SECULAR VARIATIONS IN THE ABSOLUTE BRIGHTNESS OF SHORT-PERIOD COMETS

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Abstract. Secular variations in the absolute brightness of short-period comets are investigated on the basis of their maximum apparent magnitudes in individual returns. It is found that the data on the maximum apparent brightness are affected by systematic instrumental errors. Omission of the discovery apparitions and of estimates of the brightness of the nuclear condensation lead to considerably lower values of the secular decrease than those derived previously by other authors.

For all of short-period comets with orbital period shorter than 28 years, the weighted average of the secular brightness decrease was found to be $+0^{m}.22$ per revolution. The analysis of selected groups of comets shows that the secular decrease is accelerated by the increase of orbital period and perihelion distance, respectively. Both of these changes can hardly be interpreted physically, however, they can be explained by instrumental effects. The brightness variations in the collection of short-period comets were investigated for the period 1860 to 1970.

1. Introduction

For more than 40 years, the secular variations of the brightness have constituted a basic open problem of cometary physics. They are important as quantitative indicators of cometary evolution and their life-times in the region of terrestrial planets. Progressive loss of mass, associated with a brightness decrease, and gravitational capture from outer orbits are basic factors determining the quasi-equilibrium state of short-period cometary population. Determination of the rate of aging of short-period comets, along with a better knowledge of the perturbational capture mechanism, is the only way to answer the fundamental question about the total number of comets in the inner Solar System.

Secular changes in absolute magnitudes of short-period comets have been established by different authors, however the results are rather controversial. There are two main reasons of disagreement. The duration of accurate astronomical observations is still too short to allow a reliable separation of the irregular changes of brightness from a secular decrease due to aging. In individual returns the Sun, Earth and the comet form different configurations, and the determination of the absolute brightness of the comet requires certain schematic assumptions about the dependence of the apparent brightness on heliocentric distance, geocentric distance and phase angle, respectively. In some cases, major changes of orbits due to planetary perturbations occurred between the observed returns. During the periods covered by observations the methods and the instruments used underwent appreciable changes. Due to the diffuse appearance of comets, with differences between the brightness of coma and nucleus as large as 1 : 1000 in some cases, the new observations with large telescopes are not directly comparable with the older observations. The main point of controversy on the rate of aging of comets has become a problem of instrumental effects referring to the photometry of different parts of the comet.

In this paper we attempted a uniform treatment of the data on the brightness of all short-period comets observed in more than two apparitions. Our approach differs from that of some other studies of this problem in not introducing instrumental corrections. Instead, it compares the variations of the absolute brightness determined from all available observations (Vsekhsvyatskii, 1958) with the variations of the maximum apparent brightness in individual returns reduced to a unit distance from the Sun and Earth. The application of the maximum brightness is of certain advantage, because this value was less influenced by the development of the instrumental equipment, and by the variety of photometric methods. This method was already used by Kresák (1965) to determine the secular variation in the brightness of Comet Encke. Kresák concluded that the secular decrease in the brightness of P/Encke was only 1 magnitude per century rather than 3 magnitude per century, as maintained by other authors. For other periodic comets the

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data available are much poorer, both as regards the number of observed returns and photometric data. Lower absolute brightness makes the material less homogeneous, however some cases (282 observed returns of the 42 comets) promised qualitative results at least. Vsekhsvyatskii's catalogue of physical characteristics of comets (Vsekhsvyatskii, 1958) was the main source of reference; for the period after 1958 other sources were used, processed by the same method. These were mainly Vsekhsvyatskii's Appendices, Porter's and Marsden's Annual Reports on Comets, and photometric data from the IAU Circulars.

2. Observational Data and Method of Processing

The present paper deals with periodic comets with orbital periods shorter than that of P/Crommelin, i.e. 28 years. Comet Encke investigated in detail by Kresák (1965) has not been included. The orbital period is limited to prevent substantial changes of observational methods and instrument between successive revolutions. Of these comets only those were chosen which were observed in three returns at least by December 31, 1974. Our sample thus contains 42 short-period comets (the number of observed returns is given in parentheses):

Pons—Winnecke (17)
Faye (16)
Tempel 2 (15)
Grigg—Skjellerup (12)
D'Arrest (12)
Brooks 2 (11)
Wolf (11)
Kopff (10)
Giacobini—Zinner (9)
Finlay (9)
Borelly (9)
Tuttle (9)
Schwassmann—Wachmann 2 (8)
Biela (6)
Whipple (6)
Reinmuth 1 (6)
Schaumasse (6)
Comas Solá (6)
Crommelin (6)
Honda—Mrkos—Pajdušáková (5)
Brorsen (5)
Tuttle—Giacobini—Kresák (5)
Tempel 1 (5)
Forbes (5)
Wolf—Harrington (5)
Wirtanen (5)
Perrine—Mrkos (5)
Reinmuth 2 (5)
Holmes (5)
Daniel (5)
Tempel—Swift (4)
De Vico—Swift (4)
Johnson (4)
Arend—Rigaux (4)
Ashbrook—Jackson (4)
Väisälä (4)
Neujmin 1 (4)
Harrington—Abell (3)
Arend (3)
Oterma (3)
Neujmin 3 (3)
Schwassmann—Wachmann 1 (3)

We picked out the maximum apparent magnitude M_m from Vsekhsvyatskii's catalogues (1958, 1966, 1967, 1974), IAU Circulars, and other literature for each return. Using

$$M_{42} = M_m - 10 \log r - 5 \log \Delta \qquad (1)$$

we obtain the absolute magnitude M_{42} (assumption $n=4$), where r and Δ indicate the heliocentric and geocentric distances of the comet at the time of the observation of maximum brightness M_m.

At each return of the comet it was stated whether the comet was recovered independently, or according to an ephemeris. Pittich (1971) pointed out that independent discoveries are much more probable after a sudden increase of brightness, and that such cases are by no means exceptional. In further elaboration all returns in which the comet was recovered independently were omitted. Returns during which all brightness estimates referred to the nuclear condensation recorded by large telescopes were omitted, too. The value M_r was obtained in this way. The secular variations of M_{42} and M_r were determined by a least-square solution, assuming a linear dependence on time.

Vsekhsvyatskii has determined the absolute magnitudes M_v for many returns before 1970; this is the mean value of all estimates reduced in accordance with (1). For all three sets of absolute magnitudes — M_{42}, M_r and M_v — secular change per revolution, and mean annual change were calculated. The results are shown in Tables 1—42 together with the respective root-means-quare deviations of one observation ε (in brackets).

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3. The Secular Variation of Absolute Magnitudes of Individual Comets

The successive columns in Tables 1—42 include

n — the serial number of the observed return,

N — the serial number of the return, regardless of unobserved returns,

Comet — definitive designation,

T — the date of perihelion passage (the first two figures denote the day and the next the month),

M_v — the absolute magnitude derived by Vsekhsvyatskii assuming $n=4$ (H_{10} in his notation),

t — the date of observation of maximum brightness (the first two figures denote the day, the next the month and year, respectively),

$t-T$ — the difference between the date of observation and the date of perihelion passage, in days,

M_m — the maximum apparent magnitude,

M'_{42} — the absolute magnitude derived assuming (1),

M_{42} — the average value of M'_{42}, in case that the same maximum apparent magnitude was estimated several times,

M_r — the absolute magnitude M_{42}, if the comet was recovered according to an ephemeris, and the magnitude did not refer to the nuclear condensation only (capital letter J indicates the magnitude of the nuclear condensation and capital letter N an independent discovery).

Absolute magnitudes referring to the nucleus or nuclear condensation, respectively may occur in column M_r, because the J has only been used, if this has been explicitly mentioned by the observer. All other values regardless of the size of the instrument used have been taken into account in calculating M_r.

P/Pons—Winnecke

Table 1

n	N	Comet	T	M_v	t	r	Δ	$t-T$	M_m	M'_{42}	M_{42}	M_r
1	1	1819 III	1907	8.8	200719	0.78	0.40	+001	6.0	9.1	9.1	N
2	8	1858 II	0205	9.0	150458	0.83	0.64	−017	6.5	8.3	8.3	N
3	10	1869 I	3006	9.6	080569	1.17	0.61	−053	7.0	7.4	7.4	7.4
4	11	1875 I	1203	7.6	090275	0.98	1.38	−027	7.5	6.9	6.9	6.9
5	13	1886 VI	0409	9.2	250886	0.91	1.13	−010	8.5	8.6	8.6	8.6
6	14	1892 IV	0107	10.6	210692	0.92	0.22	−010	6.5	10.2	10.2	10.2
7	15	1898 II	2003	9.6	110298	1.08	1.38	−037	12.0	11.0	11.0	11.0
8	17	1909 II	0910	9.7	081209	1.28	1.74	+060	9.5	7.2	7.2	7.2
9	18	1915 III	0109	9.2	281015	1.28	1.19	+057	9.3	7.9	7.9	N
10	19	1921 III	1306	12.4	140621	1.02	0.14	+001	6.9	11.1	11.1	11.1
11	20	1927 VII	2106	10.7	240627	1.05	0.07	+003	3.7	9.4	9.4	9.4
12	21	1933 II	1805	10.4	230633	1.21	0.62	+036	9.5	9.7	9.7	9.7
13	22	1939 V	2206	11.4	230639	1.10	0.14	+001	6.4	10.3	10.3	10.3
14	23	1945 IV	1007	12.7	070645	1.24	0.51	−033	11.4	11.9	11.9	11.9
15	24	1951 VI	0909	14.1	200851	1.23	1.41	−020	14.0	12.4	12.4	12.4
16	26	1964 I	2403	13.8	210364	1.23	1.49	−003	14.5	12.7	12.7	12.7
17	27	1970 VIII	2107	14.2	060770	1.27	0.66	−015	17.0	16.9	16.9	J

Secular brightness (Fig. 1):

$M_v\,(t\text{-}1819.55) = 7^{m}0 + 0^{m}041\,t$ ($\varepsilon = \pm 1.2$)

$M_{42}(t\text{-}1819{,}55) = 6^{m}2 + 0^{m}043\,t$ ($\varepsilon = \pm 1.9$)

$M_r(t\text{-}1869.35) = 7^{m}5 + 0^{m}050\,t$ ($\varepsilon = \pm 1.3$)

$M_v\,(N) = 7^{m}0 + 0^{m}26\,(N\text{-}1)$

$M_{42}(N) = 6^{m}2 + 0^{m}27\,(N\text{-}1)$

$M_r\,(N) = 7^{m}5 + 0^{m}32\,(N\text{-}10)$

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P/Faye

Table 2

n	N	Comet	T	M_v	t	r	Δ	$t-T$	M_m	M'_{42}	M_{42}	M_r
1	1	1843 III	1710	4.2	251143	1.72	0.79	+039	5.8	3.9	3.9	N
2	2	1851 I	0204	5.5	240151	1.82	2.39	−068	9.5	5.0	5.0	5.0
					040351	1.72	2.59	−029	9.5	5.1	—	—
3	3	1858 V	1309	8.1	150958	1.70	1.45	+002	10.5	7.4	7.4	7.4
4	4	1866 II	1402	6.4	121265	1.82	1.64	−064	9.5	5.8	5.8	5.8
5	5	1873 III	1807	7.4	030973	1.72	2.08	+047	11.5	7.6	7.4	7.4
					291173	2.10	1.62	+134	11.5	7.2	—	—
6	6	1881 I	2301	7.4	280980	2.06	1.11	−117	10.5	7.1	7.2	7.2
					081080	2.01	1.10	−107	10.5	7.3	—	—
					011180	1.91	1.17	−083	10.5	7.3	—	—
					220181	1.75	1.73	−001	10.5	6.9	—	—
7	7	1888 IV	2008	7.4	040289	2.32	1.41	+168	9.5	5.1	5.1	5.1
8	8	1896 II	1603	7.8	211095	2.22	1.67	−147	11.5	6.9	6.9	6.9
9	10	1910 V	0111	9.1	081110	1.66	0.68	+007	9.5	8.1	8.1	N
10	12	1925 V	0608	10.9	201025	1.78	1.55	+075	13.0	9.5	9.5	9.5
11	13	1932 IX	0612	9.5	221032	1.69	0.72	−045	9.5	7.9	7.9	7.9
12	14	1940 II	2404	10.7	141239	2.08	2.42	−132	15.0	9.9	10.0	10.0
					040140	1.97	2.51	−111	15.0	10.1	—	—
13	15	1947 IX	2809	11.2	201247	1.86	0.96	+083	10.0	7.4	7.4	7.4
14	16	1955 II	0403	11.1	241254	1.79	1.93	−070	15.0	11.0	11.0	11.0
15	17	1962 VII	1405	12.7	031161	2.44	2.51	−192	17.8	11.9	11.9	11.9
16	18	1969 VI	0710	10.8	011269	1.71	0.75	+055	10.4	8.6	8.6	8.6

Secular brightness (Fig. 2):

$M_v\,(t\text{-}1843.79) = 5^m.5 + 0^m.053\,t$ ($\varepsilon = \pm 0.9$)

$M_{42}(t\text{-}1843.90) = 5^m.1 + 0^m.042\,t$ ($\varepsilon = \pm 1.3$)

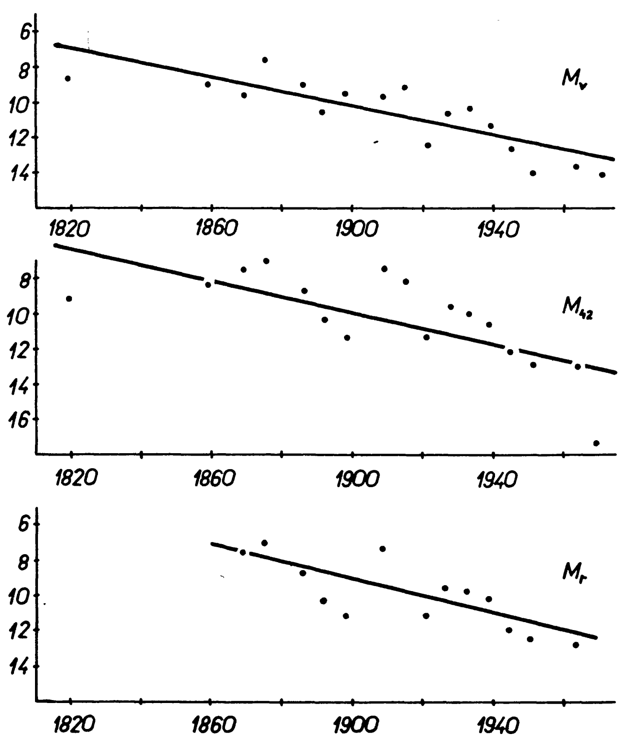
$M_r\,(t\text{-}1851.12) = 5^m.7 + 0^m.039\,t$ ($\varepsilon = \pm 1.4$)

$M_v\,(N) = 5^m.5 + 0^m.39\,(N\text{-}1)$

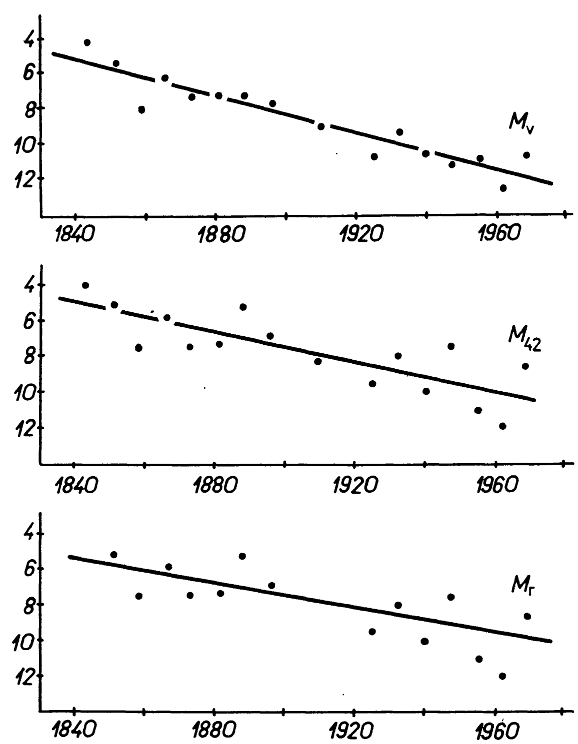
$M_{42}(N) = 5^m.1 + 0^m.31\,(N\text{-}1)$

$M_r\,(N) = 5^m.7 + 0^m.29\,(N\text{-}2)$

P/ PONS - WINNECKE



P/ FAYE



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P/Tempel 2

Table 3

n	N	Comet	T	M_v	t	r	Δ	$t-T$	M_m	M'_{42}	M_{42}	M_r
1	1	1873 II	2506	8.5	050773	1.35	0.70	+010	8.5	8.0	8.0	N
2	2	1878 III	0709	9.4	151078	1.40	1.03	+038	6.5	5.0	5.0	5.0
3	5	1894 III	2304	9.5	080594	1.36	1.68	+015	11.0	8.5	8.5	8.5
4	6	1899 IV	2807	9.4	190799	1.39	0.38	−009	8.5	9.2	9.2	9.2
5	7	1904 III	1011	9.8	301004	1.40	1.94	+020	12.5	9.6	9.6	9.6
6	9	1915 I	1504	10.0	160515	1.37	1.80	+031	12.5	9.9	9.9	9.9
7	10	1920 II	1006	10.1	200720	1.33	0.46	+040	9.0	9.4	9.4	9.4
8	11	1925 IV	0708	10.1	310725	1.32	0.34	−007	6.6	7.8	7.8	7.8
9	12	1930 VIII	0510	10.3	221030	1.33	1.32	+017	10.0	8.2	8.2	8.2
10	15	1946 III	0207	9.4	270746	1.43	0.67	+025	8.0	7.3	7.2	7.2
					300846	1.53	0.65	+059	8.0	7.1	—	—
11	16	1951 VIII	2510	11.9	311051	1.39	1.60	+006	12.0	9.5	9.4	9.4
					251151	1.44	1.75	+031	12.0	9.2	—	—
12	17	1957 II	0402	13.0	050557	2.81	2.05	+090	19.0	13.0	13.0	13.0
13	18	1962 VI	1205	12.6	050562	1.38	1.57	−007	12.5	10.1	10.1	10.1
14	19	1967 X	1408	10.4	040967	1.39	0.50	+021	7.8	7.9	7.9	7.9
15	20	1972 X	1511	—	191273	3.48	2.50	+400	19.0	11.6	11.6	J

Secular brightness (Fig. 3):

$M_v\,(t\text{-}1873.48) = 8^{m}.7 + 0^{m}.032\,t$ $(\varepsilon - \pm 0.9)$

$M_{42}(t\text{-}1873.51) = 7^{m}.4 + 0^{m}.030\,t$ $(\varepsilon = \pm 1.7)$

$M_r\,(t\text{-}1878.79) = 7^{m}.5 + 0^{m}.028\,t$ $(\varepsilon = \pm 1.8)$

$M_v\,(N) = 8^{m}.7 + 0^{m}.17\,(N\text{-}1)$

$M_{42}(N) = 7^{m}.4 + 0^{m}.16\,(N\text{-}1)$

$M_r\,(N) = 7^{m}.5 + 0^{m}.15\,(N\text{-}2)$

P/Grigg—Skjellerup

Table 4

n	N	Comet	T	M_v	t	r	Δ	$t-T$	M_m	M'_{42}	M_{42}	M_r
1	1	1902 II	0307	9.5	040802	1.00	1.15	+032	9.5	9.2	9.2	N
2	5	1922 I	1505	13.1	290522	0.93	0.28	+014	10.0	13.1	13.1	N
3	6	1927 V	1005	13.0	010627	0.96	0.21	+022	8.5	12.1	12.1	12.1
4	7	1932 II	1205	12.5	300532	0.96	0.26	+018	9.5	12.6	12.6	12.6
5	8	1937 III	2205	15.0	030537	0.96	0.66	−019	12.0	13.1	13.1	13.1
6	9	1942 V	2305	13.9	150642	0.93	0.36	+023	9.1	11.6	11.6	11.6
7	10	1947 II	1804	14.2	180447	0.85	0.18	000	9.0	13.4	13.4	13.4
8	11	1952 IV	1103	13.5	210452	1.06	0.99	+041	11.2	11.0	11.0	11.0
9	12	1957 I	0202	13.5	060157	0.98	1.11	−027	13.0	12.9	12.9	12.9
10	13	1961 IX	3112	14.9	150162	0.89	1.62	+015	13.5	13.0	13.0	13.0
11	14	1967 I	1601	14.8	191266	1.08	1.50	−028	16.0	14.8	14.8	14.8
12	15	1972 II	0203	—	130172	1.21	0.94	−049	17.5	16.8	16.8	16.8

Secular brightness (Fig. 4):

$M_v\,(t\text{-}1902.50) = 10^{m}.9 + 0^{m}.066\,t$ $(\varepsilon = \pm 1.0)$

$M_{42}(t\text{-}1902.59) = 10^{m}.0 + 0^{m}.068\,t$ $(\varepsilon = \pm 1.3)$

$M_r\,(t\text{-}1927.42) = 11^{m}.5 + 0^{m}.072\,t$ $(\varepsilon = \pm 1.3)$

$M_v\,(N) = 10^{m}.9 + 0^{m}.34\,(N\text{-}1)$

$M_{42}(N) = 10^{m}.0 + 0^{m}.35\,(N\text{-}1)$

$M_r\,(N) = 11^{m}.5 + 0^{m}.37\,(N\text{-}6)$

←

Fig. 1—Fig. 42. Secular brightness.

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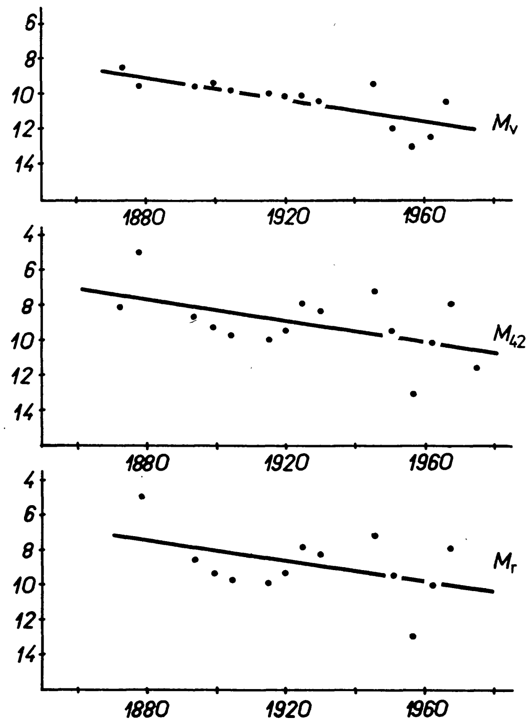
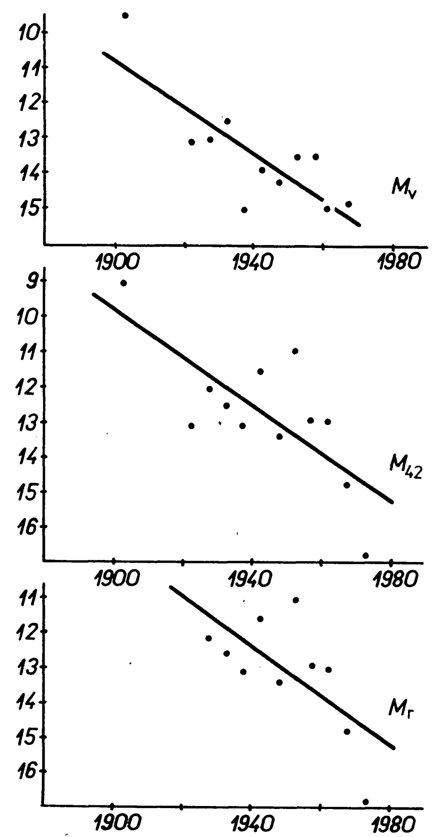
P/ TEMPEL 2



P/ GRIGG - SKJELLERUP



P/D'Arrest

Table 5

n	N	Comet	T	M_v	t	r	Δ	$t-T$	M_m	M'_{42}	M_{42}	M_r
1	1	1851 II	0907	9.5	280651	1.18	0.71	−011	10.0	10.0	10.0	N
2	2	1857 VII	2811	9.6	061257	1.18	1.70	+008	9.5	7.6	7.6	7.6
3	4	1870 III	2209	8.2	250970	1.29	0.84	+003	8.5	7.8	7.6	7.6
					181070	1.33	0.95	+026	8.5	7.4	—	—
4	5	1877 IV	1005	8.8	090777	1.49	1.60	+060	10.0	7.3	7.3	7.3
5	7	1890 V	1709	9.7	171090	1.37	0.94	+030	9.5	8.3	8.3	N
6	8	1897 II	2405	9.5	280697	1.40	1.43	+035	10.0	7.8	7.8	7.8
7	10	1910 IV	1609	10.1	231010	1.35	0.85	+037	10.5	9.5	9.5	9.5
8	12	1923 II	1409	12.0	101123	1.49	1.15	+057	11.0	9.0	9.0	9.0
9	15	1943 III	2309	11.3	041043	1.39	0.90	+011	13.0	11.8	11.8	11.8
10	16	1950 II	0606	11.7	210650	1.40	1.25	+015	10.5	8.6	8.6	8.6
11	18	1963 VII	1510	12.0	060164	1.65	1.94	+083	17.0	13.4	13.4	J
12	19	1970 VII	1805	9.5	080670	1.20	1.48	+021	11.0	9.4	9.0	9.0
					150770	1.37	1.55	+058	11.0	8.7	—	—

Secular brightness (Fig. 5):

$M_v\,(t\text{-}1851.52) = 9\overset{\mathrm{m}}{.}0 + 0\overset{\mathrm{m}}{.}021\,t$ $(\varepsilon = \pm 1.0)$

$M_{42}(t\text{-}1851.49) = 7\overset{\mathrm{m}}{.}7 + 0\overset{\mathrm{m}}{.}025\,t$ $(\varepsilon = \pm 1.6)$

$M_r\,(t\text{-}1857.93) = 7\overset{\mathrm{m}}{.}4 + 0\overset{\mathrm{m}}{.}023\,t$ $(\varepsilon = \pm 1.1)$

$M_v\,(N) = 9\overset{\mathrm{m}}{.}0 + 0\overset{\mathrm{m}}{.}13\,(N\text{-}1)$

$M_{42}(N) = 7\overset{\mathrm{m}}{.}7 + 0\overset{\mathrm{m}}{.}16\,(N\text{-}1)$

$M_r\,(N) = 7\overset{\mathrm{m}}{.}4 + 0\overset{\mathrm{m}}{.}14\,(N\text{-}2)$

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P/Brooks 2

Table 6

n	N	Comet	T	M_v	t	r	Δ	$t-T$	M_m	M'_{42}	M_{42}	M_r
1	1	1889 V	3009	7.2	310889	1.97	0.98	−030	8.8	5.9	5.9	N
2	2	1896 VI	0411	8.0	080996	2.04	1.14	−057	10.5	7.1	7.1	7.1
					120996	2.03	1.15	−053	10.5	7.1	—	—
3	3	1903 V	0612	10.3	191003	2.00	1.45	−048	12.5	8.7	8.7	8.7
4	4	1911 I	0801	10.6	280910	2.13	1.60	−102	15.5	11.2	11.2	11.2
5	6	1925 IX	0111	10.4	081025	1.89	0.94	−024	12.0	9.4	9.4	N
6	7	1932 VIII	0910	10.2	201032	1.88	0.91	+011	10.5	8.0	8.0	8.0
7	8	1939 VII	1509	11.2	071039	1.89	0.93	+022	12.5	9.9	9.9	9.9
8	9	1946 IV	2508	11.1	151146	2.01	1.06	+082	12.6	9.4	9.4	9.4
9	10	1953 V	0708	13.7	010953	1.88	1.40	+025	16.9	13.4	13.4	13.4
10	11	1960 VI	1706	14.4	040860	2.03	1.82	+048	17.8	13.4	13.4	13.4
11	13	1974 I	0401	—	030973	2.13	1.23	−123	18.7	15.0	15.0	J

Secular brightness (Fig. 6):

$M_v\,(t\text{-}1889.75) = 7\overset{m}{.}8 + 0\overset{m}{.}080\,t$ $(\varepsilon = \pm 1.0)$

$M_{42}(t\text{-}1889.67) = 6\overset{m}{.}6 + 0\overset{m}{.}087\,t$ $(\varepsilon = \pm 1.6)$

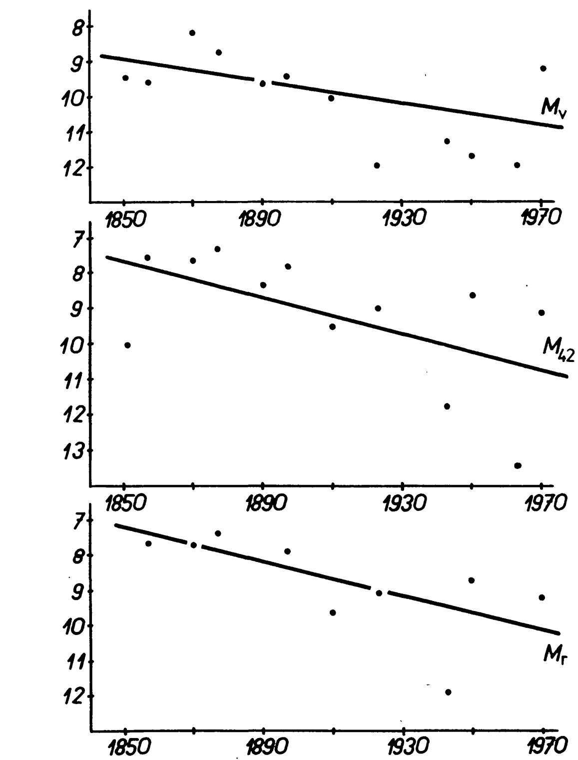
$M_r\,(t\text{-}1896.69) = 7\overset{m}{.}8 + 0\overset{m}{.}068\,t$ $(\varepsilon = \pm 1.8)$

$M_v\,(N) = 7\overset{m}{.}8 + 0\overset{m}{.}54\,(N\text{-}1)$

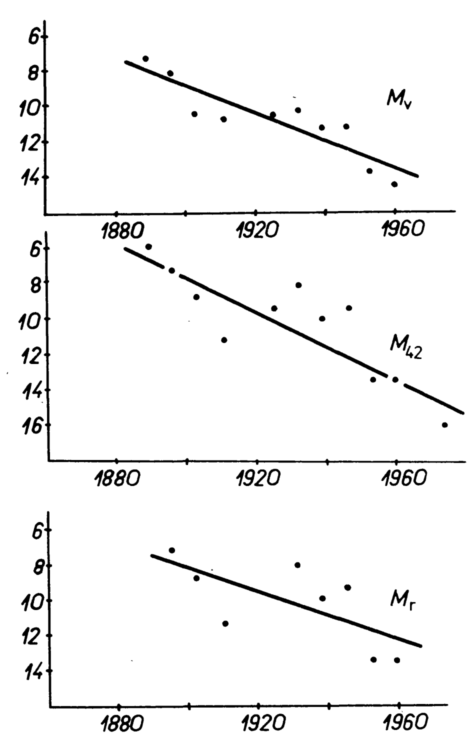
$M_{42}(N) = 6\overset{m}{.}6 + 0\overset{m}{.}58\,(N\text{-}1)$

$M_r\,(N) = 7\overset{m}{.}8 + 0\overset{m}{.}46\,(N\text{-}2)$

P/ D'ARREST



P/ BROOKS 2



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On August 31, 1889, a companion of the same brightness as the primary component ($9\overset{\mathrm{m}}{.}5$) was observed in its vicinity. For the total brightness we obtain from relation

$$m = m_1 - 2.5 \log\,[1 + 10^{-0.4\,(m_2 - m_1)}] \qquad (2)$$

a value of $m = 8\overset{\mathrm{m}}{.}8$. The companion ceased to be visible in a few days, and the brightness of the comet increased to $9\overset{\mathrm{m}}{.}0$ (Sept. 3, 1889). However, during this return the tabulated maximum brightness of August 31 remained unsurpassed.

P/Wolf

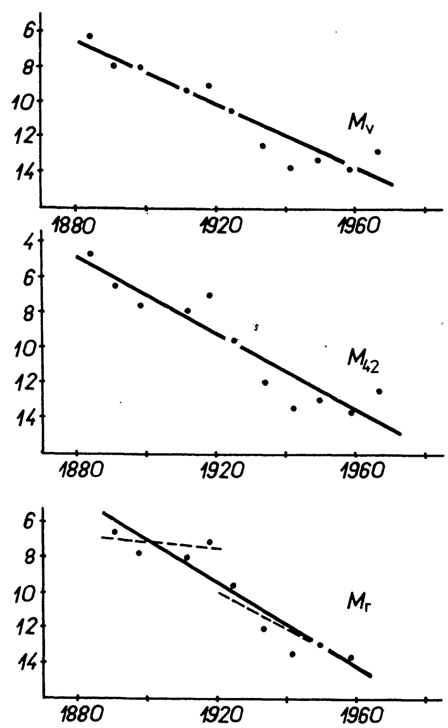
Table 7

n	N	Comet	T	M_v	t	r	Δ	$t-T$	M_m	M'_{42}	M_{42}	M_r
1	1	1884 III	1811	6.2	221084	1.67	0.82	−057	6.5	4.7	4.7	N
2	2	1891 II	0309	7.8	051191	1.72	0.83	+063	8.4	6.4	6.4	6.4
3	3	1898 IV	0507	7.8	160798	1.61	1.92	+011	11.0	7.5	7.5	7.5
4	5	1912 I	2402	9.2	160112	1.74	2.25	−039	12.0	7.8	7.8	7.8
5	6	1918 V	1312	8.9	231118	1.60	1.27	−020	9.5	6.9	6.9	6.9
6	7	1925 X	0711	10.3	280825	2.50	1.61	−071	14.5	9.5	9.5	9.5
7	8	1934 I	2702	12.4	250733	2.86	1.99	−217	18.0	11.9	11.9	11.9
8	9	1942 VI	2306	13.6	061142	2.61	1.64	+136	18.6	13.4	13.4	13.4
9	10	1950 VI	2310	13.2	021150	2.50	1.74	+010	18.0	12.9	12.9	12.9
10	11	1959 II	2103	13.7	130658	3.10	2.44	−281	20.4	13.5	13.5	13.5
11	12	1967 XII	3008	12.6	051067	2.52	1.54	+036	18.0	13.0	12.3	J
					190168	2.68	2.61	+142	18.0	11.6	—	—

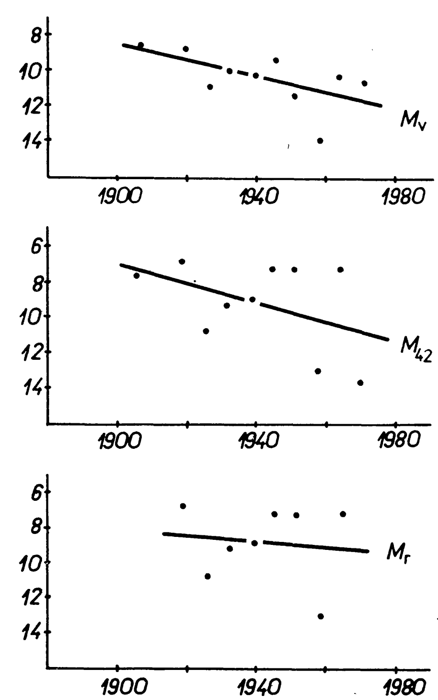
Secular brightness (Fig. 7):

$M_v\,(t\text{-}1884.88) = 6\overset{\mathrm{m}}{.}8 + 0\overset{\mathrm{m}}{.}091\,t$ ($\varepsilon = \pm 1.0$)
$M_{42}(t\text{-}1884.81) = 5\overset{\mathrm{m}}{.}3 + 0\overset{\mathrm{m}}{.}107\,t$ ($\varepsilon = \pm 1.3$)
$M_r\,(t\text{-}1891.85) = 5\overset{\mathrm{m}}{.}9 + 0\overset{\mathrm{m}}{.}120\,t$ ($\varepsilon = \pm 1.2$)
$M_v\,(N) = 6\overset{\mathrm{m}}{.}8 + 0\overset{\mathrm{m}}{.}77\,(N\text{-}1)$
$M_{42}(N) = 5\overset{\mathrm{m}}{.}3 + 0\overset{\mathrm{m}}{.}90\,(N\text{-}1)$
$M_r\,(N) = 5\overset{\mathrm{m}}{.}9 + 1\overset{\mathrm{m}}{.}01\,(N\text{-}2)$

P/ WOLF



P/ KOPFF



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A relatively large value of the secular decrease ($1^{\mathrm{m}}.01$ per revolution) is obviously due to a sudden change in the revolution period between the fifth and sixth return, being caused by a close approach to Jupiter in 1922. If we consider the data from the first to fifth return, and from the sixth return onwards, separately, we obtain the secular decrease as follows:

1—5 return	$0^{\mathrm{m}}.13$ per revolution
6—11 return	$0^{\mathrm{m}}.92$ per revolution

In Fig. 7 the trends of the secular decrease for these two periods are indicated by dashed lines. The average value is $0^{\mathrm{m}}.52$ per revolution, i.e. only one half of the original value.

P/Kopff

Table 8

n	N	Comet	T	M_v	t	r	Δ	$t-T$	M_m	M'_{42}	M_{42}	M_r
1	1	1906 IV	0305	8.4	230806	1.98	1.03	+112	10.5	7.5	7.5	N
2	3	1919 I	2806	8.6	260819	1.80	0.91	+059	9.0	6.7	6.7	6.7
3	4	1926 II	2801	10.8	130726	2.27	2.11	+166	16.0	10.8	10.7	10.7
					140926	2.60	1.75	+229	16.0	10.6	—	—
4	5	1932 III	2108	9.8	230632	1.78	0.89	−059	11.5	9.2	9.2	9.2
5	6	1939 II	1203	10.1	220439	1.72	2.07	+041	13.0	9.1	8.9	8.9
					250639	1.94	1.74	+105	13.0	8.9	—	—
					270839	2.26	1.44	+168	13.0	8.7	—	—
6	7	1945 V	1108	9.3	110845	1.49	0.84	000	8.6	7.2	7.2	7.2
7	8	1951 VII	2010	11.2	301051	1.50	2.02	+010	10.5	7.2	7.2	7.2
8	9	1958 I	2001	13.8	150858	2.46	2.06	+207	18.5	13.0	13.0	13.0
9	10	1964 III	1605	10.2	180564	1.53	1.12	+002	9.2	7.2	7.2	7.2
10	11	1970 XI	0210	10.5	270770	1.71	1.48	−067	16.8	13.6	13.6	J

Secular brightness (Fig. 8):

$M_v\,(t\text{-}1906.34) = 8^{\mathrm{m}}.7 + 0^{\mathrm{m}}.044\,t$ $(\varepsilon = \pm 1.3)$

$M_{42}(t\text{-}1906.64) = 7^{\mathrm{m}}.2 + 0^{\mathrm{m}}.056\,t$ $(\varepsilon = \pm 2.4)$

$M_r\,(t\text{-}1919.65) = 8^{\mathrm{m}}.4 + 0^{\mathrm{m}}.015\,t$ $(\varepsilon = \pm 2.3)$

$M_v\,(N) = 8^{\mathrm{m}}.7 + 0^{\mathrm{m}}.28\,(N\text{-}1)$

$M_{42}(N) = 7^{\mathrm{m}}.2 + 0^{\mathrm{m}}.36\,(N\text{-}1)$

$M_r\,(N) = 8^{\mathrm{m}}.4 + 0^{\mathrm{m}}.10\,(N\text{-}3)$

P/Giacobini—Zinner

Table 9

n	N	Comet	T	M_v	t	r	Δ	$t-T$	M_m	M'_{42}	M_{42}	M_r
1	1	1900 III	2503	10.8	201200	1.02	0.93	+270	10.5	10.6	10.6	N
2	3	1913 V	0211	10.5	181113	1.00	0.49	+016	8.5	10.0	10.0	N
3	5	1926 VI	0712	11.5	191226	1.00	1.12	+012	11.0	10.8	10.8	10.8
4	6	1933 III	1507	12.1	030733	1.03	1.24	−012	11.5	10.9	10.9	10.9
5	7	1940 I	1702	10.8	151040	1.90	2.44	+241	15.0	10.3	10.3	10.3
6	8	1946 V	1809	11.3	021046	1.02	0.29	+014	6.1	8.7	8.7	8.7
7	10	1959 VIII	2610	10.3	251059	0.94	0.41	−001	7.1	9.3	9.3	9.3
8	11	1966 I	2803	11.9	170965	2.53	3.00	−192	20.0	13.6	13.6	J
9	12	1972 VI	0408	—	110872	1.00	0.96	+007	8.8	8.9	8.9	8.9

Secular brightness (Fig. 9):

$M_v\,(t\text{-}1900.23) = 10^{\mathrm{m}}.9 + 0^{\mathrm{m}}.007\,t$ $(\varepsilon = \pm 0.7)$

$M_{42}(t\text{-}1900.97) = 10^{\mathrm{m}}.4 - 0^{\mathrm{m}}.001\,t$ $(\varepsilon = \pm 1.6)$

$M_r\,(t\text{-}1926.97) = 10^{\mathrm{m}}.7 - 0^{\mathrm{m}}.047\,t$ $(\varepsilon = \pm 0.6)$

$M_v\,(N) = 10^{\mathrm{m}}.9 + 0^{\mathrm{m}}.04\,(N\text{-}1)$

$M_{42}(N) = 10^{\mathrm{m}}.4 - 0^{\mathrm{m}}.01\,(N\text{-}1)$

$M_r\,(N) = 10^{\mathrm{m}}.7 - 0^{\mathrm{m}}.30\,(N\text{-}5)$

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P/Finlay

Table 10

n	N	Comet	T	M_v	t	r	Δ	$t-T$	M_m	M'_{42}	M_{42}	M_r
1	1	1886 VII	2211	9.2	011286	1.03	0.86	+009	8.0	8.2	8.2	N
2	2	1893 III	1207	10.1	240693	1.03	1.20	−018	8.5	8.0	8.0	8.0
3	4	1906 V	0709	9.0	270806	1.00	0.33	−011	5.0	7.4	7.4	7.4
4	6	1919 II	1510	10.9	131119	1.09	0.35	+029	8.5	10.4	10.4	N
					181119	1.12	0.33	+034	8.5	10.4	—	—
					221119	1.14	0.31	+038	8.5	10.5	—	—
5	7	1926 V	0708	12.2	070826	1.06	0.88	000	11.0	11.0	11.0	11.0
6	11	1953 VII	2512	11.6	291253	1.05	1.40	+004	10.5	9.6	9.6	9.6
7	12	1960 VIII	0109	14.0	260960	1.16	0.54	+025	11.0	11.7	11.7	11.7
8	13	1967 IX	2807	12.5	070867	1.09	1.03	+010	14.0	13.6	13.6	13.6
9	14	1974 X	0307	—	180774	1.12	1.44	+015	13.5	12.2	12.2	12.2

Secular brightness (Fig. 10):

$M_v\,(t\text{-}1886.89) = 9^{\mathrm{m}}.3 + 0^{\mathrm{m}}.048\,t$ $(\varepsilon = \pm 1.0)$

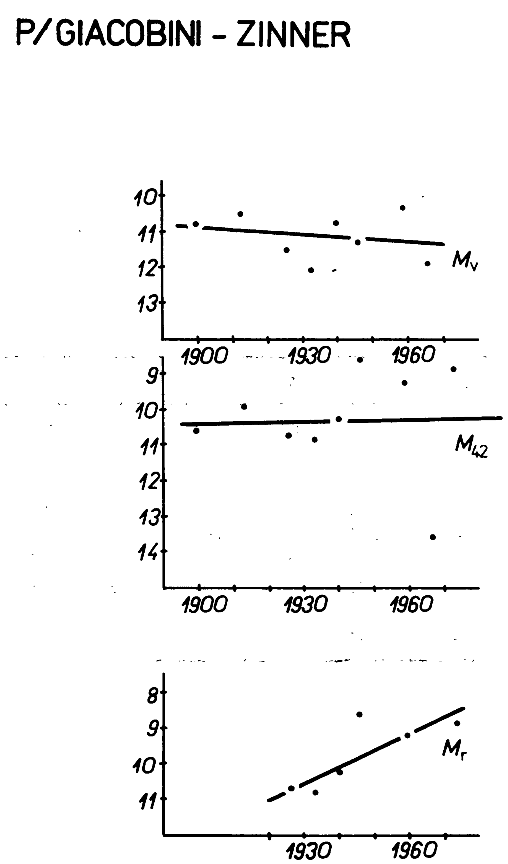
$M_{42}(t\text{-}1886.92) = 7^{\mathrm{m}}.8 + 0^{\mathrm{m}}.054\,t$ $(\varepsilon = \pm 1.2)$

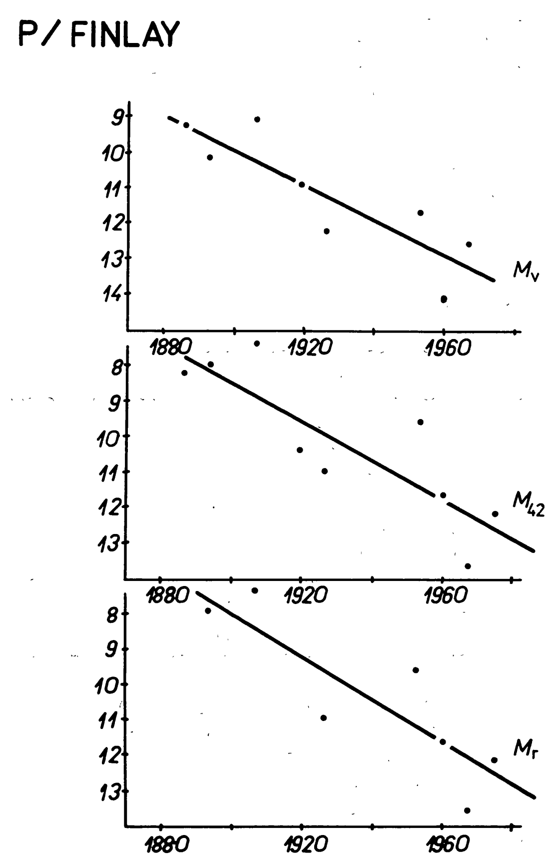
$M_r\,(t\text{-}1893.48) = 7^{\mathrm{m}}.6 + 0^{\mathrm{m}}.061\,t$ $(\varepsilon = \pm 1.3)$

$M_v\,(N) = 9^{\mathrm{m}}.3 + 0^{\mathrm{m}}.33\,(N\text{-}1)$

$M_{42}(N) = 7^{\mathrm{m}}.8 + 0^{\mathrm{m}}.37\,(N\text{-}1)$

$M_r\,(N) = 7^{\mathrm{m}}.6 + 0^{\mathrm{m}}.42\,(N\text{-}2)$





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P/Borrelly

Table 11

n	N	Comet	T	M_v	t	r	Δ	$t-T$	M_m	M'_{42}	M_{42}	M_r
1	1	1905 II	1701	9.0	080105	1.40	1.04	−009	8.8	7.3	7.3	N
2	2	1911 VIII	1812	9.5	251111	1.43	0.55	−023	8.5	8.2	8.2	8.2
3	3	1918 IV	1711	10.2	061218	1.46	0.53	+019	9.0	8.7	8.7	8.7
4	4	1925 VIII	0710	10.1	171125	1.47	1.02	+041	10.1	8.3	8.3	8.3
5	5	1932 IV	2708	9.2	280932	1.43	1.71	+032	11.0	8.3	8.2	8.2
					111032	1.49	1.68	+045	11.0	8.1	—	—
6	8	1953 IV	1106	12.5	080254	2.76	2.18	+242	18.0	11.9	11.9	11.9
7	9	1960 V	1206	12.3	050960	1.22	2.49	+085	15.0	12.2	12.2	N
8	10	1967 VIII	1706	12.5	051067	1.85	2.44	+110	16.0	11.4	11.4	11.4
9	11	1974 VII	1205	—	230175	2.86	2.61	+256	18.0	11.4	11.4	11.4

Secular brightness (Fig. 11):

$M_v(t\text{-}1905.05) = 8^{\mathrm{m}}9 + 0^{\mathrm{m}}060\,t$ ($\varepsilon = \pm 0.7$)

$M_{42}(t\text{-}1905.02) = 7^{\mathrm{m}}4 + 0^{\mathrm{m}}069\,t$ ($\varepsilon = \pm 0.8$)

$M_r(t\text{-}1911.90) = 7^{\mathrm{m}}9 + 0^{\mathrm{m}}063\,t$ ($\varepsilon = \pm 0.8$)

$M_v(N) = 8^{\mathrm{m}}9 + 0^{\mathrm{m}}42\,(N\text{-}1)$

$M_{42}(N) = 7^{\mathrm{m}}4 + 0^{\mathrm{m}}48\,(N\text{-}1)$

$M_r(N) = 7^{\mathrm{m}}9 + 0^{\mathrm{m}}44\,(N\text{-}2)$

P/Tuttle

Table 12

n	N	Comet	T	M_v	t	r	Δ	$t-T$	M_m	M'_{42}	M_{42}	M_r
1	1	1790 II	3101	7.7	100190	1.10	0.40	−021	5.5	7.1	7.1	N
2	6	1858 I	2402	7.8	270258	1.04	0.93	+003	6.5	6.5	6.5	N
3	7	1871 III	0212	8.0	011271	1.04	0.75	−001	7.5	8.0	8.0	8.0
4	8	1885 IV	1109	8.5	100885	1.14	1.90	−032	9.5	7.5	7.5	7.5
5	9	1899 III	0505	8.5	050499	1.13	1.75	−030	10.0	8.3	8.2	8.2
					140499	1.08	1.74	−021	10.0	8.5	—	—
					290699	1.28	1.79	+055	10.0	7.7	—	—
6	10	1912 IV	2910	8.6	091112	1.05	1.22	+011	7.0	6.4	6.4	N
7	11	1926 IV	2704	10.6	120426	1.07	1.67	−015	12.0	10.6	10.6	10.6
8	12	1939 X	1011	11.4	111139	1.02	1.03	+001	8.5	8.3	8.3	8.3
9	14	1967 V	3103	10.0	030467	1.03	1.36	+003	9.0	8.2	8.2	8.2

Secular brightness (Fig. 12):

$M_v(t\text{-}1790.08) = 6^{\mathrm{m}}9 + 0^{\mathrm{m}}020\,t$ ($\varepsilon = \pm 0.9$)

$M_{42}(t\text{-}1790.03) = 6^{\mathrm{m}}7 + 0^{\mathrm{m}}011\,t$ ($\varepsilon = \pm 1.2$)

$M_r(t\text{-}1871.92) = 8^{\mathrm{m}}1 + 0^{\mathrm{m}}009\,t$ ($\varepsilon = \pm 1.2$)

$M_v(N) = 6^{\mathrm{m}}9 + 0^{\mathrm{m}}28\,(N\text{-}1)$

$M_{42}(N) = 6^{\mathrm{m}}7 + 0^{\mathrm{m}}15\,(N\text{-}1)$

$M_r(N) = 8^{\mathrm{m}}1 + 0^{\mathrm{m}}12\,(N\text{-}7)$

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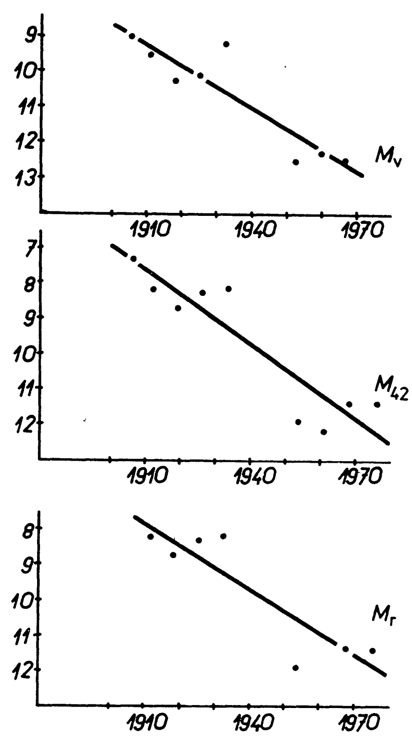
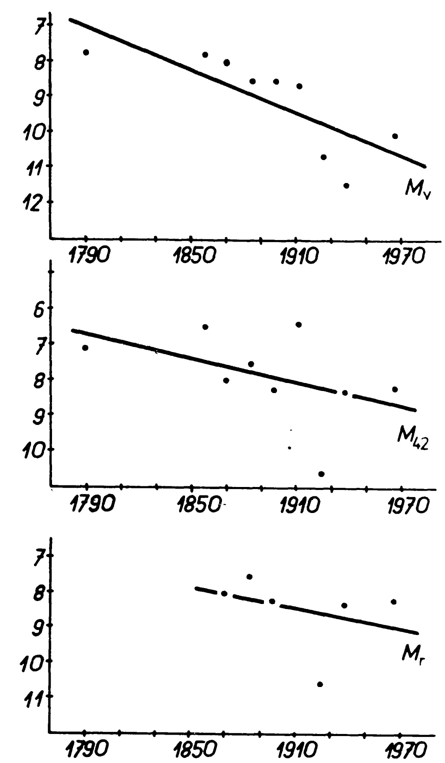
P/ BORRELLY



P/ TUTTLE



P/Schwassmann—Wachmann 2

Table 13

n	N	Comet	T	M_v	t	r	Δ	$t-T$	M_m	M'_{42}	M_{42}	M_r
1	1	1929 I	2303	8.0	310129	2.14	1.33	−051	10.8	6.9	6.9	N
2	2	1935 III	2804	9.9	310135	2.57	2.51	−087	14.0	7.9	8.4	8.4
					140435	2.53	1.61	−014	14.0	8.9	—	—
3	3	1942 I	1302	8.9	100142	2.16	1.21	−034	11.0	7.2	7.2	7.2
4	4	1948 VII	2308	10.5	051048	2.17	2.89	+043	15.0	9.3	9.4	9.4
					020449	2.64	1.75	+222	15.0	9.6	—	—
5	5	1955 I	2702	10.0	270255	2.15	1.37	000	12.5	8.5	8.5	8.5
6	6	1961 VII	0509	10.6	010362	2.44	1.70	+177	14.4	9.4	9.4	9.4
7	7	1968 II	1403	10.1	170268	2.16	1.44	−026	13.0	8.9	8.9	8.9
8	8	1974 XIII	1209	—	270375	2.54	1.55	+196	13.0	8.0	8.0	8.0

Secular brightness (Fig. 13):

$M_v\,(t\text{-}1929.22) = 8^m.8 + 0^m.048\,t$ $(\varepsilon = \pm 0.7)$

$M_{42}(t\text{-}1929.08) = 7^m.7 + 0^m.029\,t$ $(\varepsilon = \pm 0.9)$

$M_r\,(t\text{-}1935.18) = 8^m.3 + 0^m.012\,t$ $(\varepsilon = \pm 0.8)$

$M_v\,(N) = 8^m.8 + 0^m.31\,(N\text{-}1)$

$M_{42}(N) = 7^m.7 + 0^m.19\,(N\text{-}1)$

$M_r\,(N) = 8^m.3 + 0^m.08\,(N\text{-}2)$

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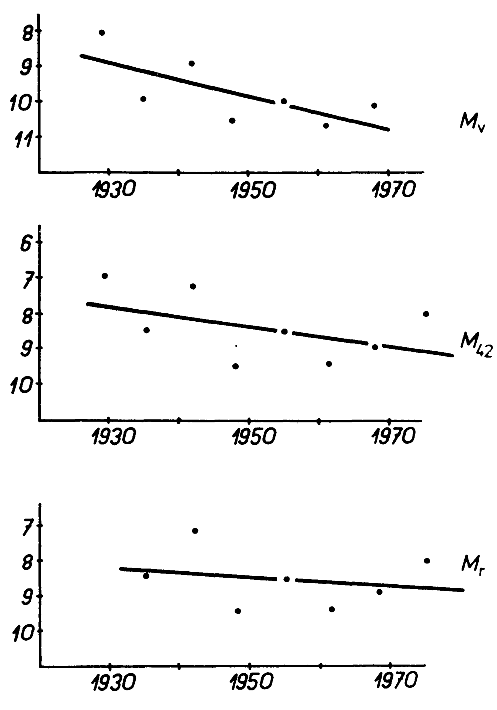
P/Biela

Table 14

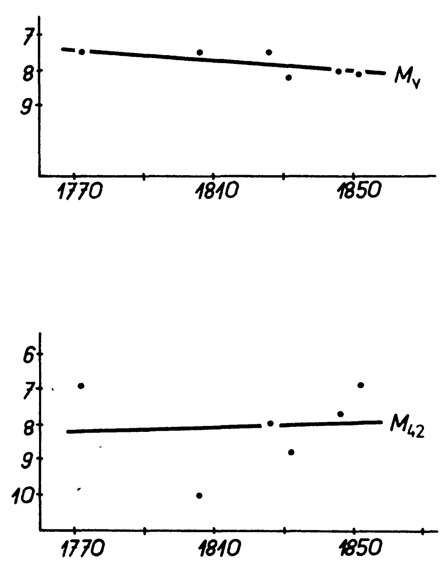
n	N	Comet	T	M_v	t	r	Δ	$t-T$	M_m	M'_{42}	M_{42}	M_r
1	1	1772	1702	7.5	080372	1.03	0.62	+020	6.0	6.9	6.9	N
2	6	1806 I	0201	7.5	081205	0.99	0.04	−026	3.0	10.0	10.0	N
3	9	1826 I	1803	7.5	140326	0.92	0.38	−004	5.5	8.0	8.0	N
4	10	1832 III	2611	8.2	201032	1.06	0.56	−037	7.5	8.5	8.8	8.8
					061132	0.94	0.58	−020	7.5	9.0	—	—
5	12	1846 II	1102	8.0	260246	0.89	0.46	+015	5.5	7.7	7.7	N
6	13	1852 III	2409	8.1	260852	0.96	1.44	−029	7.5	6.9	6.9	N

Secular brightness (Fig. 14):
$M_v\,(t\text{-}1772.13) = 7\overset{m}{.}4 + 0\overset{m}{.}008\,t$ ($\varepsilon = \pm 0.3$)
$M_{42}(t\text{-}1772.19) = 8\overset{m}{.}2 - 0\overset{m}{.}002\,t$ ($\varepsilon = \pm 1.3$)
$M_v\,(N) = 7\overset{m}{.}4 + 0\overset{m}{.}05\,(N\text{-}1)$
$M_{42}(N) = 8\overset{m}{.}2 - 0\overset{m}{.}01\,(N\text{-}1)$

P/SCHWASSMAN-WACHMANN 2



P/BIELA



This is the well-known periodic comet which splitted into two parts and vanished one revolution later. During the sixth return (September 20, 1852), the same brightness of $8\overset{m}{.}5$ was estimated for both the northern and southern component; assuming (2) we obtain $7\overset{m}{.}75$. In Table 14 the value $7\overset{m}{.}5$ attained by the north component on August 26, 1852 is listed. No brightness estimate of the southern component is available for this date.

The secular decrease of M_r was not calculated, because the comet was recovered according to an ephemeris in one return only.

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P/Whipple

Table 15

n	N	Comet	T	M_v	t	r	Δ	$t-T$	M_m	M'_{42}	M_{42}	M_r
1	1	1933 V	0108	8.0	211033	2.55	1.63	+081	13.0	7.9	7.9	N
					091133	2.58	1.61	+100	13.0	7.8	—	—
2	2	1941 III	2201	9.6	040940	2.64	1.66	−140	14.5	9.2	9.2	9.2
3	3	1948 VI	2506	10.0	040948	2.49	2.13	+071	14.0	8.4	8.5	8.5
					011048	2.53	1.88	+098	14.0	8.6	—	—
4	4	1955 VIII	2911	10.4	121155	2.45	1.76	−017	13.0	7.9	7.9	7.9
5	5	1963 II	2904	12.4	141263	2.86	1.91	+229	17.8	11.8	11.8	11.8
6	6	1970 XIV	0910	11.4	221070	2.48	1.50	+013	16.0	11.2	11.2	11.2

Secular brightness (Fig. 15):

$M_v\,(t\text{-}1933.58) = 8\overset{m}{.}5 + 0\overset{m}{.}099\,t$ $(\varepsilon = \pm 0.7)$

$M_{42}(t\text{-}1933.83) = 7\overset{m}{.}7 + 0\overset{m}{.}091\,t$ $(\varepsilon = \pm 1.2)$

$M_r\,(t\text{-}1940.68) = 8\overset{m}{.}2 + 0\overset{m}{.}097\,t$ $(\varepsilon = \pm 1.4)$

$M_v\,(N) = 8\overset{m}{.}5 + 0\overset{m}{.}74\,(N\text{-}1)$

$M_{42}(N) = 7\overset{m}{.}7 + 0\overset{m}{.}68\,(N\text{-}1)$

$M_r\,(N) = 8\overset{m}{.}2 + 0\overset{m}{.}72\,(N\text{-}2)$

P/Reinmuth 1

Table 16

n	N	Comet	T	M_v	t	r	Δ	$t-T$	M_m	M'_{42}	M_{42}	M_r
1	1	1928 I	3101	10.0	260228	1.88	0.92	+026	12.0	9.4	9.4	N
2	2	1935 II	2904	11.5	260235	1.96	1.56	−062	15.0	11.1	11.1	11.1
3	4	1950 IV	2307	12.4	291149	2.62	1.86	−236	17.6	12.1	12.1	12.1
4	5	1958 II	2503	13.9	181257	2.18	1.24	−097	17.0	13.1	13.1	13.1
5	6	1965 V	0708	13.0	240165	2.54	2.28	−195	18.0	12.2	12.2	12.2
6	7	1973 IV	2103	—	090173	2.08	1.12	−071	17.0	13.6	13.6	13.6

Secular brightness (Fig. 16):

$M_v\,(t\text{-}1928.08) = 10\overset{m}{.}5 + 0\overset{m}{.}087\,t$ $(\varepsilon = \pm 0.7)$

$M_{42}(t\text{-}1928.16) = 10\overset{m}{.}1 + 0\overset{m}{.}080\,t$ $(\varepsilon = \pm 0.7)$

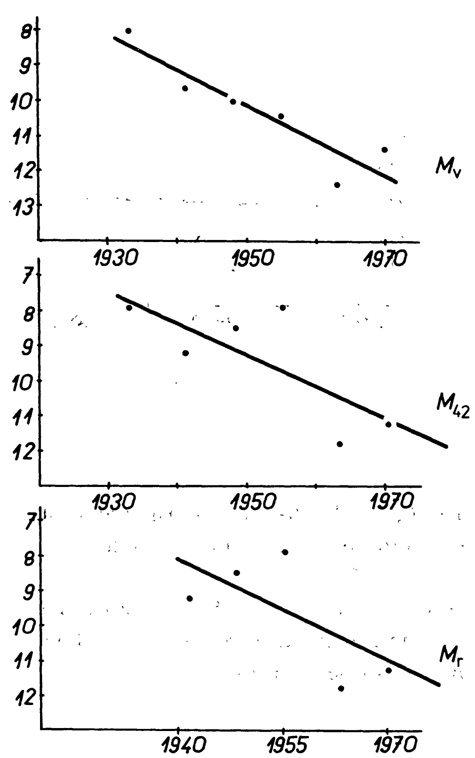
$M_r\,(t\text{-}1935.16) = 11\overset{m}{.}2 + 0\overset{m}{.}058\,t$ $(\varepsilon = \pm 0.6)$

$M_v\,(N) = 10\overset{m}{.}5 + 0\overset{m}{.}66\,(N\text{-}1)$

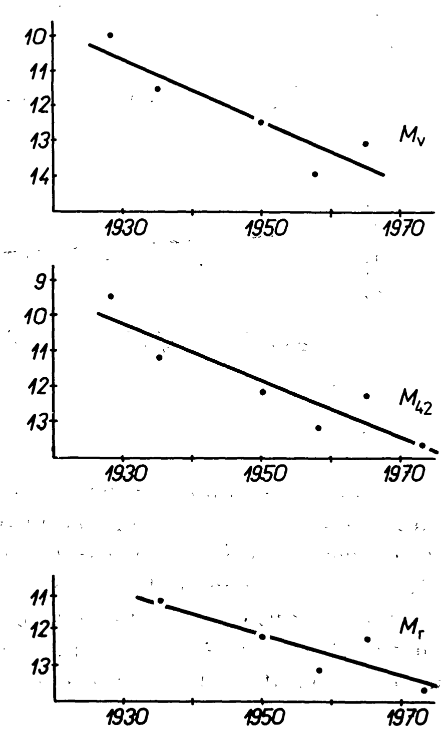
$M_{42}(N) = 10\overset{m}{.}1 + 0\overset{m}{.}61\,(N\text{-}1)$

$M_r\,(N) = 11\overset{m}{.}2 + 0\overset{m}{.}44\,(N\text{-}2)$

P/ WHIPPLE



P/ REINMUTH 1



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P/Schaumasse

Table 17

n	N	Comet	T	M_v	t	r	Δ	$t-T$	M_m	M'_{42}	M_{42}	M_r
1	1	1911 VII	1311	10.3	071211	1.28	1.66	+024	10.5	8.3	8.3	N
2	2	1919 IV	2010	10.9	291019	1.18	1.55	+009	10.5	8.8	8.8	8.8
3	3	1927 VIII	0110	10.5	041027	1.18	1.99	+003	12.0	9.8	9.8	9.8
4	5	1943 V	2511	12.0	240344	1.92	1.26	+120	15.0	11.7	11.7	N
5	6	1952 III	1002	9.6	010252	1.21	0.27	−009	4.9	6.9	6.9	6.9
6	7	1960 III	1704	12.0	260460	1.22	1.29	+009	10.0	8.6	8.6	8.6

Secular brightness (Fig. 17):

$M_v\,(t\text{-}1911.87) = 10^{m}.5 + 0^{m}.018\,t$ ($\varepsilon = \pm 1.0$)

$M_{42}(t\text{-}1911.93) = 9^{m}.1 - 0^{m}.004\,t$ ($\varepsilon = \pm 1.8$)

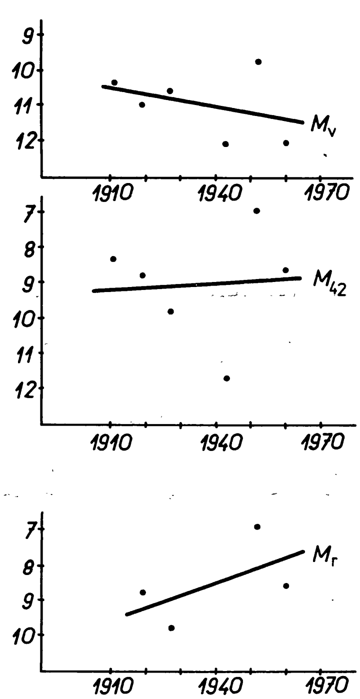
$M_r\,(t\text{-}1919.83) = 9^{m}.2 - 0^{m}.035\,t$ ($\varepsilon = \pm 1.2$)

$M_v\,(N) = 10^{m}.5 + 0^{m}.15\,(N\text{-}1)$

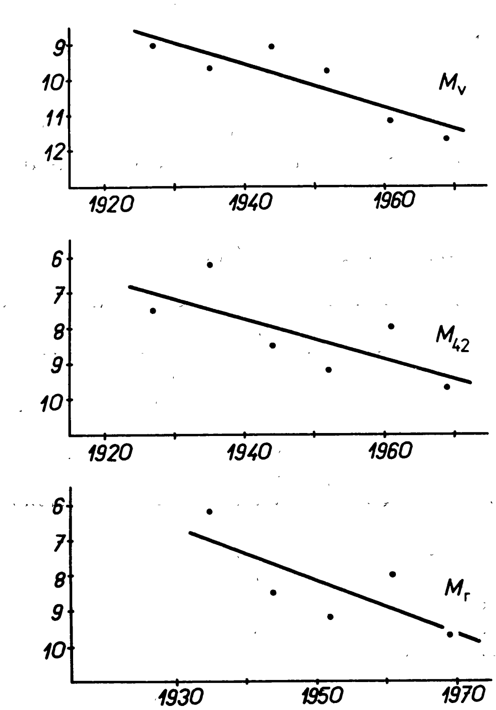
$M_{42}(N) = 9^{m}.1 - 0^{m}.03\,(N\text{-}1)$

$M_r\,(N) = 9^{m}.2 - 0^{m}.29\,(N\text{-}2)$

P/ SCHAUMASSE



P/ COMAS SOLÁ



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P/Comas Solá

Table 18

n	N	Comet	T	M_v	t	r	Δ	$t-T$	M_m	M'_{42}	M_{42}	M_r
1	1	1927 III	2203	9.0	100626	2.17	1.34	−132	11.5	7.5	7.5	N
2	2	1935 IV	0810	9.6	090436	2.70	2.43	+184	12.5	6.2	6.2	6.2
3	3	1944 II	1104	9.0	120244	1.86	1.75	−059	12.5	8.6	8.5	8.5
					240244	1.83	1.83	−047	12.5	8.5	—	—
					240444	1.78	2.23	+013	12.5	8.3	—	—
4	4	1952 VII	1009	9.7	161052	1.81	2.18	+036	13.5	9.2	9.2	9.2
					181052	1.81	2.16	+038	13.5	9.3	—	—
					141152	1.88	2.02	+065	13.5	9.2	—	—
					211252	2.02	1.81	+102	13.5	9.2	—	—
5	5	1961 III	0404	11.1	231160	2.18	1.33	−132	12.0	8.0	8.0	8.0
6	6	1969 VIII	2910	11.6	151169	1.78	1.53	+017	13.0	9.6	9.7	9.7
					191269	1.84	1.31	+051	13.0	9.8	—	—
					020270	2.00	1.14	+096	13.0	9.7	—	—

Secular brightness (Fig. 18):

$M_v\,(t\text{-}1927.22) = 8^{m}7 + 0^{m}061\,t$ $(\varepsilon = \pm 0.6)$

$M_{42}(t\text{-}1926.42) = 6^{m}9 + 0^{m}056\,t$ $(\varepsilon = \pm 1.0)$

$M_r\,(t\text{-}1936.27) = 7^{m}0 + 0^{m}077\,t$ $(\varepsilon = \pm 1.0)$

$M_v\,(N) = 8^{m}7 + 0^{m}52\,(N\text{-}1)$

$M_{42}(N) = 6^{m}9 + 0^{m}48\,(N\text{-}1)$

$M_r\,(N) = 7^{m}0 + 0^{m}66\,(N\text{-}2)$

P/Crommelin

Table 19

n	N	Comet	T	M_v	t	r	Δ	$t-T$	M_m	M'_{42}	M_{42}	M_r
1	1	1457 I	2401	6.2	140157	0.71	0.74	−010	3.0	5.1	5.1	N
2	7	1625	3001	5.2	260125	0.74	0.54	−004	2.5	5.1	5.1	N
3	14	1818 I	0602	9.0	240218	0.80	0.53	+018	7.5	9.8	9.8	N
4	16	1873 VII	0212	11.6	161173	0.78	0.25	−016	7.0	11.1	11.1	N
5	18	1928 IV	0411	9.5	241128	0.83	0.98	+020	7.0	7.9	7.9	N
6	19	1956 VI	2510	10.7	271156	1.23	0.98	+033	7.3	6.4	6.4	N

Secular brightness (Fig. 19):

$M_v\,(t\text{-}1457.07) = 5^{m}2 + 0^{m}011\,t$ $(\varepsilon = \pm 1.5)$

$M_{42}(t\text{-}1457.04) = 5^{m}2 + 0^{m}008\,t$ $(\varepsilon = \pm 2.3)$

$M_v\,(N) = 5^{m}2 + 0^{m}31\,(N\text{-}1)$

$M_{42}(N) = 5^{m}2 + 0^{m}22\,(N\text{-}1)$

The secular variation of M_r was not calculated — in all returns the comet had been discovered independently.

P/Honda—Mrkos—Pajdušáková

Table 20

n	N	Comet	T	M_v	t	r	Δ	$t-T$	M_m	M'_{42}	M_{42}	M_r
1	1	1948 XII	1711	12.0	071248	0.69	0.60	+020	8.0	10.7	10.7	N
2	2	1954 III	0502	12.1	280254	0.73	0.69	+023	8.9	11.1	11.1	11.1
3	4	1964 VII	0806	14.5	140664	0.74	1.28	+006	14.0	14.8	14.8	14.8
4	5	1969 V	2309	11.6	210969	0.57	0.81	−002	8.1	11.0	11.0	11.0
5	6	1974 XVI	2812	—	020175	0.60	0.56	+005	6.0	9.5	9.5	9.5

Secular brightness (Fig. 20):

$M_v\,(t\text{-}1948.88) = 12^{m}2 + 0^{m}030\,t$ $(\varepsilon = \pm 1.6)$

$M_{42}(t\text{-}1948.93) = 11^{m}7 - 0^{m}017\,t$ $(\varepsilon = \pm 2.3)$

$M_r\,(t\text{-}1954.16) = 12^{m}6 - 0^{m}085\,t$ $(\varepsilon = \pm 2.6)$

$M_v\,(N) = 12^{m}2 + 0^{m}16\,(N\text{-}1)$

$M_{42}(N) = 11^{m}7 - 0^{m}09\,(N\text{-}1)$

$M_r\,(N) = 12^{m}6 - 0^{m}44\,(N\text{-}2)$

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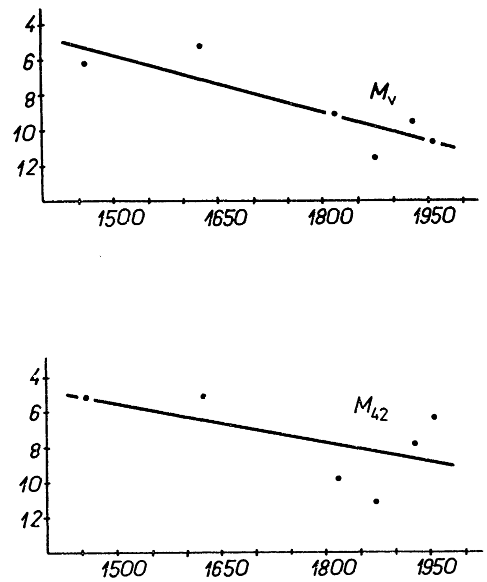
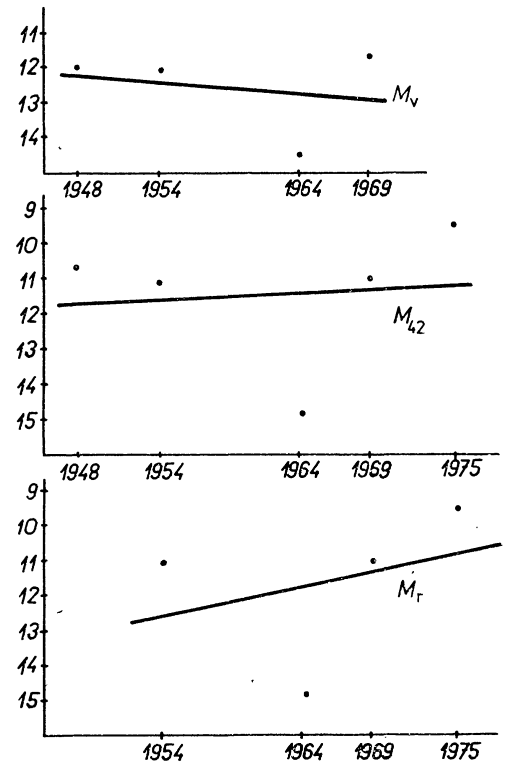
P/ CROMMELIN



P/HONDA-MRKOS-PAJDUŠÁKOVÁ



P/Brorsen

Table 21

n	N	Comet	T	M_v	t	r	Δ	$t-T$	M_m	M'_{42}	M_{42}	M_r
1	1	1846 III	2502	7.7	160346	0.76	0.56	+019	6.0	8.5	8.5	N
2	3	1857 II	2903	7.7	180357	0.65	1.10	−011	5.5	7.2	7.2	N
					200457	0.75	0.80	+022	5.5	7.2	—	—
3	5	1868 I	1704	9.0	110568	0.76	0.98	+024	7.0	8.2	8.2	8.2
4	6	1873 VI	1010	9.2	190973	0.73	1.02	−021	7.5	8.8	9.1	9.1
					031073	0.61	1.13	−007	7.5	9.4	—	—
5	7	1879 I	3103	9.3	140479	0.66	0.85	+014	7.0	9.1	9.1	9.1

Secular brightness (Fig. 21):

$M_v\,(t\text{-}1846.15) = 7^{\rm m}.5 + 0^{\rm m}.057\,t$ $(\varepsilon = \pm 0.3)$

$M_{42}(t\text{-}1846.21) = 7^{\rm m}.8 + 0^{\rm m}.032\,t$ $(\varepsilon = \pm 0.8)$

$M_r\,(t\text{-}1868.36) = 8^{\rm m}.4 + 0^{\rm m}.082\,t$ $(\varepsilon = \pm 0.4)$

$M_v\,(N) = 7^{\rm m}.5 + 0^{\rm m}.31\,(N\text{-}1)$

$M_{42}(N) = 7^{\rm m}.8 + 0^{\rm m}.18\,(N\text{-}1)$

$M_r\,(N) = 8^{\rm m}.4 + 0^{\rm m}.45\,(N\text{-}5)$

P/Tuttle—Giacobini—Kresák

Table 22

n	N	Comet	T	M_v	t	r	Δ	$t-T$	M_m	M'_{42}	M_{42}	M_r
1	1	1858 III	0305	11.3	020558	1.14	0.35	−001	9.5	11.2	11.2	N
2	10	1907 III	2805	12.3	010607	1.15	0.98	+004	13.0	12.4	12.4	N
					040607	1.15	0.98	+007	13.0	12.4	—	—
3	18	1951 IV	0905	12.0	120551	1.13	0.50	+003	9.7	10.7	10.7	N
4	20	1962 V	2304	13.9	010562	1.13	0.28	+008	9.5	11.7	11.7	11.7
5	22	1973 VI	2905	—	270573	1.16	0.85	−002	4.0	3.7	3.7	3.7

Secular brightness (Fig. 22):

$M_v\,(t\text{-}1858.34) = 11^{\rm m}.3 + 0^{\rm m}.018\,t$ $(\varepsilon = \pm 0.9)$

$M_{42}(t\text{-}1858.33) = 12^{\rm m}.7 - 0^{\rm m}.038\,t$ $(\varepsilon = \pm 3.5)$

$M_r\,(t\text{-}1962.33) = 11^{\rm m}.7 - 0^{\rm m}.723\,t$ $(\varepsilon = 0.0)$

$M_v\,(N) = 11^{\rm m}.3 + 0^{\rm m}.10\,(N\text{-}1)$

$M_{42}(N) = 12^{\rm m}.7 - 0^{\rm m}.21\,(N-1)$

$M_r\,(N) = 11^{\rm m}.7 - 4^{\rm m}.00\,(N\text{-}20)$

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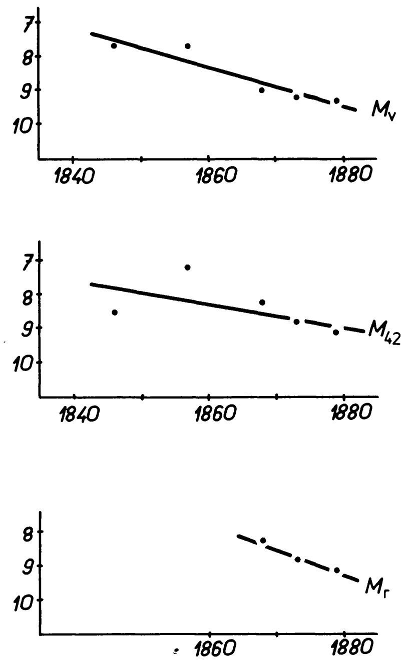
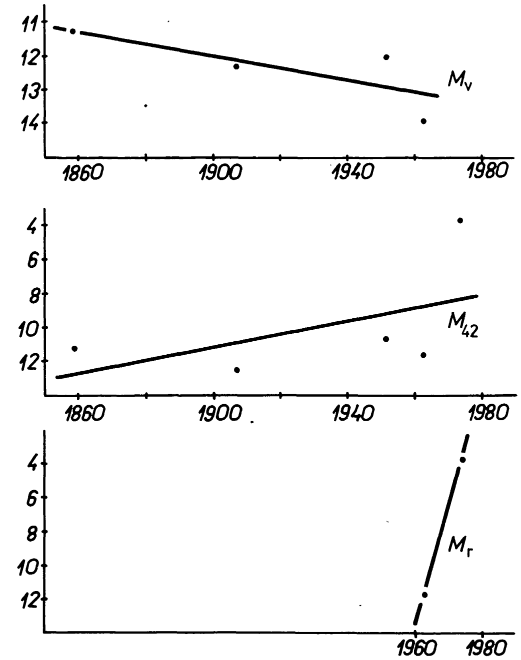
P/ BRORSEN



P/TUTTLE-GIACOBINI-KRESÁK



P/Tempel 1

Table 23

n	N	Comet	T	M_v	t	r	Δ	$t-T$	M_m	M'_{42}	M_{42}	M_r
1	1	1867 II	2405	8.4	030467	1.62	0.71	−051	9.0	7.6	7.9	N
					030567	1.58	0.57	−021	9.0	8.2	—	—
2	2	1873 I	1005	9.2	300573	1.78	0.78	+020	10.0	8.0	8.0	8.0
3	3	1879 III	0705	10.4	240479	1.77	0.88	−014	10.5	8.3	8.4	8.4
					190579	1.77	0.78	+012	10.5	8.6	—	—
4	17	1966 VII	1201	—	080667	2.05	1.92	+147	18.2	13.7	13.7	13.7
5	18	1972 V	1507	—	200472	1.72	0.81	−086	12.0	10.1	10.3	10.3
					100572	1.64	0.82	−066	12.0	10.3	—	—
					150572	1.62	0.83	−061	12.0	10.3	—	—
					310572	1.57	0.87	−045	12.0	10.3	—	—

Secular brightness (Fig. 23):

$M_v\,(t\text{-}1867.39) = 8^m.3 + 0^m.167\,t$ $(\varepsilon = \pm 0.2)$

$M_{42}(t\text{-}1867.30) = 7^m.9 + 0^m.040\,t$ $(\varepsilon = \pm 1.5)$

$M_r\,(t\text{-}1873.41) = 8^m.1 + 0^m.040\,t$ $(\varepsilon = \pm 1.8)$

$M_v\,(N) = 8^m.3 + 0^m.92\,(N\text{-}1)$

$M_{42}(N) = 7^m.9 + 0^m.22\,(N\text{-}1)$

$M_r\,(N) = 8^m.1 + 0^m.22\,(N\text{-}2)$

For the fourth return, the year of the perihelion passage disagrees with the definitive designation. The recovery was first announced as uncertain, and confirmed until after the comets having passed perihelion in 1967 have got definitive designations. In order to need not change these, P/Tempel 1 was added as the last one of year 1966, though it passaged the perihelion on January 12, 1967.

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P/Forbes

Table 24

n	N	Comet	T	M_v	t	r	Δ	$t-T$	M_m	M'_{42}	M_{42}	M_r
1	1	1929 II	2606	10.5	010829	1.56	0.57	+036	10.0	9.3	9.3	N
2	3	1942 III	1604	12.7	050642	1.63	1.46	+050	14.5	11.6	11.6	11.6
3	4	1948 VIII	1609	13.0	020948	1.55	1.42	−014	14.5	11.8	11.8	11.8
4	6	1961 VI	2407	13.6	080761	1.56	0.60	−016	10.0	9.2	9.2	9.2
5	8	1974 IX	1905	—	170774	1.65	0.88	+059	12.6	10.7	10.7	10.7
					210774	1.66	0.87	+063	12.6	10.7	—	—
					220774	1.66	0.87	+064	12.6	10.7	—	—

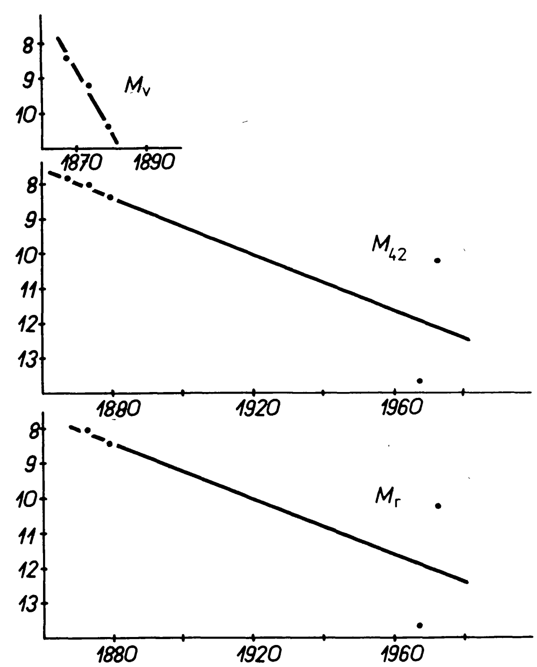
Secular brightness (Fig. 24):

$M_v\,(t\text{-}1929.48) = 10^{m}.9 + 0^{m}.095\,t$ ($\varepsilon = \pm 0.6$) $M_v\,(N) = 10^{m}.9 + 0^{m}.61\,(N\text{-}1)$

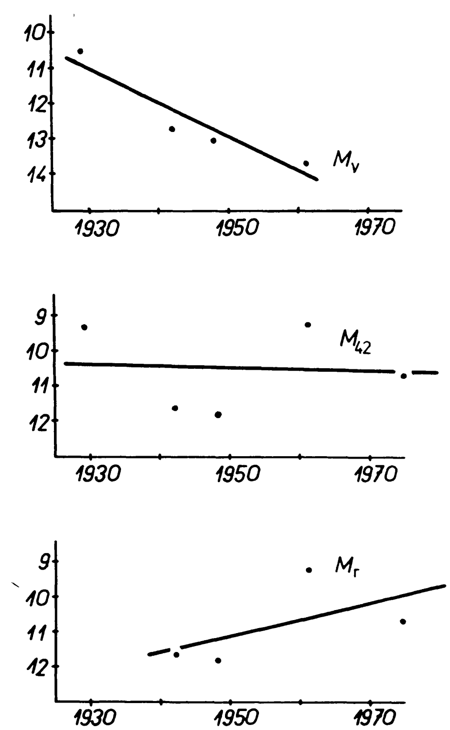
$M_{42}(t\text{-}1929.58) = 10^{m}.4 + 0^{m}.004\,t$ ($\varepsilon = \pm 1.4$) $M_{42}(N) = 10^{m}.4 + 0^{m}.03\,(N\text{-}1)$

$M_r\,(t\text{-}1942.43) = 11^{m}.5 - 0^{m}.047\,t$ ($\varepsilon = \pm 1.2$) $M_r\,(N) = 11^{m}.5 - 0^{m}.30\,(N\text{-}3)$

P/ TEMPEL 1



P/ FORBES



P/Wolf—Harrington

Table 25

n	N	Comet	T	M_v	t	r	Δ	$t-T$	M_m	M'_{42}	M_{42}	M_r
1	1	1925 I	0301	11.4	261224	2.43	1.48	−008	15.0	10.3	10.3	N
2	5	1952 II	0602	10.8	090152	1.62	1.13	−028	11.0	8.6	8.6	N
3	6	1958 V	1108	13.5	140958	1.64	2.14	+034	16.2	12.4	12.4	12.4
4	7	1965 III	1502	12.5	081164	1.88	1.02	−099	15.0	12.2	12.2	12.2
5	8	1971 VI	0109	—	151071	1.68	1.87	+044	15.0	11.4	11.4	11.4

Secular brightness (Fig. 25):

$M_v\,(t\text{-}1925.01) = 11^{m}.2 + 0^{m}.035\,t$ ($\varepsilon = \pm 1.3$) $M_v\,(N) = 11^{m}.2 + 0^{m}.23\,(N\text{-}1)$

$M_{42}(t\text{-}1924.99) = 9^{m}.8 + 0^{m}.040\,t$ ($\varepsilon = \pm 1.6$) $M_{42}(N) = 9^{m}.8 + 0^{m}.26\,(N\text{-}1)$

$M_r\,(t\text{-}1958.70) = 12^{m}.5 - 0^{m}.077\,t$ ($\varepsilon = \pm 0.2$) $M_r\,(N) = 12^{m}.5 - 0^{m}.50\,(N\text{-}6)$

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P/Wirtanen

Table 26

n	N	Comet	T	M_v	t	r	Δ	$t-T$	M_m	M'_{42}	M_{42}	M_r
1	1	1947 XIII	0312	14.4	170148	1.71	0.87	+045	16.0	14.0	14.0	N
2	2	1954 XI	1308	14.7	080954	1.65	2.13	+026	18.0	14.2	14.2	14.2
3	3	1961 IV	1504	15.3	150261	1.74	2.24	−059	18.0	13.8	13.9	13.9
					090361	1.66	2.31	−037	18.0	14.0	—	—
4	4	1967 XIV	1512	14.3	241167	1.63	0.66	−021	14.8	13.6	13.6	13.6
5	5	1974 XI	0507	—	201274	2.19	2.32	+168	21.5	16.3	16.3	J

Secular brightness (Fig. 26):

$M_v\,(t\text{-}1947.92) = 14^m.6 + 0^m.005\,t$ ($\varepsilon = \pm 0.5$)

$M_{42}(t\text{-}1948.05) = 13^m.6 + 0^m.061\,t$ ($\varepsilon = \pm 1.0$)

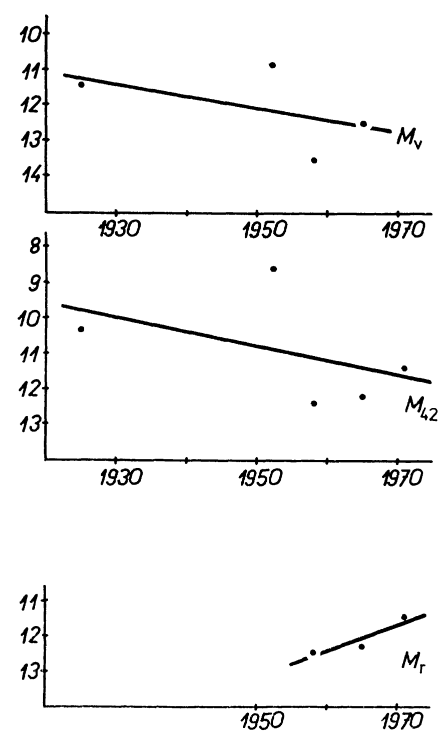
$M_r\,(t\text{-}1954.69) = 14^m.2 - 0^m.045\,t$ ($\varepsilon =$ 0.0)

$M_v\,(N) = 14^m.6 + 0^m.03\,(N\text{-}1)$

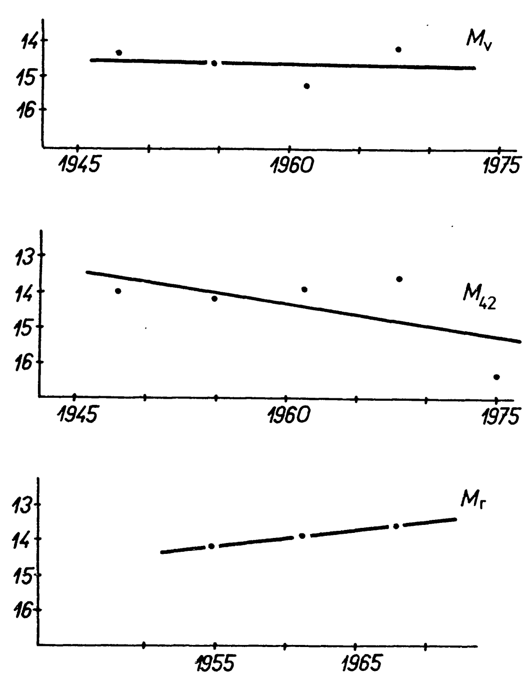
$M_{42}(N) = 13^m.6 + 0^m.41\,(N\text{-}1)$

$M_r\,(N) = 14^m.2 - 0^m.30\,(N\text{-}2)$

P/ WOLF - HARRINGTON



P/ WIRTANEN



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P/Perrine—Mrkos Table 27

n	N	Comet	T	M_v	t	r	Δ	$t-T$	M_m	M'_{42}	M_{42}	M_r
1	1	1896 VII	2511	9.9	081296	1.12	0.27	+013	8.0	10.4	10.4	N
2	3	1909 III	0111	13.3	150909	1.31	0.49	−047	12.5	12.9	12.9	12.9
3	10	1955 VII	2709	11.5	191055	1.19	0.89	+022	9.0	8.5	8.5	N
4	11	1962 I	1102	15.5	040362	1.31	1.76	+021	17.5	15.1	15.1	15.1
5	12	1968 VIII	0211	15.6	151268	1.38	0.42	+043	12.0	12.5	12.5	12.5

Secular brightness (Fig. 27):

$M_v\,(t\text{-}1896.90) = 10\overset{m}{.}9 + 0\overset{m}{.}054\,t$ ($\varepsilon = \pm 2.0$) $M_v\,(N) = 10\overset{m}{.}9 + 0\overset{m}{.}36\,(N\text{-}1)$

$M_{42}(t\text{-}1896.94) = 11\overset{m}{.}2 + 0\overset{m}{.}016\,t$ ($\varepsilon = \pm 2.8$) $M_{42}(N) = 11\overset{m}{.}2 + 0\overset{m}{.}11\,(N-1)$

$M_r\,(t\text{-}1909.71) = 13\overset{m}{.}1 + 0\overset{m}{.}012\,t$ ($\varepsilon = \pm 1.9$) $M_r\,(N) = 13\overset{m}{.}1 + 0\overset{m}{.}08\,(N\text{-}3)$

P/Reinmuth 2 Table 28

n	N	Comet	T	M_v	t	r	Δ	$t-T$	M_m	M'_{42}	M_{42}	M_r
1	1	1947 VII	1908	10.9	100947	1.87	0.87	+022	12.5	10.1	10.1	N
2	2	1954 VI	2703	12.2	031053	2.37	2.63	−175	17.5	11.7	11.7	11.7
3	3	1960 IX	2411	14.2	170860	1.90	1.09	−099	17.6	14.6	14.4	14.4
					260960	1.88	1.30	−059	17.6	14.3	—	—
4	4	1967 XI	1808	11.7	061167	2.05	1.26	+080	13.0	9.4	9.4	9.4
5	5	1974 VI	0805	–	111174	2.44	1.47	+187	15.0	10.3	10.3	10.3
					141174	2.45	1.48	+190	15.0	10.3	—	—

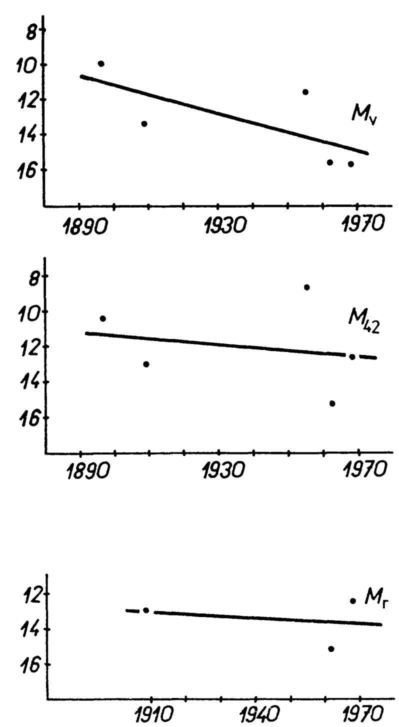
Secular brightness (Fig. 28):

$M_v\,(t\text{-}1947.63) = 11\overset{m}{.}6 + 0\overset{m}{.}065\,t$ ($\varepsilon = \pm 1.6$) $M_v\,(N) = 11\overset{m}{.}6 + 0\overset{m}{.}44\,(N\text{-}1)$

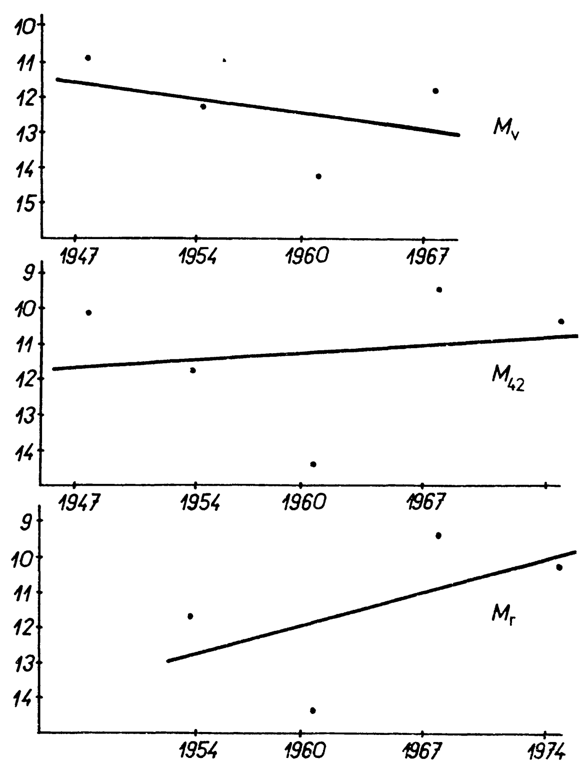
$M_{42}(t\text{-}1947.69) = 11\overset{m}{.}6 - 0\overset{m}{.}032\,t$ ($\varepsilon = \pm 2.3$) $M_{42}(N) = 11\overset{m}{.}6 - 0\overset{m}{.}22\,(N\text{-}1)$

$M_r\,(t\text{-}1953.76) = 12\overset{m}{.}8 - 0\overset{m}{.}132\,t$ ($\varepsilon = \pm 2.2$) $M_r\,(N) = 12\overset{m}{.}8 - 0\overset{m}{.}92\,(N\text{-}2)$

P/ PERRINE - MRKOS



P/ REINMUTH 2



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P/Holmes

Table 29

n	N	Comet	T	M_v	t	r	Δ	$t-T$	M_m	M'_{42}	M_{42}	M_r
1	1	1892 III	1306	3.0	241192	2.45	1.66	+164	3.5	−1.5	−1.5	N
2	2	1899 II	2804	9.5	090799	2.19	2.52	+072	14.0	8.6	8.6	8.6
3	3	1906 III	1403	9.8	250906	2.55	2.08	+195	15.0	9.3	9.3	9.3
4	11	1964 X	1611	13.5	290964	2.37	1.59	−048	18.8	14.0	14.0	J
5	12	1972 I	3101	—	151071	2.30	2.13	−108	19.2	13.9	13.9	J

Secular brightness (Fig. 29):

$M_v\,(t\text{-}1892.45) = 6^{m}.5 + 0^{m}.104\,t$ ($\varepsilon = \pm 3.3$) $M_v\,(N) = 6^{m}.5 + 0^{m}.73\,(N\text{-}1)$

$M_{42}(t\text{-}1892.90) = 4^{m}.3 + 0^{m}.134\,t$ ($\varepsilon = \pm 4.3$) $M_{42}(N) = 4^{m}.3 + 0^{m}.94\,(N\text{-}1)$

$M_r\,(t\text{-}1899.52) = 8^{m}.6 + 0^{m}.097\,t$ ($\varepsilon =$ 0.0) $M_r\,(N) = 8^{m}.6 + 0^{m}.68\,(N\text{-}2)$

P/Daniel

Table 30

n	N	Comet	T	M_v	t	r	Δ	$t-T$	M_m	M'_{42}	M_{42}	M_r
1	1	1909 IV	2911	9.5	061209	1.39	0.42	+007	9.0	9.5	9.5	N
2	5	1937 I	2801	12.1	020237	1.54	1.22	+005	12.6	10.3	10.3	10.3
3	6	1943 IV	2211	13.7	301143	1.54	0.64	+008	13.5	12.6	12.6	12.6
4	7	1950 V	2408	12.8	200950	1.49	1.91	+027	15.0	11.9	11.8	11.8
					191050	1.58	1.84	+056	15.0	11.7	—	—
5	9	1964 II	2104	16.0	090364	1.71	2.29	−043	20.0	15.9	15.9	J

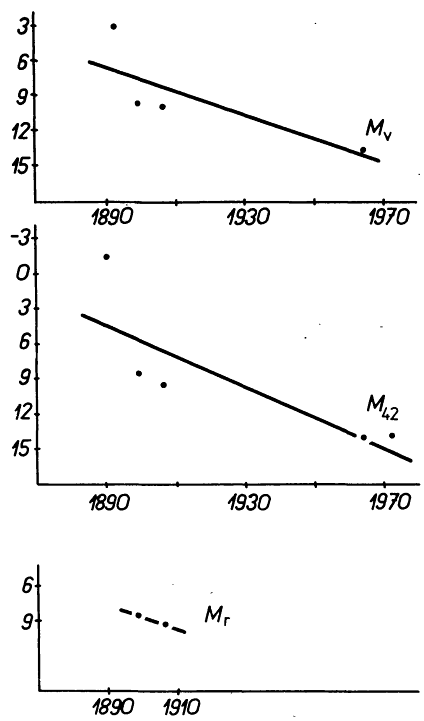
Secular brightness (Fig. 30):

$M_v\,(t\text{-}1909.91) = 9^{m}.4 + 0^{m}.116\,t$ ($\varepsilon = \pm 0.6$) $M_v\,(N) = 9^{m}.4 + 0^{m}.82\,(N\text{-}1)$

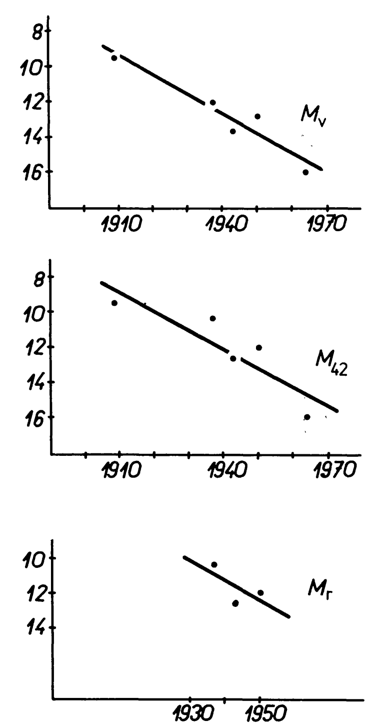
$M_{42}(t\text{-}1909.93) = 8^{m}.7 + 0^{m}.108\,t$ ($\varepsilon = \pm 1.4$) $M_{42}(N) = 8^{m}.7 + 0^{m}.77\,(N\text{-}1)$

$M_r\,(t\text{-}1937.09) = 10^{m}.8 + 0^{m}.110\,t$ ($\varepsilon = \pm 1.3$) $M_r\,(N) = 10^{m}.8 + 0^{m}.78\,(N\text{-}5)$

P/ HOLMES



P/ DANIEL



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P/Tempel—Swift

Table 31

n	N	Comet	T	M_v	t	r	Δ	$t-T$	M_m	M'_{42}	M_{42}	M_r
1	1	1869 III	1911	11.4	081269	1.13	0.25	+019	8.5	11.0	11.0	N
2	3	1880 IV	0811	12.2	241080	1.14	0.22	−015	8.0	10.7	10.7	N
3	5	1891 V	1711	13.8	241091	1.14	0.32	−024	10.0	11.9	11.9	11.9
4	8	1908 II	0110	12.2	271008	1.24	0.68	+026	12.0	11.9	11.9	11.9

Secular brightness (Fig. 31):

$M_v\,(t\text{-}1869.88) = 11^{m}9 + 0^{m}025\,t$ ($\varepsilon = \pm 1.1$) $M_v\,(N) = 11^{m}9 + 0^{m}14\,(N\text{-}1)$

$M_{42}(t\text{-}1869.94) = 10^{m}8 + 0^{m}030\,t$ ($\varepsilon = \pm 0.5$) $M_{42}(N) = 10^{m}8 + 0^{m}17\,(N\text{-}1)$

$M_r\,(t\text{-}1891.81) = 11^{m}9 + 0^{m}000\,t$ ($\varepsilon = 0.0$) $M_r\,(N) = 11^{m}9 + 0^{m}00\,(N\text{-}5)$

P/De Vico—Swift

Table 32

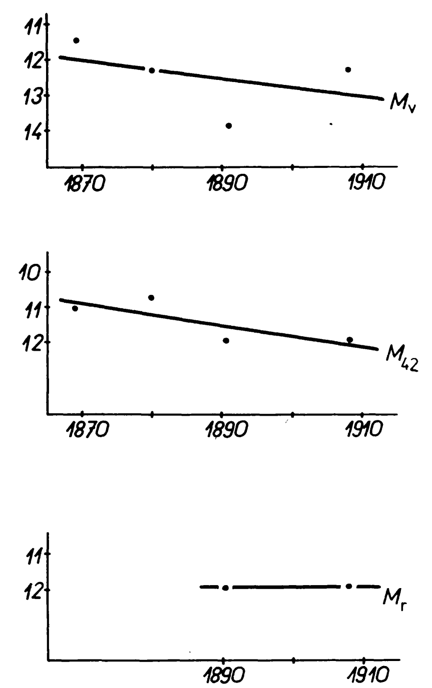
n	N	Comet	T	M_v	t	r	Δ	$t-T$	M_m	M'_{42}	M_{42}	M_r
1	1	1678	1808	6.5	110978	1.26	0.29	+024	5.5	7.2	7.2	N
2	31	1844 I	0209	8.0	060944	1.20	0.20	+004	5.0	7.7	7.7	N
3	40	1894 IV	1210	10.2	011294	1.49	1.13	+050	12.0	10.2	10.2	N
4	52	1965 VII	2308	14.7	040865	1.67	0.79	−019	16.0	14.3	14.4	14.4
					030965	1.66	0.74	+011	16.0	14.5	—	—

Secular brightness (Fig. 32):

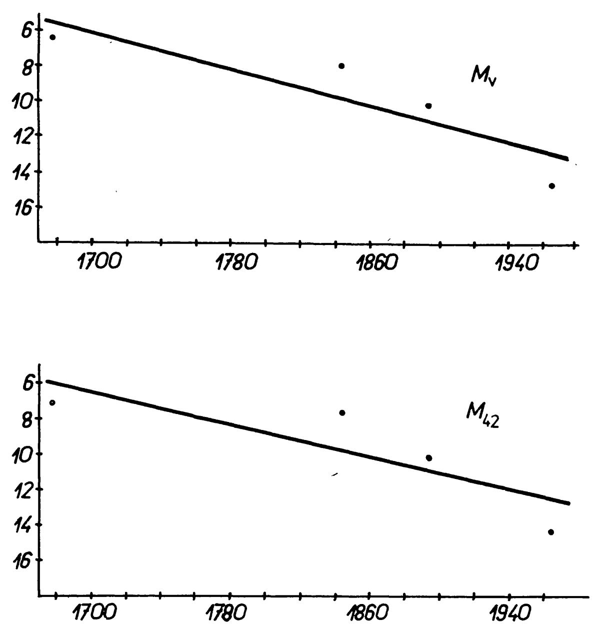
$M_v\,(t\text{-}1678.63) = 5^{m}5 + 0^{m}026\,t$ ($\varepsilon = \pm 2.0$) $M_v\,(N) = 5^{m}5 + 0^{m}16\,(N\text{-}1)$

$M_{42}(t\text{-}1678.70) = 6^{m}1 + 0^{m}023\,t$ ($\varepsilon = \pm 2.2$) $M_{42}(N) = 6^{m}1 + 0^{m}14\,(N\text{-}1)$

P / TEMPEL - SWIFT



P / DE VICO - SWIFT



The secular variation of M_r was not calculated, because the comet was recovered according to the ephemeris in one return only.

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P/Johnson

Table 33

n	N	Comet	T	M_v	t	r	Δ	$t-T$	M_m	M'_{42}	M_{42}	M_r
1	1	1949 II	1609	9.6	150849	2.26	1.27	−032	13.5	9.4	9.4	N
2	2	1956 V	2607	10.0	060856	2.26	1.32	+011	13.5	9.4	9.4	9.4
3	3	1963 IV	0806	11.0	270863	2.32	1.46	+080	17.6	13.1	13.1	J
4	4	1970 IV	3003	14.1	050770	2.31	2.26	+097	18.8	13.4	13.4	J

Secular brightness (Fig. 33):

$M_v(t\text{-}1949.71) = 9^m.0 + 0^m.212\,t$ $(\varepsilon = \pm 1.0)$ $M_v(N) = 9^m.0 + 1^m.44\,(N\text{-}1)$

$M_{42}(t\text{-}1949.62) = 9^m.0 + 0^m.226\,t$ $(\varepsilon = \pm 1.1)$ $M_{42}(N) = 9^m.0 + 1^m.53\,(N\text{-}1)$

The secular variation of M_r was not calculated, because among four values of M_{42} there is one independent discovery, and the next two values refer to the nuclear condensation.

P/Arend—Rigaux

Table 34

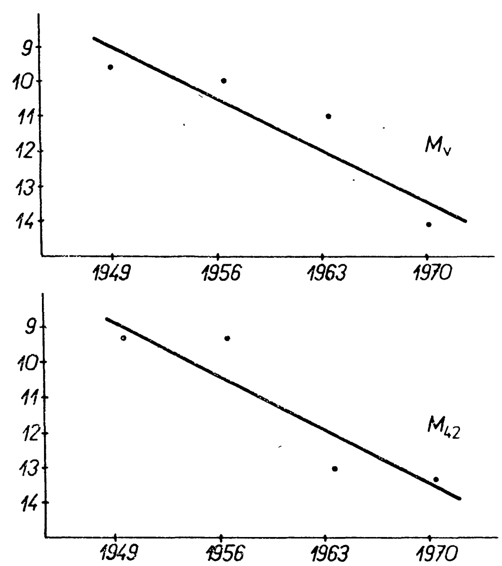
n	N	Comet	T	M_v	t	r	Δ	$t-T$	M_m	M'_{42}	M_{42}	M_r
1	1	1950 VII	1812	12.1	080151	1.41	0.44	+021	10.5	10.8	10.8	N
2	2	1957 VII	0809	13.0	290158	2.11	1.63	+143	19.0	14.7	14.6	J
					160258	2.24	1.56	+161	19.0	14.5	—	—
3	3	1964 V	0506	12.5	181063	2.65	1.98	−231	19.4	13.7	13.7	J
4	4	1971 IV	0604	--	011170	2.16	1.47	−156	18.8	14.6	14.6	J

Secular brightness (Fig. 34):

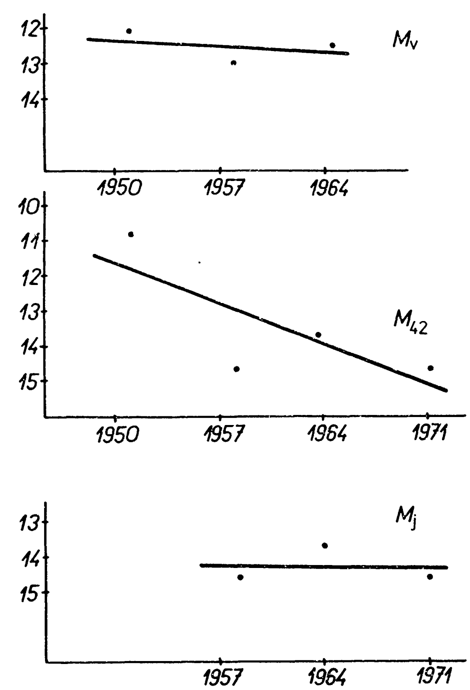
$M_v(t\text{-}1950.96) = 12^m.3 + 0^m.030\,t$ $(\varepsilon = \pm 0.6)$ $M_v(N) = 12^m.3 + 0^m.20\,(N\text{-}1)$

$M_{42}(t\text{-}1951.02) = 11^m.8 + 0^m.165\,t$ $(\varepsilon = \pm 1.4)$ $M_{42}(N) = 11^m.8 + 1^m.13\,(N\text{-}1)$

P/JOHNSON



P/AREND - RIGAUX



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This comet has an asteroid-like appearance, a coma having been observed in the first return only. All three other estimates refer to nucleus. Instead of M_r, the time-dependence of the absolute magnitude of the nucleus M_j was calculated.

$M_j(t\text{-}1958.10) = 14\overset{\mathrm{m}}{.}3 + 0\overset{\mathrm{m}}{.}005\ t$ ($\varepsilon = \pm 0.7$)

$M_j(N) = 14\overset{\mathrm{m}}{.}3 + 0\overset{\mathrm{m}}{.}00\ (N\text{-}2)$

P/Ashbrook—Jackson

Table 35

n	N	Comet	T	M_v	t	r	Δ	$t-T$	M_m	M'_{42}	M_{42}	M_r
1	1	1948 IX	0410	7.8	260848	2.34	1.34	−039	11.0	6.7	6.7	N
					300848	2.34	1.34	−035	11.0	6.7	—	—
					100948	2.32	1.33	−024	11.0	6.7	—	—
					130948	2.32	1.33	−021	11.0	6.7	—	—
2	2	1956 II	0604	9.2	121055	2.64	2.50	−177	12.0	5.8	5.8	5.8
3	3	1963 VI	0210	6.8	150663	2.44	2.04	−109	12.0	6.6	7.2	7.2
					110963	2.32	1.34	−021	12.0	7.7	—	—
4	4	1971 III	1303	—	070670	2.96	2.05	−279	17.5	11.2	11.2	J

Secular brightness (Fig. 35):

$M_v\ (t\text{-}1948.76) = 8\overset{\mathrm{m}}{.}4 - 0\overset{\mathrm{m}}{.}067\ t$ ($\varepsilon = \pm 1.6$)

$M_{42}(t\text{-}1948.67) = 5\overset{\mathrm{m}}{.}5 + 0\overset{\mathrm{m}}{.}202\ t$ ($\varepsilon = \pm 1.8$)

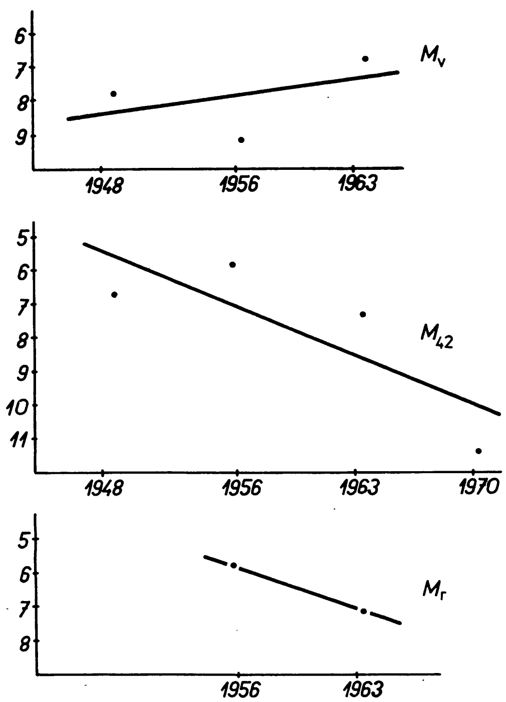
$M_r\ (t\text{-}1955.78) = 5\overset{\mathrm{m}}{.}8 + 0\overset{\mathrm{m}}{.}179\ t$ ($\varepsilon = 0.0$)

$M_v\ (N) = 8\overset{\mathrm{m}}{.}4 - 0\overset{\mathrm{m}}{.}50\ (N\text{-}1)$

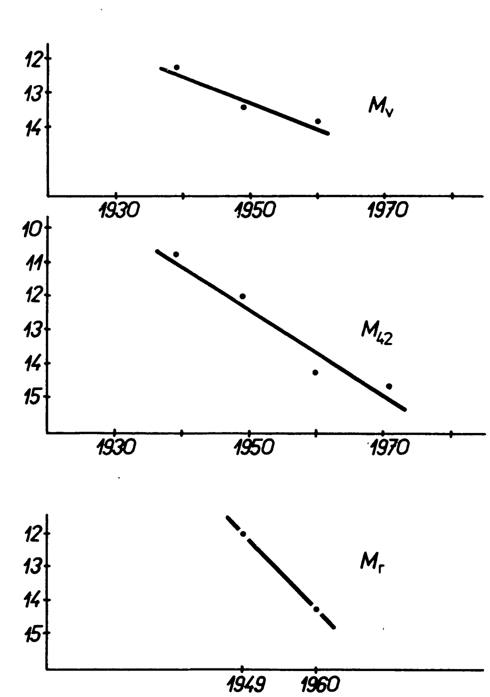
$M_{42}(N) = 5\overset{\mathrm{m}}{.}5 + 1\overset{\mathrm{m}}{.}50\ (N\text{-}1)$

$M_r\ (N) = 5\overset{\mathrm{m}}{.}8 + 1\overset{\mathrm{m}}{.}33\ (N\text{-}2)$

P/ASHBROOK - JACKSON



P/ VÄISÄLÄ



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P/Väisälä

Table 36

n	N	Comet	T	M_v	t	r	Δ	$t-T$	M_m	M'_{42}	M_{42}	M_r
1	1	1939 IV	2604	12.2	200339	1.81	0.92	−037	13.2	10.8	10.8	N
2	2	1949 V	1011	13.4	191249	2.36	1.81	+039	17.0	12.0	12.0	12.0
3	3	1960 IV	1005	13.8	200360	1.83	1.06	−051	17.0	14.2	14.2	14.2
4	4	1971 VII	1209	—	200471	2.33	2.47	−145	20.4	14.8	14.8	J

Secular brightness (Fig. 36):

$M_v\,(t\text{-}1939.32) = 12^{\rm m}3 + 0^{\rm m}076\,t$ ($\varepsilon = \pm 0.3$)
$M_{42}(t\text{-}1939.22) = 10^{\rm m}8 + 0^{\rm m}133\,t$ ($\varepsilon = \pm 0.5$)
$M_r\,(t\text{-}1949.97) = 12^{\rm m}0 + 0^{\rm m}215\,t$ ($\varepsilon = 0.0$)
$M_v\,(N) = 12^{\rm m}3 + 0^{\rm m}86\,(N\text{-}1)$
$M_{42}(N) = 10^{\rm m}8 + 1^{\rm m}50\,(N\text{-}1)$
$M_r\,(N) = 12^{\rm m}0 + 2^{\rm m}42\,(N\text{-}2)$

P/Neujmin 1

Table 37

n	N	Comet	T	M_v	t	r	Δ	$t-T$	M_m	M'_{42}	M_{42}	M_r
1	1	1913 III	1608	10.3	030913	1.55	0.54	+018	10.0	9.4	9.4	N
2	2	1931 I	3004	10.9	170931	2.24	1.84	+140	15.0	10.1	10.1	10.1
3	3	1948 XIII	1512	11.9	030948	1.97	1.82	−103	16.0	11.8	12.2	12.2
					301148	1.56	2.04	−015	16.0	12.5	—	—
4	4	1966 VI	0912	11.0	240666	2.46	1.60	−168	15.8	10.8	10.8	10.8

Secular brightness (Fig. 37):

$M_v\,(t\text{-}1913.62) = 10^{\rm m}6 + 0^{\rm m}017\,t$ ($\varepsilon = \pm 0.6$)
$M_{42}(t\text{-}1913.67) = 9^{\rm m}7 + 0^{\rm m}036\,t$ ($\varepsilon = \pm 1.1$)
$M_r\,(t\text{-}1931.71) = 10^{\rm m}7 + 0^{\rm m}020\,t$ ($\varepsilon = \pm 1.4$)
$M_v\,(N) = 10^{\rm m}6 + 0^{\rm m}30\,(N\text{-}1)$
$M_{42}(N) = 9^{\rm m}7 + 0^{\rm m}64\,(N\text{-}1)$
$M_r\,(N) = 10^{\rm m}7 + 0^{\rm m}36\,(N\text{-}2)$

P/Harrington—Abell

Table 38

n	N	Comet	T	M_v	t	r	Δ	$t-T$	M_m	M'_{42}	M_{42}	M_r
1	1	1954 XIII	1312	15.0	220355	1.99	1.05	+099	17.0	13.9	13.9	N
2	2	1962 II	2502	15.4	260162	1.81	0.92	−030	17.0	14.6	14.6	14.6
3	3	1969 III	1005	14.3	231168	2.32	1.43	−322	19.0	14.6	14.7	14.6
					190469	1.79	2.12	−021	19.0	14.8	—	—

Secular brightness (Fig. 38):

$M_v\,(t\text{-}1954.95) = 15^{\rm m}3 - 0^{\rm m}049\,t$ ($\varepsilon = \pm 0.6$)
$M_{42}(t\text{-}1955.22) = 14^{\rm m}0 + 0^{\rm m}057\,t$ ($\varepsilon = \pm 0.2$)
$M_r\,(t\text{-}1962.07) = 14^{\rm m}6 + 0^{\rm m}000\,t$ ($\varepsilon = 0.0$)
$M_v\,(N) = 15^{\rm m}3 - 0^{\rm m}35\,(N\text{-}1)$
$M_{42}(N) = 14^{\rm m}0 + 0^{\rm m}41\,(N\text{-}1)$
$M_r\,(N) = 14^{\rm m}6 + 0^{\rm m}00\,(N\text{-}2)$

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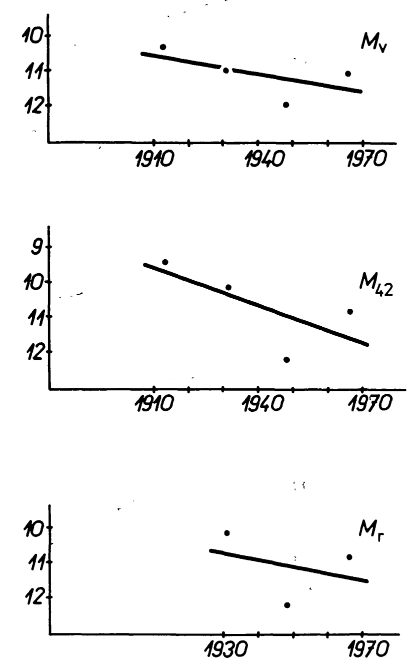
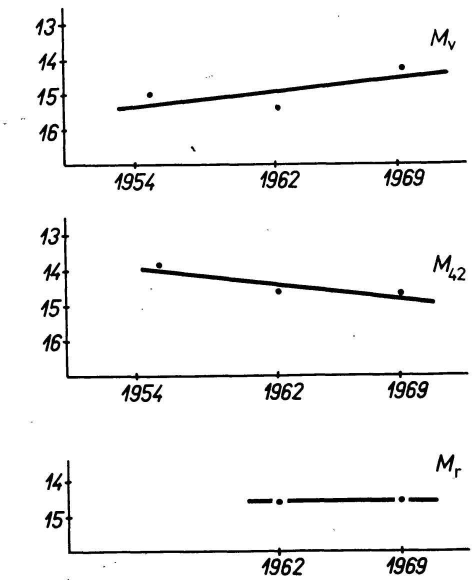
P/ NEUJMIN 1



P/ HARRINGTON - ABELL



In the third return M_r differs from M_{42}, because the estimate of April 19, 1969 refers to the nuclear condensation. Therefore, only the estimate of November 23, 1968, is used in column M_r.

P/Arend

Table 39

n	N	Comet	T	M_v	t	r	Δ	$t-T$	M_m	M'_{42}	M_{42}	M_r
1	1	1951 X	2311	11.9	031151	1.82	0.91	−020	12.5	10.1	10.1	N
2	2	1959 V	0109	14.1	251159	1.99	1.22	+085	15.5	12.1	12.1	12.1
3	3	1967 VI	1306	13.3	051067	2.09	2.21	+114	18.0	13.1	13.1	13.1

Secular brightness (Fig. 39):

$M_v\,(t\text{-}1951.90) = 12^m.4 + 0^m.090\,t$	$(\varepsilon = \pm 1.2)$	$M_v\,(N) = 12^m.4 + 0^m.70\,(N\text{-}1)$
$M_{42}(t\text{-}1951.84) = 10^m.3 + 0^m.189\,t$	$(\varepsilon = \pm 0.4)$	$M_{42}(N) = 10^m.3 + 1^m.47\,(N\text{-}1)$
$M_r\,(t\text{-}1959.90) = 12^m.1 + 0^m.127\,t$	$(\varepsilon = 0.0)$	$M_r\,(N) = 12^m.1 + 0^m.99\,(N\text{-}2)$

P/Oterma

Table 40

n	N	Comet	T	M_v	t	r	Δ	$t-T$	M_m	M'_{42}	M_{42}	M_r
1	1	1942 VII	2108	7.8	030443	3.49	2.51	+225	15.0	7.6	7.6	N
2	2	1950 III	1603	7.8	110250	3.45	2.71	−033	14.5	7.0	6.8	6.8
					050251	3.48	3.01	+326	14.5	6.7	—	—
3	3	1958 IV	1006	9.6	170158	3.43	2.63	−144	16.0	8.5	8.3	8.3
					120259	3.50	3.15	+247	16.0	8.1	—	—

Secular brightness (Fig. 40):

$M_v\,(t\text{-}1942.64) = 7^m.5 + 0^m.115\,t$	$(\varepsilon = \pm 0.7)$	$M_v\,(N) = 7^m.5 + 0^m.91\,(N\text{-}1)$
$M_{42}(t\text{-}1943.25) = 7^m.2 + 0^m.048\,t$	$(\varepsilon = \pm 0.9)$	$M_{42}(N) = 7^m.2 + 0^m.38\,(N\text{-}1)$
$M_r\,(t\text{-}1950.61) = 6^m.8 + 0^m.188\,t$	$(\varepsilon = 0.0)$	$M_r\,(N) = 6^m.8 + 1^m.48\,(N\text{-}2)$

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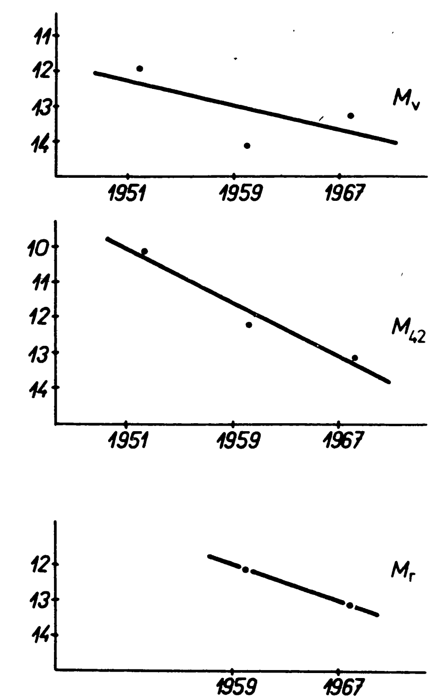
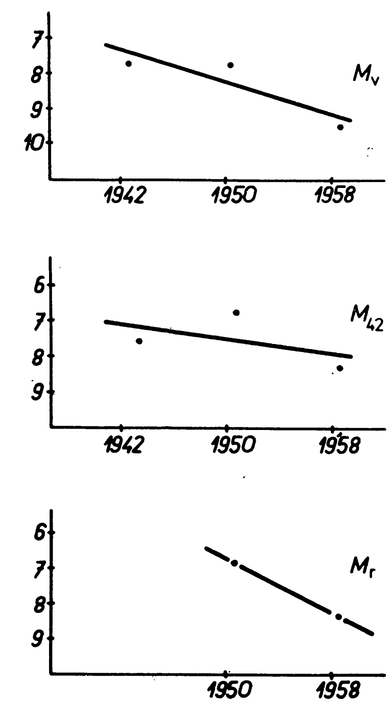
P/AREND



P/ OTERMA



P/Neujmin 3

Table 41

n	N	Comet	T	M_v	t	r	Δ	$t-T$	M_m	M'_{42}	M_{42}	M_r
1	1	1929 III	2806	10.8	020829	2.06	1.05	+035	13.5	10.3	10.3	N
2	3	1951 V	2805	13.7	070851	2.15	1.27	+071	16.5	12.7	12.7	12.7
3	5	1972 IV	1605	—	140872	2.08	1.24	+090	17.7	14.1	14.1	J

Secular brightness (Fig. 41):

$M_v\,(t\text{-}1929.49) = 10^m\!.9 + 0^m\!.132\,t$ ($\varepsilon =$ 0.0) $M_v\,(N) = 10^m\!.9 + 1^m\!.45\,(N\text{-}1)$

$M_{42}(t\text{-}1929.59) = 10^m\!.4 + 0^m\!.088\,t$ ($\varepsilon = \pm 0.4$) $M_{42}(N) = 10^m\!.4 + 0^m\!.96\,(N\text{-}1)$

The secular variation of M_r was not calculated, because among the three values of M_{42} is one independent discovery, and one estimate of the brightness of the nuclear condensation.

P/Schwassmann—Wachmann 1

Table 42

n	N	Comet	T	M_v	t	r	Δ	$t-T$	M_m	M'_{42}	M_{42}	M_r
1	1	1925 II	0203	2.5	231127	6.0	5.4	+ 996	12.0	0.6	0.6	N
2	2	1941 VI	2104	3.5	260146	6.73	6.11	+1583	9.4	−2.8	−2.8	−2.8
3	3	1957 IV	1205	3.2	201055	5.73	6.18	− 570	9.2	−2.4	−2.4	−2.4

Secular brightness (Fig. 42):

$M_v\,(t\text{-}1925.17) = 2^m\!.7 + 0^m\!.022\,t$ ($\varepsilon = \pm 0.5$) $M_v\,(N) = 2^m\!.7 + 0^m\!.35\,(N\text{-}1)$

$M_{42}(t\text{-}1927.90) = 0^m\!.3 - 0^m\!.118\,t$ ($\varepsilon = \pm 1.2$) $M_{42}(N) = 0^m\!.3 - 1^m\!.90\,(N\text{-}1)$

$M_r\,(t\text{-}1946.07) = -2^m\!.8 + 0^m\!.041\,t$ ($\varepsilon =$ 0.0) $M_r\,(N) = -2^m\!.8 + 0^m\!.66\,(N\text{-}2)$

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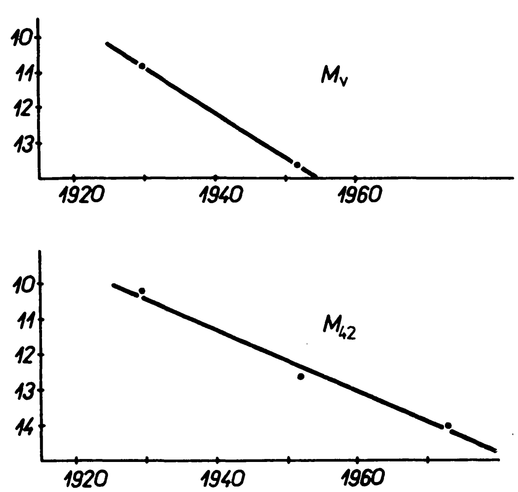
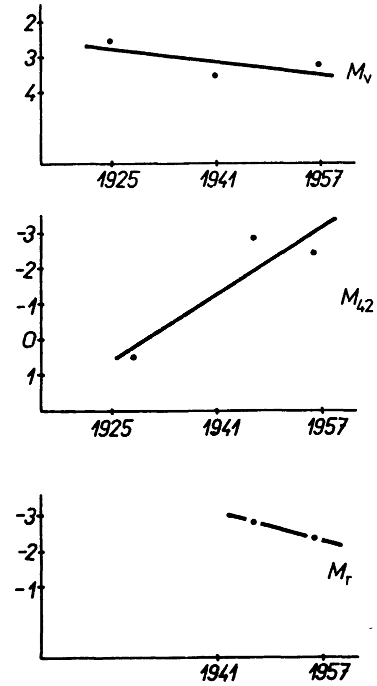
This comet has a nearly circular orbit, and can be observed at every opposition. The comet already passed the perihelion in its fourth return, too (February 15, 1974). Since the comet, well-known by its outburst, often reaches the maximum apparent magnitude at large heliocentric distances (e.g., 1583 days after perihelion in the second return), we used three returns only.

P/ NEUJMIN 3



P/ SCHWASSMANN - WACHMANN 1



4. The Statistical Distribution of the Secular Variations of Brightness

A histogram of the distribution of the secular variations M_r per revolution is presented in Fig. 43. The blank histogram corresponds to all 42 comets, the shaded areas to those comets for which the secular variation of M_r is based on 6 returns at least (13 comets). The figure shows unambiguously that the large dispersion is due to comets which made only a few apparitions. The values for the comets which returned more than five times are well concentrated. The median for all comets (37 objects with a calculated variation of M_r) is 0.29 magnitude per return.

The mean value of the secular variations of M_v, M_{42} and M_r was calculated by the method of weighted average. The weight of individual values was stated as follows. The secular variation was calculated from n returns, i.e. we used $(n-1)$ magnitude differences. Denoting $n-1=a_k$ the weight g_i was defined as follows:

$$g_i = \frac{a_i}{\sum_{k=1}^{m} a_k}, \qquad (3)$$

where m equals 42 for M_v and M_{42}; and 37 for M_r.

In Table 43 secular variations of the brightness per revolution are listed. The second numbers in columns 3—5 are the respective values a_k. The comets are arranged according to their orbital periods.

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The mean weighted values of secular variations per revolution are determined as follows:
the mean weighted secular variation of M_v is $+0^{m}.36$ per revolution,
the mean weighted secular variation of M_{42} is $+0^{m}.36$ per revolution,
the mean weighted secular variation of M_r is $+0^{m}.22$ per revolution.

The influence of the length of the observing period of the comet upon the computed secular variation of brightness is investigated in Fig. 44. On the horizontal scale the time-difference between the last and the first returns included in calculating M_r is plotted. The vertical scale gives the secular variation of M_r in magnitudes per year. It is evident that both the excessive and negative values of secular variations correspond to comets with short observing intervals (or with short intervals of comparable estimates). The dispersion reduces with the extent of the observing interval. Real secular variations of the brightness are apparently masked in short observing intervals by random fluctuations.

Table 43

Comet	P	M_v	M_{42}	M_r
P/Grigg—Skjellerup	5.12	$+0^{m}.34$,10	$+0^{m}.35$,11	$+0^{m}.37$,9
P/Honda—Mrkos—Pajdušáková	5.22	$+0^{m}.16$,3	$-0^{m}.09$,4	$-0^{m}.44$,3
P/Tempel 2	5.26	$+0^{m}.17$,13	$+0^{m}.16$,14	$+0^{m}.15$,12
P/Brorsen	5.46	$+0^{m}.31$,4	$+0^{m}.18$,4	$+0^{m}.45$,2
P/Tuttle—Giacobini—Kresák	5.49	$+0^{m}.10$,3	$-0^{m}.21$,4	$-4^{m}.00$,1
P/Tempel 1	5.50	$+0^{m}.92$,2	$+0^{m}.22$,4	$+0^{m}.22$,3
P/Tempel—Swift	5.68	$+0^{m}.14$,3	$+0^{m}.17$,3	$0^{m}.00$,1
P/D'Arrest	6.23	$+0^{m}.13$,11	$+0^{m}.16$,11	$+0^{m}.14$,8
P/De Vico—Swift	6.31	$+0^{m}.16$,3	$+0^{m}.14$,3	—
P/Pons—Winnecke	6.34	$+0^{m}.26$,16	$+0^{m}.27$,16	$+0^{m}.32$,12
P/Giacobini—Zinner	6.41	$+0^{m}.04$,7	$-0^{m}.01$,8	$-0^{m}.30$,5
P/Kopff	6.42	$+0^{m}.28$,9	$+0^{m}.36$,9	$+0^{m}.10$,7
P/Forbes	6.42	$+0^{m}.61$,3	$+0^{m}.03$,4	$-0^{m}.30$,3
P/Schwassmann—Wachmann 2	6.52	$+0^{m}.31$,6	$+0^{m}.19$,7	$+0^{m}.08$,6
P/Wolf—Harrington	6.55	$+0^{m}.23$,3	$+0^{m}.26$,4	$-0^{m}.50$,2
P/Biela	6.62	$+0^{m}.05$,5	$-0^{m}.01$,5	—
P/Wirtanen	6.65	$+0^{m}.03$,3	$+0^{m}.41$,4	$-0^{m}.30$,2
P/Perrine—Mrkos	6.72	$+0^{m}.36$,4	$+0^{m}.11$,4	$+0^{m}.08$,2
P/Brooks 2	6.72	$+0^{m}.54$,9	$+0^{m}.58$,10	$+0^{m}.46$,7
P/Reinmuth 2	6.73	$+0^{m}.44$,3	$-0^{m}.22$,4	$-0^{m}.92$,3
P/Johnson	6.77	$+1^{m}.44$,3	$+1^{m}.53$,3	—
P/Arend—Rigaux	6.84	$+0^{m}.20$,2	$+1^{m}.13$,3	$0^{m}.00$,2
P/Finlay	6.90	$+0^{m}.33$,7	$+0^{m}.37$,8	$+0^{m}.42$,6
P/Borrelly	6.99	$+0^{m}.42$,7	$+0^{m}.48$,8	$+0^{m}.44$,6
P/Holmes	7.05	$+0^{m}.73$,3	$+0^{m}.94$,4	$+0^{m}.68$,1
P/Daniel	7.09	$+0^{m}.82$,4	$+0^{m}.77$,4	$+0^{m}.78$,2
P/Harrington—Abell	7.19	$-0^{m}.35$,2	$+0^{m}.41$,2	$0^{m}.00$,1
P/Faye	7.41	$+0^{m}.39$,15	$+0^{m}.31$,15	$+0^{m}.29$,13
P/Ashbrook—Jackson	7.43	$-0^{m}.50$,2	$+1^{m}.50$,3	$+1^{m}.33$,1
P/Whipple	7.47	$+0^{m}.74$,5	$+0^{m}.68$,5	$+0^{m}.72$,4
P/Reinmuth 1	7.60	$+0^{m}.66$,4	$+0^{m}.61$,5	$+0^{m}.44$,4
P/Arend	7.76	$+0^{m}.70$,2	$+1^{m}.47$,2	$+0^{m}.99$,1
P/Oterma	7.88	$+0^{m}.91$,2	$+0^{m}.38$,2	$+1^{m}.48$,1
P/Schaumasse	8.18	$+0^{m}.15$,5	$-0^{m}.03$,5	$-0^{m}.29$,3
P/Wolf	8.43	$+0^{m}.77$,10	$+0^{m}.90$,10	$+0^{m}.52$,8
P/Comas Solá	8.55	$+0^{m}.52$,5	$+0^{m}.48$,5	$+0^{m}.66$,4
P/Neujmin 3	10.95	$+1^{m}.45$,1	$+0^{m}.96$,2	—
P/Väisälä	11.28	$+0^{m}.86$,2	$+1^{m}.50$,3	$+2^{m}.42$,1
P/Tuttle	13.77	$+0^{m}.28$,8	$+0^{m}.15$,8	$+0^{m}.12$,5
P/Schwassmann—Wachmann 1	16.10	$+0^{m}.35$,2	$-1^{m}.90$,2	$+0^{m}.66$,1
P/Neujmin 1	17.93	$+0^{m}.30$,3	$+0^{m}.64$,3	$+0^{m}.36$,2
P/Crommelin	27.87	$+0^{m}.31$,5	$+0^{m}.22$,5	—

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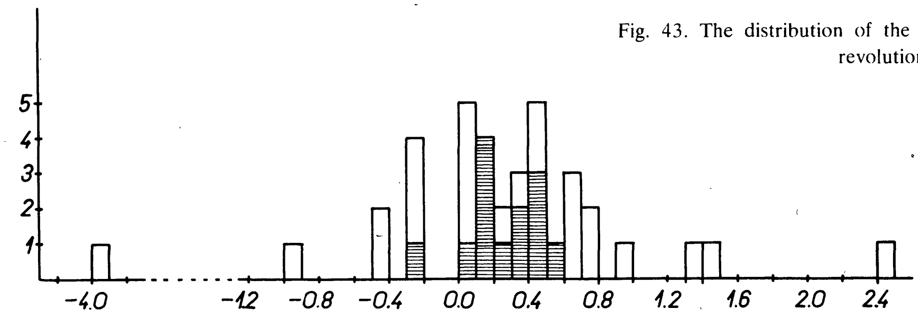

Fig. 43. The distribution of the secular variations M_r per revolution.

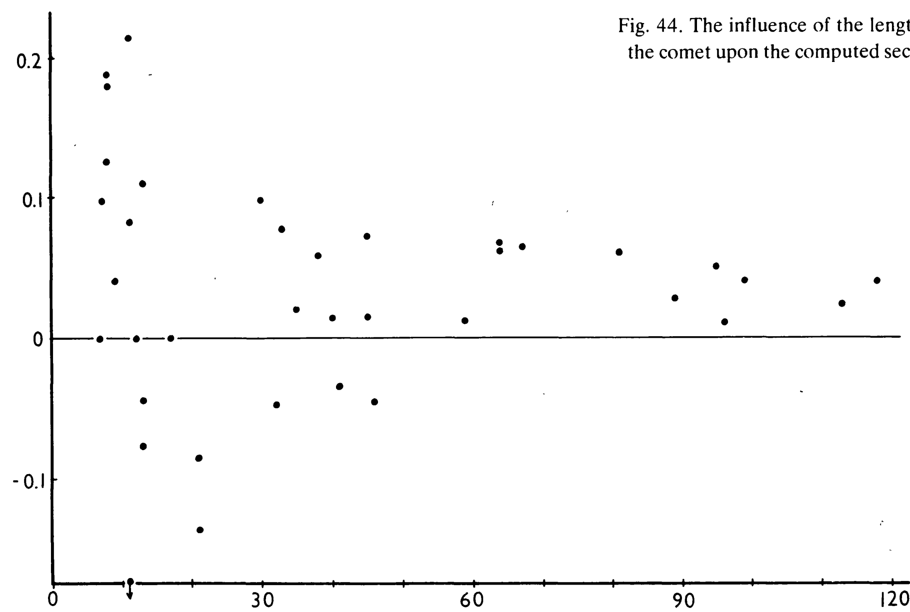

Fig. 44. The influence of the length of the observing period of the comet upon the computed secular variation of brightness.

5. The Time Dependence of Size of the Instruments Used

The influence of instrumental effects upon the values M_{42} and M_r is investigated qualitatively in Figure 45. The date (1800—1974) is plotted against a characteristic diameter of the telescopes used (in centimetres). The characteristic diameter of the telescopes used was obtained as follows: First we had looked up in a literature the diameter of the instrument by which the maximum brightness was estimated (85 data). We divided the period from 1800 to 1974 into 9 intervals (the duration of each interval is 20 years, only last interval from 1960 to 1974 being incomplete) and calculated an average value of these diameters in each interval. These resulting values were plotted in the middle of each interval.

It is evident that observations of the maximum brightness until the end of 19th century were mostly made by small telescopes, however, the size of the instruments used increased considerably during the next decades. Observations made by small telescopes — mostly visual estimates using a low magnification — are expected to agree closely with the total brightness of the comet. However, photographs made by large telescopes, recording only the nuclear condensation of the comet, lead to considerable systematic underestimate of the total brightness.

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6. The Secular Variations of Brightness for Selected Samples of Comets

In the next table the comets are arranged according to the orbital period. *P* indicates the orbital period in years, *M* — the mean absolute magnitudes derived from the maximum observed magnitude in each return. Capital letters in columns 5—9 denote the following characteristics of comets:

A — 10 comets of shortest orbital period,
B — 10 comets of longest orbital period,
C — 10 comets brightest in the maximum,
D — 10 comets faintest in the maximum,
E — 10 comets with most expressive erratic variations in brightness,
F — 10 comets of shortest perihelion distance,
G — 10 comets of largest perihelion distance,
H — 10 comets discovered first,
I — 10 comets discovered last.

Table 44

n	Comet	*P*	*M*	A/B	C/D	E	F/G	H/I
1	P/Grigg—Skjellerup	5.12	$12\stackrel{m}{.}9$	A	D	—	F	—
2	P/Honda—Mrkos—Pajdušáková	5.22	$11\stackrel{m}{.}0$	A	—	—	F	I
3	P/Tempel 2	5.26	$9\stackrel{m}{.}2$	A	—	E	—	—
4	P/Brorsen	5.46	$8\stackrel{m}{.}5$	A	—	—	F	H
5	P/Tuttle—Giacobini—Kresák	5.49	$11\stackrel{m}{.}2$	A	—	E	F	H
6	P/Tempel 1	5.50	$8\stackrel{m}{.}4$	A	—	—	—	H
7	P/Tempel—Swift	5.68	$11\stackrel{m}{.}4$	A	—	—	F	—
8	P/D'Arrest	6.23	$8\stackrel{m}{.}8$	A	—	E	—	H
9	P/De Vico—Swift	6.31	$9\stackrel{m}{.}0$	A	—	—	—	H
10	P/Pons—Winnecke	6.34	$9\stackrel{m}{.}7$	A	—	—	—	H
11	P/Giacobini—Zinner	6.41	$10\stackrel{m}{.}3$	—	—	E	F	—
12	P/Kopff	6.42	$8\stackrel{m}{.}2$	—	C	E	—	—
13	P/Forbes	6.42	$10\stackrel{m}{.}7$	—	—	—	—	—
14	P/Schwassmann—Wachmann 2	6.52	$8\stackrel{m}{.}4$	—	C	—	G	—
15	P/Wolf—Harrington	6.55	$11\stackrel{m}{.}4$	—	—	—	—	—
16	P/Biela	6.62	$7\stackrel{m}{.}8$	—	C	—	F	H
17	P/Wirtanen	6.65	$14\stackrel{m}{.}0$	—	D	—	—	I
18	P/Perrine—Mrkos	6.72	$12\stackrel{m}{.}5$	—	D	E	—	—
19	P/Brooks 2	6.72	$9\stackrel{m}{.}4$	—	—	—	—	—
20	P/Reinmuth 2	6.73	$11\stackrel{m}{.}0$	—	—	—	—	I
21	P/Johnson	6.77	$11\stackrel{m}{.}3$	—	—	—	G	I
22	P/Arend—Rigaux	6.84	$14\stackrel{m}{.}1$	—	D	—	—	I
23	P/Finlay	6.90	$10\stackrel{m}{.}4$	—	—	—	F	—
24	P/Borrelly	6.99	$8\stackrel{m}{.}7$	—	—	—	—	—
25	P/Holmes	7.05	$9\stackrel{m}{.}3$	—	—	E	G	—
26	P/Daniel	7.09	$11\stackrel{m}{.}8$	—	D	—	—	—
27	P/Harrington—Abell	7.19	$14\stackrel{m}{.}6$	—	D	—	—	I
28	P/Faye	7.41	$7\stackrel{m}{.}4$	—	C	—	—	H
29	P/Ashbrook—Jackson	7.43	$7\stackrel{m}{.}0$	—	C	—	G	I
30	P/Whipple	7.47	$8\stackrel{m}{.}8$	—	—	—	G	—
31	P/Reinmuth 1	7.60	$12\stackrel{m}{.}1$	—	D	—	G	—
32	P/Arend	7.76	$12\stackrel{m}{.}1$	—	D	E	—	I
33	P/Oterma	7.88	$7\stackrel{m}{.}6$	B	C	—	G	I
34	P/Schaumasse	8.18	$8\stackrel{m}{.}7$	B	—	E	—	—
35	P/Wolf	8.43	$9\stackrel{m}{.}5$	B	—	—	G	—
36	P/Comas Solá	8.55	$8\stackrel{m}{.}2$	B	C	—	—	—
37	P/Neujmin 3	10.95	$12\stackrel{m}{.}7$	B	D	—	G	—
38	P/Väisälä	11.28	$13\stackrel{m}{.}1$	B	D	—	—	I
39	P/Tuttle	13.77	$8\stackrel{m}{.}0$	B	C	—	F	H
40	P/Schwassmann—Wachmann 1	16.10	$-2\stackrel{m}{.}4$	B	C	E	G	—
41	P/Neujmin 1	17.93	$10\stackrel{m}{.}4$	B	—	—	—	—
42	P/Crommelin	27.87	$7\stackrel{m}{.}2$	B	C	—	F	H

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In all samples the average values of secular decrease of the brightness per revolution were determined; the largest and the smallest values in each sample were omitted. The following values, arranged according to the variation of M_r were obtained:

Table 45

		M_r	M_{42}	M_v	$M_{42}-M_r$	M_v-M_r
1	G	0.72	0.77	0.74	+0.05	+0.02
2	B	0.63	0.46	0.54	−0.17	−0.09
3	C	0.53	0.26	0.31	−0.27	−0.22
4	I	0.44	0.84	0.37	+0.40	−0.07
5	D	0.38	0.76	0.50	+0.38	+0.12
6	H	0.28	0.17	0.24	−0.11	−0.04
7	E	0.15	0.18	0.28	+0.03	+0.13
8	A	0.11	0.15	0.21	+0.04	+0.10
9	F	0.03	0.12	0.21	+0.09	+0.18

(1) Results of the groups A and B show that the secular decrease conspicuously accelerates with increasing orbital period (qualitatively the same result is obtained for all three methods of treatment). We obtained similar result for P/Wolf, too, where a change of orbital period from 6.79 to 8.43 years was followed by a change of the mean secular decrease of the brightness from $0\overset{m}{.}13$ to $0\overset{m}{.}92$ per revolution (from $0\overset{m}{.}019$ to $0\overset{m}{.}109$ per year). It is difficult to interpret this change physically, because the orbital arc around the perihelion is decisive for the loss of mass. It is irrelevant whether the comet stays at a large heliocentric distances for a shorter or longer period. Moreover, an increase of orbital period by Jupiter's perturbations near aphelion tends to increase the perihelion distance, and in this case we should rather expect a reduction of the mass loss and of the secular brightness variation. On the other hand, a longer orbital period leaves more time for changes in observing methods and instruments used between two successive returns, so that the dependence can be explained by instrumental effects.

(2) Results for groups F and G show that the secular decrease accelerates considerably with the increase of perihelion distance (again qualitatively the same result for the all three methods of treatment, and again borne out by P/Wolf, too). In case of a real consequence of aging the dependence would be reversed, because the mass loss is greater at small perihelion distances. An explanation in terms of instrumental effects does not contradict this dependence, because comets coming near to the Sun are observed, as a rule, by a greater variety of instruments, including low-power telescopes.

(3) Group C (the 10 brightest short-period comets — average brightness in maximum $6\overset{m}{.}7$) has the average secular decrease of the brightness M_r greater than the remaining comets. The reason of this difference is obscure.

(4) Group D (the 10 faintest comets of the collection — average brightness in maximum $13\overset{m}{.}0$) has the average secular decrease of M_r smaller than group C. The comets of this group differ from those of group C by the length of observing period. All comets of group D were discovered after 1896, one half of them after 1939. The observing material is more homogeneous than in group C, because within a shorter time the instruments and methods did not change so much. Comets of group D did not become brighter than $11\overset{m}{.}8$ at the maximum, so that they were unobservable in small instruments. This may be why the influence of the instrumental effects was small.

(5) A very small value of the average decrease of M_r for group E ($0\overset{m}{.}15$ per revolution) is probably due to a large dispersion produced by the bursts. Comets both with a secular increase and decrease of brightness appear in this group, and the average is not sufficiently representative.

(6) Table 45 shows a conspicuous difference between the values of M_{42} and M_r in group I. This difference ($+0\overset{m}{.}40$ per revolution) is probably due to two following effects:

a) A high brightness of these comets during the first apparition is often followed by an rather constant, but considerably lower brightness at the later returns. For example (sets of M_{42} — thick figures were omitted in calculating M_r): P/Arend—Rigaux — **10.8** — 14.6 — 13.7 — 14.6, P/Harrington—Abell — **13.9** — 14.6 — 14.7, P/Arend — **10.1** — 12.1 — 13.1.

b) During the last decades observation of comets of extremely low brightness with large telescopes often allowed to estimate only the brightness of the nuclear condensation. For example (sets of M_{42} — thick figures were omitted in calculating M_r): P/Wirtanen — **14.0** — 14.2 — 13.9 — 13.6 — **16.3**, P/Johnson — **9.4** — 9.4 — **13.1** — **13.4**, P/Ashbrook—Jackson — **6.7** — 5.8 — 7.2 — **11.2.**

(7) The substantial difference between values M_{42} and M_r in group D can be explained by the same effects as in group I, because both groups have 50% of comets in common.

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7. Time Variations of the Secular Brightness

In our rather representative material (282 apparitions of short-period comets), time variations of the secular brightness from 1860 to 1970 should be detectable even without distinguishing between individual comets. For this purpose differences in M_r between each two successive returns were calculated. P/Tempel 1 between the 3rd and the 17th return, and P/Perrine—Mrkos between the 3rd and the 11th return were not taken into account, because the large time lapse would misrepresent the results. In the case of a smaller number of unobserved returns we assumed a linear brightness decrease, with interpolated values. Individual values of secular changes were attributed to the aphelion passages between the two apparitions in question, and rounded off to 0.5 year and 0.05 magnitude.

Table 46 includes the resulting averages and medians with t denoting the epoch, n — the number of differences Δm falling into this interval, Δm_a — the average brightness variation per revolution, and Δm_m — the median of the individual variations per revolution.

Table 46

t	n	Δm_a	Δm_m
1860	4	+0.20	0.00
1870	4	+0.42	+0.30
1880	7	−0.10	0.00
1890	11	+0.90	+1.10
1900	15	+0.07	+0.15
1910	13	+0.87	+0.65
1920	15	+0.22	−0.25
1930	8	+0.06	+0.20
1935	10	+0.48	+0.78
1940	18	+0.01	−0.35
1945	15	−0.06	+0.20
1950	12	+0.68	+0.35
1955	20	+0.89	+0.38
1960	16	+0.07	+0.15
1965	19	−0.99	−0.30
1970	9	−0.41	−0.80

The values of Δm_a (full dots) and Δm_m (open circles) are plotted against time t in Figure 46. The figure shows a strong increase of Δm from 1890 to 1910, another increase from 1950 to 1960 and a transition into negative values after 1960. The first increase can be associated with the introduction of astronomical photography and constructions of large refractors, the second increase with the commencement of systematic searches for faint comets with large reflectors. Certain similarities with Figure 45 (e.g. the increase about 1890 and the decrease after 1960) are apparent, which is an important argument in favour of the explanation by instrumental effects.

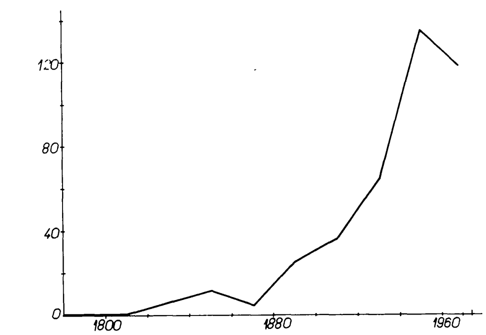

Fig. 45. Characteristic diameters of the telescopes used.

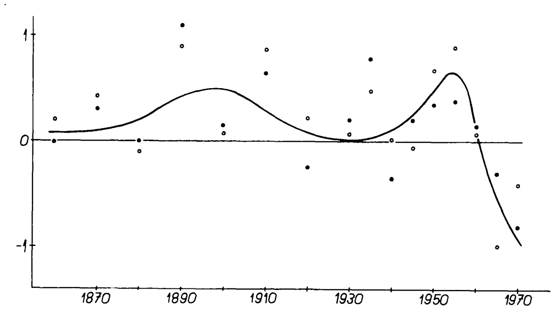

Fig: 46. Time variations of the secular brightness.

8. Conclusions

It was found that the values of secular variations of the brightness derived from Vsekhsvyatskii's values $H_{10} = M_v$ are in reasonable agreement with those derived from the maximum apparent magnitudes in each return, the weighted average being $0^m.36$ per revolution in both cases. The elimination of the discovery apparitions, and of estimates of the brightness of the nuclear condensation, resulted in a better homogeneity of the data and in a significant decrease of the secular variations, the weighted average of 37 comets being $0^m.22$ per revolution, i.e. only 61% of Vsekhsvyatskii's value.

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The individual values of the secular brightness variations are rather unreliable for the comets with a low number of observed returns; this is evident from Figure 43. The few secular increases of brightness belong exclusively to comets with very few observed returns and deserve a very low degree of reliability.

The dispersion of the secular variations was found to decrease considerably with the length of the observing period. In short time intervals the real variations are completely masked by random fluctuations in the brightness.

In section 5 it was demonstrated that the application of maximum brightness eliminated instrumental effects unsatisfactorily, and corrections on the magnification and aperture of the telescopes should be used for the reduction of maximum apparent magnitudes, too.

Section 6 compares the secular variations brightness for selected subsamples of comets. A definite dependence of the rate of secular variations upon the orbital period was established. An acceleration of the secular decrease with the increase of the orbital period was found both for different subsamples (group A and B), and for an individual object (P/Wolf). Secular variations tend to accelerate with the increase of the perihelion distance. Both these dependences can hardly be interpreted physically, however they can be readily explained by instrumental effects.

An investigation of time variations of the secular brightness decrease from 1860 to 1970, without distinguishing between individual comets, indicated a steep increase of the rate $\Delta m/P$ from 1890 to 1910, another increase from 1950 to 1960, and transition into negative values after 1960.

Acknowledgements

The author would like to thank Dr. Ľ. Kresák for his valuable suggestions, Dr. E. Pittich and Mr. M. Litavský for preparing the programs for the computers and Mr. T. Čiško for drawing the figures.

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SEKULÁRNE ZMENY ABSOLÚTNEJ JASNOSTI KRÁTKOPERIODICKÝCH KOMÉT

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Súhrn

Na základe maximálnych zdanlivých jasností v jednotlivých návratoch sa skúmajú sekulárne zmeny absolútnej jasnosti krátkoperiodických komét. Ukazuje sa, že i maximálne zdanlivé jasnosti sú zaťažené systematickými chybami prístrojov. Vylúčenie nezávislých objavov a odhadov jasnosti jadra, resp. stredovej kondenzácie viedlo k podstatne nižším hodnotám sekulárneho poklesu, než boli skôr určené hodnoty od iných autorov.

Pre celý súbor krátkoperiodických komét s obežnou dobou menšou ako 28 rokov sa zistila priemerná váhovaná hodnota sekulárneho poklesu jasnosti $+0^{m}_{.}22$ za obeh. Rozbor vybratých skupín komét ukázal výrazné zrýchľovanie sekulárnych zmien s rastúcou vzdialenosťou perihélia i s rastúcou obežnou dobou. Pre tieto závislosti je ťažké nájsť fyzikálne vysvetlenie, obe však svedčia v prospech prístrojových efektov. V práci sa skúmali aj sekulárne variácie jasnosti súboru krátkoperiodických komét bez rozlíšenia na jednotlivé kométy pre obdobie 1860—1970.

ВЕКОВЫЕ ИЗМЕНЕНИЯ АБСОЛЮТНОГО БЛЕСКА КОРОТКО-ПЕРИОДИЧЕСКИХ КОМЕТ

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Резюме

Исследуется изменение абсолютного блеска коротко-периодических комет на основании их максимальных видимых звездных величин в отдельных возвращениях. Показано, что даже максимальные видимые звездные величины отягощены систематическими ошибками приборов. Исключение независимых открытий и тоже оценок блеска ядра, или-же центральной конденсации, вело к существенно более низким значениям векового падения по сравнению с прежными значениями, определенными другими авторами.

Для всех коротко-периодических комет с периодом обращения меньше 28 лет было вычислено среднее весовое значение векового падения $+0^{m}_{.}22$ в обращение. Анализ избранных групп комет показал очень выразительную зависимость ускорения падения блеска с увеличением перигелийного расстояния и тоже с увеличением периода обращения. Очень трудно найти для этих зависимостей какое-либо физическое объяснение, обе они говорят, однако, в пользу систематических ошибок приборов. Исследуются тоже временные вариации векового блеска целого комплекса коротко-периодических комет с 1860 до 1970 гг., без различения отделных комет.

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