. The wide range in magnitude reported in the literature indicate whether or not the observations have been corrected for galactic extinction, not the range of intrinsic variability. The 1978–1979 monitoring by Lloyd (1984) shows small changes in magnitude. The 1980–1981 magnitudes reported by Hutchings *et al.* (1982) suggest an outburst. That paper also presents contour maps showing the underlying galaxy. Ford (1978) observed the object with the Kitt Peak ISIT video camera and suggests that the underlying galaxy is a spiral with $V = 17.5$ ($r < 12''$) for the exponential component and $V = 16.7$ for the stellar component.

0316+413 (NGC 1275). The nucleus shows both a slow quasiperiodic cycle of 1–2 yr and flares with timescales of about 8 days. The 1967–1976 U band light curve (Lyutyi 1977), the band that exhibits the greatest variations, is the most extensive light curve in the literature and shows the various components clearly. The mean magnitudes in the literature depend on the aperture used and are difficult to compare directly. The entry (27'') in column 2 indicates that the data listed is for the 27 arcsec aperture.

0336—091 (CTA 26). While $P_{\text{avg}} = 17.6$, this source does exhibit large amplitude flickering and has been observed brighter than $P = 17$ four times (Pica *et al.* 1988).

0405—123. The historical light curve (1900–55) from the Harvard Observatory plate collection shows a 1 mag variation and a quasiperiodic behavior (Angione 1973). Observations in the 1960's and 1970's show much less variation and cover too short a time period to see if the quasiperiodic behavior still exists. Observations by Lü (1972) and Tritton and Selmes (1971) suggest that repeated outbursts of 0.3 mag occur on timescales of 75–85 days. The model of recent VLBI observations at 2.290 GHz produces two point sources separated by either 200 or 400 mas at a position angle of -10° with the southern source having a 35 mas concentric Gaussian halo (Preston *et al.* 1989).

0430+052 (3C 120). The nucleus of this Seyfert galaxy has been observed since 1971 and analysis of the data shows a 12.45 yr sinusoidal period (Webb *et al.* 1988). From the published graph we estimate that minimum occurred at the end of 1977 or early 1978 [this agrees with the observations of Lloyd (1984) which show a general decline from 1968 to 1977–1978] and that maximum occurred at the end of 1983 or early 1984. Thus the next minimum will occur in either late 1989 or early 1990. The source should start rising out of minimum in 1990. Superimposed on the general sinusoidal behavior is short timescale flickering (0.5 mag in weeks).

0440—003 (NRAO 190) has been observed from 1969 through 1985. The source has always shown short timescale outbursts. The range of the variability and size of the out-

bursts have been increasing with time. The average magnitude was at minimum from 1975–1980, rising from 1981–1983 and reached its maximum values 1983–1986. In early 1989 it increased in brightness by 1.4 mag in 28 days and decreased by 1.8 magnitudes in 34 days. The total variation in brightness is more than 4 mag (Webb *et al.* 1988).

0528—250 is an extremely variable object. Observations show that it has decreased in brightness by 2 mag in 7 months (Jauncey *et al.* 1978). It also changes in brightness by a few tenths of a magnitude on timescales of one to a few days (Adam 1985).

0537—441. The light curve is dominated by erratic fluctuations and perhaps quasiperiodic outbursts separated by approximately 27.7 yr. Liller (1974) reduced 430 plates from the Harvard Observatory plate collection extending from 1892 through 1952 and presented a light curve for that data plus the 1971–1972 photoelectric observations of Eggen (1973). Prior to 1934 most of the points plotted are upper limits; however, there are three data points showing an outburst in 1917 with the peak $m_B = 12.6$ occurring in 1917.3. From 1934 through 1952 the source fluctuated between $m_B = 14.0$ and 16.5 except for 1944–1945 when there was an outburst. The peak of the outburst was $m_B = 12.6$ and the source remained above $m_B = 14.0$ for about a year. In addition there were short timescale fluctuations: a 0.7 mag drop followed by an equivalent rise in a few days. Peterson and Bolton (1972) estimated that $m_V = 17.5$ on the Palomar Sky Survey Whiteoak Extension plate taken in October 1964. Eggen's (1973) photoelectric observations from September 1971 to May 1972, showed that in less than three months the brightness had increased from $B = 15.97$ to 14.32. It remained at about $B = 14.5$, with variations from that of 0.2–0.3 mag, for about five months; and then decreased to $B > 16.9$ within two months. Gilmore (1979) monitored the source photographically from April 1975 through March 1977. Using Adam's (1978) January 1977 photoelectric observations, which occurred within 0.11 days of one of Gilmore's plates, to convert from iris reading to magnitude, gives a range of $m_B = 16.05$ to 18.05 assuming $B - V = 0.52$. Impey and Tapia (1988) observed the source in March 1984 and February 1985; if $B - V = 0.5$, then $B = 16.29$ and 16.90, respectively. The source meets their criteria for classification as a blazer. Hamuy and Maza (1987) observed the source 9–12 January 1987; $B_{\text{avg}} = 16.38$ with $\sigma = 0.05$.

The outbursts in 1917, 1944–1945, and 1972 are consistent with a period of approximately 27.7 yr. If the same pattern continues the next outburst should occur in 2000. The outbursts in 1917 and 1944–1945 both reached a peak of $m_B = 12.6$ with the later one lasting for a year. The outburst in 1972 only reached a peak of $B = 14.32$ and lasted only five months. The average B band magnitude has decreased from 14.8 for 1934–1952 to 16.7 for 1976–1977: observations since then are consistent with this average magnitude. In both the outburst phase and the “quiescent” phase, changes in brightness greater than 0.5 mag can be expected on timescales of days and greater than 1.5 magnitudes on timescales of months.

0607—157. A red star is only 3.7'' southeast of the quasar (Hunstead, Murdoch, and Shobbrook 1978). The two objects are blended on the Palomar Sky Survey and both are about 18th magnitude: the star is red and the quasar is neutral in color (D. Wills, private communication). Except for the listing of $m_V = 18.0$ in a paper by Hutchings, Crampton,

and Campbell (1984) [called Hutchings *et al.* (1984) in Table I], all other published magnitudes are greater than 20th magnitude. The report by Wills and Wills that $V \geq 20$ in 1974.2 was confirmed by Hunstead *et al.* (1978) who measured $V = 20.2$ in the continuum at 5500 Å in 1976.9. An R band image of the field is presented by Hutchings, *et al.* (1984); they suggest that the quasar may be interacting with two nearby faint galaxies. They also state that their data are consistent with $V \geq 20$. Hutchings, Johnson, and Pyke (1988) report that the quasar is unresolved and appears to be in a low luminosity galaxy with a faint halo. There is no data to suggest the timescale of the variability and all observations will be limited by the proximity and brightness of the nearby red star.

0716+714. Biermann *et al.* (1981) measured $m_{pg} = 15.5$ on 29 August 1979; almost two magnitudes fainter than the Palomar Sky Survey magnitude. They also report that VLBI observations show that the source is a double separated by 1.2 mas at position angle 10° at 6 cm. There is no other variable information on this source.

0736+017. Pica *et al.* (1988) have been observing this source since 1970. It may have a quasiperiodic behavior. It was observed at maximum for about four years in the early 1970s (there are no observations for mid 1971–mid 1972), declined to a minimum in 1981, and then immediately started climbing toward maximum. It reached its previously maximum level in late 1984 and has remained at that level: at maximum $P_{avg} = 15.8$. The first observation in this series given by McGimsey *et al.* (1975) with $m_{pg} = 16.7$ on 11 December 1969 suggests that the source was rising out of minimum in 1969. If correct, the source remains near maximum for 4–5 yr and may begin declining in late 1989. Short-term fluctuations of up to 0.7 mag occur on timescales of weeks.

0743–673. Gilmore's observations (1980) do not meet his requirement for detected variability. The light curve he presents is suggestive of low level variability, but most of the points fall within their mutual error bars. The magnitudes listed for Gilmore's observations are based on his conversion of iris reading to magnitude; the zero point was determined from Adam's 1977 observation. Adam (1985) reports no significant variation between his 1977 observation ($V = 16.37$) and a later observation ($V = 16.42$).

0818–128 (OJ–131). Pica *et al.* (1988), present no light curve for this source. They report that $m_B = 16.0$ in 1980–1981. It then faded reaching $m_B = 18.0$ in 1983–1984, after which it started to brighten. In addition there were short timescale outbursts exceeding one magnitude in 1982. Tapia *et al.* (1977) observed this source from March 1976 to January 1977. They report a 2.2 mag brightening in 7 months ($m_B = 17.5$ to 15.3).

0828+493 (OJ 448). The only variability information is the estimate by Walsh *et al.* (1984) that the object was 2 mag brighter than on the Palomar Sky Survey in April 1981.

0851+202 (OJ 287) is a well-observed source. The m_V light curve presented by Webb *et al.* (1988) extends from December 1971 to January 1986. The peak brightness $m_V = 12.2$ occurred in December 1971. This is the end of an outburst that first reached its peak range in brightness in November 1970 (Pollock *et al.* 1979): the outburst lasted more than a year. The source then decreased in average brightness until late February 1976 when it reached a minimum $m_V = 16.39$, this was followed by a rise in brightness. From 1977.0 through 1982.6 the average brightness re-

mained at about $m_V = 14.9$. This was followed by an outburst that lasted from 1983.0–1984.2; the peak of this outburst was $m_V = 13.45$. Since then it has been decreasing in brightness, and by January 1988 the average had fallen to $m_V = 16.19$. The previous decrease in brightness extended for more than four years. If the source again follows this same pattern, it should have reached minimum brightness in 1988 and then started rising. The historical light curves (Craine and Warner 1973; Visvanathan and Elliot 1973) are not extensive enough to determine if this pattern has occurred in the past. Flickering is superimposed on this general pattern.

0912+297. The historical light curve (Zekl, Klare, and Appenzeller 1981) shows that the source decreased from a maximum ($m_{pg} = 14.8$) in 1917 to a minimum ($m_{pg} = 17.05$) in 1947. From 1959 to 1961 it rose from $m_{pg} = 16.5$ to 16.0. Battistini, Braccisi, and Formiggini (1974) observed the source in April 1972 and February 1973 and reported that $B = 16.79$ and did not indicate that any variation in brightness had occurred. The source then increased to $B = 16.21$ in 1975 (Tapia, Craine, and Johnson 1976).

0923+392 (4C 39.23). Nothing is known about the variability of this source other than the fact that it has changed in brightness by 1.3 mag.

0955+326 (3C 232). The observations by Lloyd (1984) show an asymmetric shape to the light curve. The time from maximum to minimum is 8.87 yr while the time from minimum to maximum is only 3.89 yr. The overall variation is about 0.5 mag.

1038+064 (4C 06.41). The only information monitoring the variability of this source shows less than a 0.2 mag change between the Palomar Sky Survey and 1974–1975 (Uomoto, Wills, and Wills 1976). The 1970 date given for the Wills and Lynds (1978) entry is assumed from the discussion of their observations, no specific date was given.

1101–325. Gilmore (1980) classifies this as a long term (≥ 30 days) low amplitude (≤ 0.5 mag) variable. There is not enough data to determine if this variation is quasiperiodic.

1127–145. The χ^2 test indicates a very low confidence level for variability (Pica *et al.* 1980).

1144–379. Nothing is known about the variability of this source other than it has varied by almost 2 mag. This source is classified as a blazer (Impey and Tapia 1988).

1148–001 (4C–00.47). Pica *et al.* (1988) have monitored this source since 1969 but have presented no light curve.

1150+497 (4C 49.22). The χ^2 test indicates a very low confidence level for variability (Pica *et al.* 1988). The observations of Tritton and Selmes (1971) show that the source faded by about 0.4 mag from April 1967 to March 1968.

1206–339. Hewitt and Burbidge (1989) give no reference for their updated magnitude. However, it is consistent with the comment by Adam (1985) that the source is weakening. The date for the Adam (1985) entry is for $V = 16.98$. No observation date is given for $V = 17.01$; it is a later observation and was taken sometime between 1977–1980.

1215+303 (ON 325). The average magnitude of this source increased by 0.1 mag per year for 1975–1985. Since then, the trend has been downward. Superimposed in this pattern are short-term fluctuations of more than a magnitude on a timescale of months (Pica *et al.* 1988).

1219+825 (ON 231). This source showed a series of 2

mag outbursts in 1975–1976. Although the variation has decreased to more like a magnitude, this type of outburst has continued through 1986 into 1987. (Webb *et al.* 1988).

1226+023 (3C 273) is a well-observed source. The greatest activity occurred in 1978–1979 (Pica *et al.* 1980; Pica *et al.* 1988). Since 1984, the total amplitude of the variations has been decreasing and the average brightness has been increasing (Corso *et al.* 1987); see Table I for details.

1244–255. Adam (1985) on the basis of six observations (1977–1980) reports slow large amplitude variations with the total variation in B being at least 2 mag. Gilmore's observations (1979) show a 2 mag variation in 100 days and a 0.8 mag variation in 14 days. The observations by Impey and Tapia (1988) show a 0.5 mag variation in just 7 days. They classify this source as a blazer. Daily monitoring might show large variations on timescales of a day or less.

1302–102. Nothing is known about the variability of this source, other than the fact that it varies by more than 1 mag; this is based on observations separated by more than three years (Adam 1978).

1404+286 (OQ 208). A long-term moderate rise and fall occurring from 1969–71 was observed by both McGimsey *et al.* (1975) and Lü (1972). The mean magnitude dropped from $P = 15.2$ in 1969–1971 to $P = 15.6$ in 1974–1975. The greatest brightness difference is between the peak in 1970 and the nadir in 1974: 1 mag in 4.05 yr. Although the 1969–71 observations were less frequent than those in 1974–75, it appears that an increase in amplitude and decrease in timescale of the variations occurred in conjunction with a decrease in average brightness.

1418+546 (OQ 530). Miller (1978) has reduced data from over 200 plates from the Harvard Observatory plate collection and has determined the long-term behavior of this source from 1900–1977, no data was available from 1953–1966. This source shows erratic high amplitude fluctuations superimposed on a long-term decline. The source over this 77 yr period has shown a 4.8 mag variation: it was brightest on 27 April 1901 and faintest on 12 February 1978 (Bradley Observatory plate). In 1938 the source decreased by 1.2 mag in 2 days followed by a 0.9 mag brightening the next 2 days. Pica *et al.* (1988) report that the source dimmed by 1.1 mag in 1980 in 2 months reaching $m_B = 16.1$. This was followed by a gradual brightening of over 1 mag.

1510–089 (OR–017) is a well-observed source. Pica *et al.* (1988) report that there was a long-term downward trend in brightness from 1968–1977, followed by an average brightening of 0.1 mag per year. A major outburst occurred with a peak brightness $P = 15.58$ reached in 1987.3. The source then swiftly fell below magnitude 17. Liller and Liller (1975) presented the historical light curve using the Harvard Observatory plate collection for 1933–1952 and reported that the source had shown a total variation of 5.4 mag. The source's average magnitude for 1935–1945 was about $m_B = 15.55$. It then decreased in brightness by more than one magnitude in 1946. By 1947 it had brightened to about $m_B = 14.8$. Starting at this level a double-peaked outburst occurred in 1948 lasting about 100 days. The peaks of the outburst were separated by 57 days and the maximum brightness reached was $m_B = 11.8$. After the outburst the average magnitude slowly decreased and was about $m_B = 15$ by 1952. The time interval between the two major outbursts is about 38.7 yr. In addition to the major outbursts the source also shows fluctuations of about 0.7 mag (Pica *et al.* 1988).

1514–241 (AP Librae). Webb *et al.* (1988) presented a light curve extending from 1972–1986. Changes in brightness of up to 1 mag on timescales of months occur frequently. There was a major outburst in 1977 with the source brightness increasing by a total of 2.43 mag in 27 days; as it was approaching the peak it increased by 1.3 mag in just 6 days. There may have been another major outburst in 1985 that was missed. In addition to the outbursts the average brightness rose from $m_B = 16.3$ in 1971 to 15.2 in 1981. This was followed by a decrease to 15.8 where it remained through the end of the observations (1986.4).

1633+382 (4C 38.41). Barbieri *et al.* (1977) presented a light curve extending from 1969–1976 and report that this source is one of the largest amplitude variables known with outbursts of more than a magnitude occurring in less than a month. There is no pattern to the outbursts but the average level appears to be dropping: the average m_B dropped from 16.8 in 1969 to 18.9 by 1975–1976. It was only observed three times in 1975–76, so an outburst may have been missed; but the three observations are only separated in magnitude by 0.2 mag.

1638+398 (NRAO 512). A 3 mag outburst lasting months occurred in 1970 followed by somewhat smaller outbursts in 1971 and 1972. Since then the source has been less active. On many of the plates taken since 1976, the source has been below the plate limit; although, outbursts greater than 1 mag continue to occur (Webb *et al.* 1988). The average magnitude estimated from the light curve is most likely too high. If the source is spending much time below the plate limit, the average magnitude of 18.4 may be more representative of the mean value of recent outbursts. Barbieri *et al.* (1977) attempted to model the periodic behavior and concluded that most of the activity could be accounted for with periods of 240, 720, and 161 days.

1641+399 (3C 345) shows quasiperiodic behavior as well as short timescale outbursts. Webb *et al.* (1988) model the periodic behavior and obtained periods of 11.4 and 5.6 yr, not much different from the period of 11.01 yr we estimated directly from their data for the period between major peaks. A secondary peak occurred 5.99 yr after the major peak. The last major peak occurred in October 1982. If the source followed previous behavior, a secondary peak should have occurred in October 1988; and the next major peak should occur in October 1993. The major peaks reach magnitude $m_B = 15.2$; the secondary peak was about half a magnitude fainter.

1656+053. Adam (1985) classifies this source as a variable. The tabulated entry is $V = 16.58$ and in the notes $V = 16.45$ for a 1978 observation: no observing dates are given for either observation. The Craine *et al.* (1975) results are also contained in those notes.

1727+502 (I Zw 187) shows rapid short-term variability. There is no overall pattern. The rapid variations are now on the order of one magnitude. Scott *et al.* (1976) report the source now shows a smaller range in variability than the greater than 2.1 mag range in the archival data presented by Hall and Usher.

1749+701. In 1979–1980 the mean magnitude was about 17 with a peak of about 16.7. In 1981 it dropped to about 17.8 where it stayed through 1985. It rose rapidly in 1986 reaching a peak $m_B = 16.7$ and then declined again to a mean of about 17.5 in 1987 (Pica *et al.* 1988). Rapid fluctuations greater than 0.5 mag occur on timescales of months.

1921–293 (OV–236). This source is a very rapid erratic

variable. From a minimum brightness of $P = 18.1$ in 1976, the source increased in brightness. This increase ended with a rapid outburst in 1977 reaching $P = 15.5$. The source then declined in brightness reaching $P = 17.1$ in 1978. Another outburst occurred in 1979 again reaching $P = 15.5$, this was followed by a decline to $P = 17.8$ in 1980. Another large outburst occurred in 1981. From the end of 1981 the observations are less extensive, but this pattern may have continued through 1986. In 1987 the source fell rapidly reaching $P = 18.1$: the minimum it had in 1976 (Pica *et al.* 1988).

1928+738 is classified as a probable variable by Biermann *et al.* (1981) based on the magnitude difference between their observations and the PSS. Eckart *et al.* (1985) reported that this source may exhibit superluminal motion based on 6 cm VLBI observations. Observations at 20 and 49 cm show that it has a complex radio structure: it has a large complex double structure and jetlike emission extending from either side of the compact core (Johnston *et al.* 1987).

2005-489. Wall *et al.* (1986) reported that the object is clearly nebulous with a diameter of $\frac{2}{3}$ of an arcmin. They estimate that the magnitude of the underlying galaxy is $B = 15.3$. The values in Table I are for the nucleus only. They also estimated the magnitude as $B = 13.95$ in March 1984 measured with the fine error sensor on the *International Ultraviolet Explorer* satellite.

2128-123 (PHL 1598). There is no pattern to the variability. Angione *et al.* (1981) report that the recent behavior appears to be similar to that found in the historical light curve. Gilmore (1980) classified this as a source for which he had detected no variations in his 1976-1979 data.

2134+004 (PHL 61). The χ^2 test by Pica *et al.* (1988) indicates a very low confidence level for variability. The 1977-1979 observations by Lloyd (1984) show a maximum variation of only 0.23 mag.

2155-152 (OX-192). Willson (1975) reported that the source has varied by 6.5 magnitudes since 1885. In 1899 there was a major outburst of 3.5 mag. Outbursts of about 3 mag occurred in 1933, 1941, and 1948. That data extended to 1950. There has been no recent monitoring of this source.

2200+420 (BL Lac), the prototype for BL Lacertae objects, is well observed. Webb *et al.* (1988) report that from 1971-1981 the source showed rapid 1-2 mag flares. Starting in January 1981 when $m_B = 17.2$ (its faintest value during the 1971-1985 monitoring period), it started to brighten slowly and reached a peak brightness of $m_B = 15.6$ in November 1985. Also during this period there has been very little flare activity.

2201+315 is classified as a probable variable by Tritton *et al.* (1973). This is the only information on the variability of this source.

2251+158 (3C 454.3). From 1966-1971 the source was very active, although the average brightness decreased from about $m_B = 16.4$ in 1966 to about 17.25 in 1971 (Lloyd 1984). The source was relatively inactive from August 1971 until July 1979, when from a minimum brightness of $m_B = 17.54$ a 1.4 mag flare occurred. From this peak, the source declined in brightness for 3 yr. Since 1983 it has been slowly brightening and by 1985 the average brightness was $m_B = 16.6$ (Webb *et al.* 1988).

2254+074 (OY 091). From a minimum brightness of $m_B = 17.7$ in 1979, the source rose to an average magnitude of 17 by 1980. In 1981 it flared by 1.8 mag reaching a peak brightness of $m_B = 15.65$. The brightness then fell 1.3 mag in 18 days. From 1983-87 the average magnitude has re-

mained near $m_B = 17.7$. The minimum brightness has remained near $m_B = 18$ with outbursts reaching maximum brightness of $m_B = 17.2$ (Pica *et al.* 1988).

2345-167 (OZ-176). Pollock *et al.* (1979) reported that since the 2 mag flare that occurred in 1969, the average brightness of the source has been declining: 0.05 mag/yr. The source has also been relatively quiescent, varying by less than a magnitude each year. By 1979 the average brightness had declined to about $P = 17.7$.

IV. DISCUSSION

The superset of sources contains 89 EGOs. Only 31 of these are not known to be optical variables. The majority, 58, are known variables. To be included in the set a source had to have both a compact-core radio source and a bright stellar-like nucleus: these sources are preferentially optical variables. The limited dynamic range of the PC requires that we have good magnitude estimates; this includes estimates of the timescales of the variability. Figure 1 presents a histogram of number per maximum known variability in 0.5 mag intervals: 19 vary by one magnitude or less, 16 by one to two magnitudes, 13 by two to three, and nine by more than three magnitudes. Assuming that the usable dynamic range of the PC is 2.5 mag (3000 to 30 000 electrons), it is for the EGOs that vary by more than one magnitude that the best estimates are needed. All of the EGOs classified as blazars fall into this category; they are large amplitude, erratic variables. A good example is 0537-441. In 1971-1972 it varied by more than 2.7 mag in 72 days. The historical light curve shows a 4 mag variation. It has exhibited quasiperiodic behavior with a period of almost 28 yr. The last outburst was in 1972. Since then its average brightness has decreased and now is very close to its minimum brightness. However, even in the "quiescent" phase it can brighten by about a magnitude in a few days.

Sources that appear to be systematically decreasing or in-

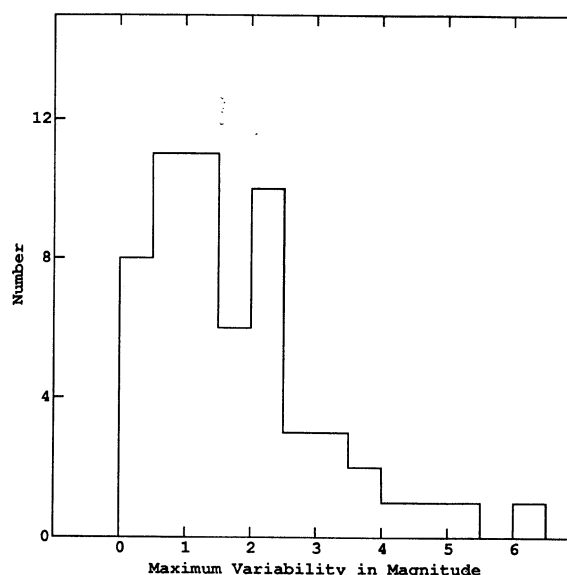


FIG. 1. Histogram of number of EGOs per maximum known variability in 0.5 mag intervals.

creasing in brightness are also a concern. The QSO 0607 – 157 has been reported as bright as 18th magnitude but all the recent results estimate that it is now fainter than 20th magnitude. The QSO 0736 + 017 started climbing out of its minimum range in 1981 and reached its peak brightness in 1984. If it follows past behavior, it will stay at this level for 4–5 yr and then start to decline. In addition, short-term fluctuations of 0.7 mag occur on timescales of weeks.

The source that is known to be the largest amplitude variable is the BL Lac 2155 – 152. The historical light curve shows a 6.5 mag variation. The last recorded outburst (3 mag) was in 1948. The most recent observation was in 1975 when it was near minimum. There has been no recent monitoring of this source. While many sources that show large amplitude variations in their historical light curves are now much less active, many still show more than 2 mag of variation.

Our search of the literature has provided valuable information and has enabled us to make realistic estimates of exposure times for the PC observations. If just the average magnitudes given in various compilations were used to estimate exposure times, much of the data would be at best marginally useful.

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