# ANALYSIS OF OBSERVATIONS OF LONG-PERIOD COMETS AT MAXIMUM HELIOCENTRIC DISTANCES

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ABSTRACT. The historical evolution of extreme observations is analysed using compiled material and determined comet brightnesses at large distances from the Sun. It is demonstrated that the brightness does not increase linearly with time, but that it contains two distinct jumps probably due to the development of observation equipment. In each observation interval, the values of the brightness at the time of extreme observation $m_o$ are concentrated in a narrow interval of 3-4 magnitudes, which enables the duration of the interval over which the individual objects can be observed to be predicted fairly reliably. A statistical comparison is also made of the northern and southern hemisphere data, as well as of the dependence of brightness $m_o$ on the absolute brightness of the comet $M$. Using the extrapolation of the empirical dependence, the possibility of observing P/Halley until its aphelion in 2024 is predicted.

АНАЛИЗ НАБЛЮДАНИЙ ДОЛГО-ПЕРИОДИЧЕСКИХ КОМЕТ НА ЭКСТРЕМНЫХ РАССТОЯНИЯХ ОТ СОЛНЦА. На основании собранного материала и определенных кривых блеска комет на больших расстояниях от Солнца сделан анализ исторической эволюции экстремных положений долго-периодических комет. Приводится, что блеск во время экстремного наблюдения $м_о$ не растёт линейно с временем, а содержит два выразительных скачка, причиненные вероятно эволюцией наблюдательных приборов. Величины $м_о$ в отдельных промежутках времени сосредоточены в узкий интервал 3-4 звездных величин, из чего может быть довольно достоверно предсказана дли-

на наблюдательного периода для отдельных объектов. Статистически тоже сравниваются данные из северного и южного полушарий и зависимость блеска $m_0$ от абсолютного блеска кометы M . На основании экстраполяции эмпирического отношения предсказана возможность наблюданий кометы Галлея вплоть до афелия в 2024 году.

ANALÝZA POZOROVANÍ DLHO-PERIODICKÝCH KOMÉT V MAXIMÁLNYCH HELIOCENTRICKÝCH VZDIALENOSTIACH. Na základe zozbieraného materiálu a určených priebehov jasností komét vo veľkých vzdialenostiach od Slnka je urobený rozbor historického vývoja extrémnych pozorovaní. Je ukázané, že jasnosť v čase extrémneho pozorovania $m_0$ nerastie s časom lineárne, ale obsahuje dva výrazné skoky spôsobené pravdepodobne vývojom pozorovacej techniky. Hodnoty $m_0$ sú v každom časovom úseku sústredené do úzkeho intervalu 3-4 magnitúd, čo umožňuje dosť spoľahlivo predpovedať dĺžku obdobia pozorovateľnosti pre jednotlivé objekty. Štatisticky sú tiež porovnávané údaje zo severnej a južnej pologule a závislosť jasnosti $m_0$ na absolútnej jasnosti kométy M . Na základe extrapolácie empirickej závislosti je predpovedaná možnosť pozorovania P/Halley až do afélia v roku 2024.

## 1. INTRODUCTION

This analysis is based on a set of brightness of long-period comets selected according to the two following criteria:

(1) The observability of the comet at large distances from the Sun over a sufficient range of heliocentric distances, which is the condition for reliably calculated photometric parameters.

(2) Knowledge of reliably determined orbits which would enable differentiation between old and new comets in Oort's sense (1950).

The list of excerpted photometric data was published in Contr. Astron. Obs. Skalnaté Pleso (Svoreň, 1983; 1984a; 1985a). The compiled data were used to determine the brightness variations at large distances from the Sun and to calculate the photometric parameters M and n , defined as

$$M = m - 5 \log \Delta - 2.5\, n \log r \qquad (1)$$

The brightness variations and the calculated parameters were also published (Svoreň, 1984b; 1985b). In the former of these papers, the methods of determining the photometric parameters is discussed in detail.

## 2. HISTORICAL EVOLUTION OF EXTREME OBSERVATIONS

Table 1 presents a list of the extreme observations of comets (separately for the pre- and post-perihelion arc) in the order of maximum heliocentric distance $r_0$ , from which a brightness value is still available. For the sake of completeness, comets whose data were inadequate for calculating the parameters have also been included.

Table 1

List of the extreme observations of comets

| Comet | S | q | $t_o$ | d | $r_o$ | $\varphi_o$ | M | $m_o$ |
|---|---|---|---|---|---|---|---|---|
| 1927 IV | + | 3.68 | 310312 | (1.02) | 11.52 | 4 | 8.3 | 17.5 |
| 1947 VIII | + | 3.26 | 500911 | (0.91) | 9.55 | 5 | 8.2 | 18.0 |
| 1957 VI | + | 4.45 | 600925 | (1.02) | 9.43 | 4 | 13.1 | 20.2 |
| 1962 VIII | + | 2.13 | 650430 | 1.02 | 8.36 | 6 | - | 17.7 |
| 1972 XII | + | 4.86 | 750617 | 1.54 | 8.27 | 6 | - | 16.0 |
| 1974 XII | + | 6.02 | 761031 | 1.00 | 8.19 | 5 | - | 20.0 |
| 1946 VI | + | 1.14 | 481123 | 0.91 | 8.17 | 7 | 5.3 | 19.3 |
| 1969 I | + | 3.32 | 710530 | 2.29 | 7.98 | 6 | 7.9 | 21.0 |
| 1956 I | + | 4.08 | 580515 | (1.02) | 7.79 | 5 | 9.2 | 20.9 |
| 1955 VI | + | 3.87 | 571126 | (1.02) | 7.75 | 6 | 9.6 | 19.0 |
| 1907 IV | + | 0.51 | 090419 | (0.41) | 7.27 | 3 | - | 16.5 |
| 1951 I | + | 2.57 | 530119 | 2.08 | 7.26 | 5 | - | 18.0 |
| 1972 IX | + | 4.28 | 741110 | 2.29 | 7.14 | 6 | 4.9 | 20.5 |
| 1971 I | + | 3.28 | 730108 | 2.29 | 7.10 | 7 | 8.3 | 21.0 |
| 1932 VI | + | 2.31 | 340719 | 0.91 | 6.83 | 7 | 4.5 | 17.5 |
| 1949 I | + | 2.52 | 510304 | 1.52 | 6.80 | 5 | 9.7 | 19.0 |
| 1968 I | + | 1.70 | 691104 | 2.29 | 6.69 | 5 | - | 21.5 |
| 1950 I | + | 2.55 | 511103 | 2.08 | 6.66 | 6 | - | 20.0 |
| 1948 V | + | 2.11 | 500209 | 0.91 | 6.64 | 8 | 10.0 | 19.2 |
| 1947 I | + | 2.41 | 481002 | 2.08 | 6.32 | 9 | 7.2 | 18.5 |
| 1889 I | + | 1.81 | 900817 | 0.90 | 6.19 | 9 | - | 13.8 |
| 1957 VI | - | 4.45 | 560316 | 0.51 | 6.14 | 5 | - | 15.2 |
| 1936 I | + | 4.04 | 371112 | 0.61 | 6.06 | 9 | - | 17.0 |
| 1973 II | + | 2.15 | 740821 | 1.55 | 6.01 | 8 | 11.0 | 20.2 |
| 1925 III | + | 1.63 | 261231 | 0.61 | 5.88 | 10 | 7.7 | 17.0 |
| 1975 VIII | - | 3.01 | 740321 | 0.60 | 5.65 | 2 | 12.0 | 13.0 |
| 1972 VIII | + | 2.51 | 740226 | 2.29 | 5.58 | 10 | 11.7 | 19.6 |
| 1946 I | + | 1.72 | 470809 | 0.91 | 5.56 | 4 | 7.8 | 19.4 |
| 1949 IV | + | 2.06 | 510304 | 1.52 | 5.53 | 8 | 10.2 | 19.0 |
| 1930 IV | + | 2.08 | 310813 | 0.61 | 5.44 | 10 | 6.6 | 17.5 |
| 1957 III | + | 0.32 | 580411 | 1.02 | 5.35 | 10 | 12.0 | 21.0 |
| 1956 I | - | 4.08 | 541218 | 0.80 | 5.29 | 3 | - | 15.8 |
| 1962 VIII | - | 2.13 | 610901 | (1.22) | 5.26 | 9 | 11.6 | 14.0 |
| 1898 VII | + | 1.70 | 991201 | (0.30) | 5.22 | 4 | - | 16.7 |
| 1922 II | + | 2.26 | 240128 | - | 5.22 | 11 | 4.6 | 16.5 |
| 1975 VIII | + | 3.01 | 761121 | 0.41 | 5.21 | 10 | 10.8 | 16.1 |
| 1917 III | - | 1.69 | 160403 | (0.41) | 5.20 | 1 | 10.7 | 13.0 |
| 1973 XII | - | 0.14 | 730128 | 0.80 | 5.16 | 3 | 1.6 | 16.0 |
| 1925 I | + | 1.10 | 260512 | 0.61 | 5.15 | 11 | 5.3 | 16.5 |
| 1947 VI | + | 2.83 | 481002 | 2.08 | 5.08 | 11 | 6.5 | 20.0 |

Table 1 (cont.)

| Comet | S | q | $t_o$ | d | $r_o$ | $\varphi_o$ | M | $m_o$ |
|---|---|---|---|---|---|---|---|---|
| 1889 II | + | 2.26 | 900823 | 0.90 | 5.05 | 3 | - | 14.8 |
| 1955 VI | - | 3.87 | 540731 | 1.20 | 5.04 | 11 | - | 15.0 |
| 1957 V | + | 0.35 | 580709 | (1.02) | 5.04 | 9 | 7.8 | 19.0 |
| 1904 I | + | 2.71 | 050509 | 0.47 | 4.97 | 11 | 5.8 | 13.5 |
| 1973 XII | + | 0.14 | 741110 | 2.29 | 4.97 | 10 | 11.5 | 22.0 |
| 1959 I | + | 1.63 | 600421 | (1.02) | 4.92 | 11 | 17.8 | 19.7 |
| 1948 I | + | 0.75 | 490206 | 0.91 | 4.89 | 7 | 15.9 | 17.5 |
| 1962 III | + | 0.03 | 630125 | 1.02 | 4.88 | 1 | 16.1 | 20.4 |
| 1972 XII | - | 4.86 | 721115 | 0.51 | 4.87 | 11 | - | 13.0 |
| 1936 I | - | 4.04 | 350703 | (0.25) | 4.83 | 5 | - | 13.0 |
| 1932 VI | - | 2.31 | 310814 | 0.26 | 4.78 | 11 | - | 13.0 |
| 1955 III | + | 0.53 | 560417 | 0.51 | 4.59 | 6 | 4.1 | 17.5 |
| 1970 II | + | 0.54 | 710120 | 2.29 | 4.50 | 13 | 13.2 | 18.9 |
| 1972 IX | - | 4.28 | 720609 | 1.22 | 4.48 | 10 | - | 13.0 |
| 1861 II | + | 0.82 | 620501 | - | 4.45 | 12 | - | 10.5 |
| 1890 II | + | 1.91 | 910529 | 0.71 | 4.45 | 12 | - | 15.0 |
| 1945 I | + | 2.41 | 460102 | 2.08 | 4.44 | 11 | 15.3 | 16.5 |
| 1948 II | + | 1.50 | 490128 | 0.60 | 4.41 | 11 | 1.1 | 17.5 |
| 1892 I | + | 1.03 | 930216 | (0.46) | 4.29 | 11 | - | 15.2 |
| 1907 I | + | 2.05 | 080226 | (0.42) | 4.29 | 12 | 5.0 | 14.2 |
| 1970 III | + | 1.72 | 710221 | 1.54 | 4.26 | 12 | 4.3 | 20.0 |
| 1914 V | - | 1.10 | 131217 | - | 4.25 | 10 | - | 11.0 |
| 1959 IX | + | 1.25 | 600926 | (1.02) | 4.22 | 13 | 15.4 | 19.1 |
| 1914 V | + | 1.10 | 150830 | 0.24 | 4.18 | 14 | - | 10.5 |
| 1931 III | + | 1.05 | 320415 | 0.61 | 4.16 | 14 | 0.9 | 17.5 |
| 1975 V | + | 1.22 | 760127 | 2.29 | 4.04 | 12 | - | 18.7 |
| 1895 IV | + | 0.19 | 960809 | - | 4.00 | 14 | - | 16.7 |
| 1949 I | - | 2.52 | 480715 | 0.50 | 3.92 | 9 | - | 15.5 |
| 1954 X | - | 0.97 | 531015 | 1.20 | 3.81 | 15 | - | 15.0 |
| 1927 IV | - | 3.68 | 270310 | 0.50 | 3.69 | 14 | - | 10.0 |
| 1945 I | - | 2.41 | 440418 | - | 3.66 | 5 | - | 14.5 |
| 1976 VI | + | 0.20 | 760919 | 2.29 | 3.66 | 16 | - | 19.3 |
| 1950 I | - | 2.55 | 490520 | (0.25) | 3.60 | 7 | - | 12.5 |
| 1951 I | - | 2.57 | 500519 | 1.20 | 3.59 | 12 | 7.6 | 11.0 |
| 1912 II | + | 0.72 | 130526 | 0.32 | 3.58 | 11 | 10.8 | 14.0 |
| 1976 VI | - | 0.20 | 750810 | 1.00 | 3.57 | 7 | 2.8 | 16.5 |
| 1941 IV | + | 0.79 | 410917 | 0.91 | 3.53 | 7 | 1.4 | 17.0 |
| 1925 VII | + | 1.57 | 260610 | 0.61 | 3.47 | 16 | 4.1 | 14.5 |
| 1964 VI | + | 0.50 | 650126 | (1.02) | 3.44 | 4 | 12.4 | 19.2 |
| 1963 I | + | 0.63 | 631023 | 1.02 | 3.42 | 17 | 15.0 | 19.2 |
| 1970 III | - | 1.72 | 690723 | 0.80 | 3.39 | 13 | 5.9 | 14.0 |
| 1882 II | + | 0.01 | 830308 | - | 3.37 | 17 | 8.6 | 12.5 |

Table 1 (cont.)

| Comet | S | q | $t_o$ | d | $r_o$ | $\varphi_o$ | M | $m_o$ |
|---|---|---|---|---|---|---|---|---|
| 1915 II | + | 1.01 | 160227 | 1.02 | 3.34 | 17 | - | 14.0 |
| 1969 I | - | 3.32 | 681219 | 0.33 | 3.32 | 15 | - | 13.0 |
| 1917 III | + | 1.69 | 180129 | - | 3.24 | 16 | 5.1 | 15.0 |
| 1974 III | + | 0.50 | 740915 | 1.55 | 3.09 | 18 | - | 17.5 |
| 1930 IV | - | 2.08 | 291008 | (0.25) | 3.03 | 19 | - | 8.6 |
| 1959 I | - | 1.63 | 580907 | 0.33 | 2.86 | 10 | - | 14.0 |
| 1957 III | - | 0.32 | 561108 | 0.40 | 2.84 | 6 | - | 10.2 |
| 1881 III | + | 0.73 | 811122 | 0.38 | 2.67 | 22 | - | 11.5 |
| 1947 I | - | 2.41 | 461101 | (0.08) | 2.64 | 20 | - | 11.0 |
| 1889 I | - | 1.81 | 880903 | 0.30 | 2.60 | 19 | - | 11.0 |
| 1915 II | - | 1.01 | 150210 | - | 2.58 | 21 | - | 9.5 |

The individual data in the table indicate: Comet - the definitive designation of the comet; S - the - sign indicates the pre-perihelion arc of the orbit, the + sign the post-perihelion arc; q - perihelion distance in AU; $t_o$ - date of the extreme observations (the first two digits represents the last two digits of the year, the next two digits the month and the last two digits the day); d - diameter of the instrument objective used make the extreme observation, in metres (the instrument data, whose use can be assumed with large probability, but the author does not explicitly specify their use, are given in parentheses); $\varphi_o$ - phase angle at time $t_o$ in degrees; M - absolute brightness (this value is only given if it is characteristic for region $r_o$); $m_o$ - apparent brightness of comet at the time of the extreme observation.

The values in this table were used to construct several functions. Figure 1 documents the historical evolution of extreme observations and shows the gradual increase in the heliocentric distances, at which comets were observed, namely after their perihelion passage. Since this set does not contain short-period comets, it is understandable that the increase in $r_o$ for pre-perihelion observations is substantially smaller due to the unexpected appearance of the comet.

Figure 2 shows the evolution of the value of the apparent comet brightness $m_o$ at the time of observation at the maximum heliocentric distance over the last 120 years. In most cases the $m_o$-values are equal to the minimum apparent brightness recorded for the comet over the appropriate arc of the orbit. Exceptions are due to brightness increases in the region of extreme observation. Several conclusions can be drawn from the figure. Firstly, there is the increase in the value of $m_o$ with time, which is not linear, but contains two pronounced jumps in 1880-95 and 1945-50. This non-linearity was studied in connection with the progress in observation equipment. The study of the development of instruments is important because the diameters of the objectives of instruments used has increased substantially over the last four decades, namely in the region of extreme observations. Of the total of 66 extreme observations, for which instrument data are available, 47% were made with instruments whose

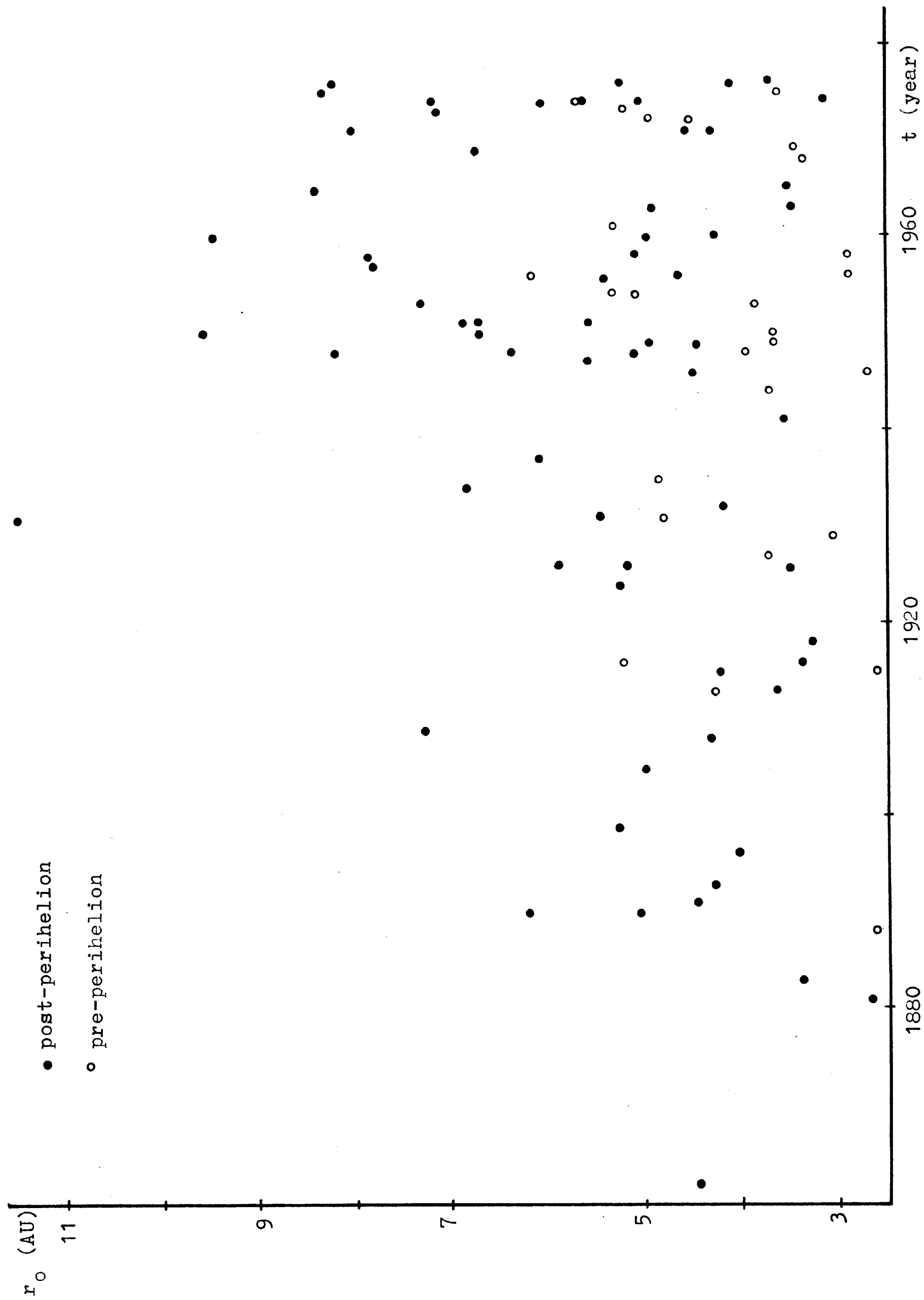


Fig. 1: The historical evolution of extreme observations

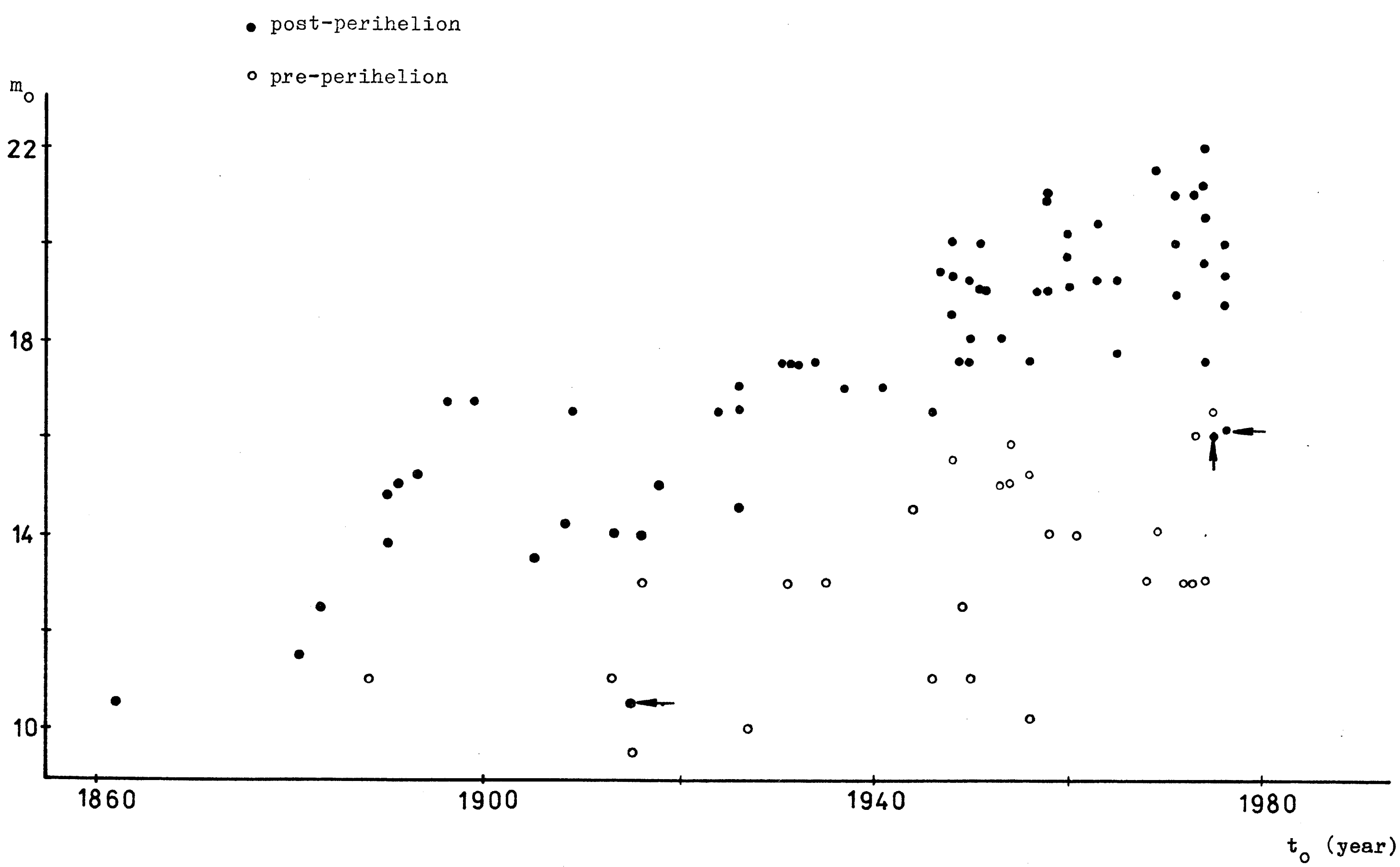


Fig. 2: The evolution of the value of the apparent comet brightness

diameter was over 1.0 m and 21% over 2.0 m. As regards pre-perihelion observations (18 available data) 28% of the instruments had diameters over 1.0 m and no instrument over 2.0 m; with post-perihelion observations (48 data) 54% over 1.0 m and 29% over 2.0 m. The increase in the diameters of telescope objectives, used in making extreme observations, with time is shown in Fig. 3. On the right of the diameter scale are the observers who made the largest series of extreme observations with the instruments indicated. By comparing Figs 2 and 3 one can see that they look very similarly, and that the jumps in the increase of the $m_0$-value with time is related to the progress in observation equipment. In the first period, 1880-95, this mainly involves the introduction of astronomical photography and Barnard's systematic observations with the 0.90-m refractor, and Holetschek's and Spitaler's observations with the 0.71-m refractor. After World War II, the beginning of systematic observations of comets using large reflectors, namely Van Biesbroeck's (2.08-m reflector) and Cunningham's (1.52-m reflector) observations and later Roemer's observations (1.54 and 2.29-m reflectors).

The other outstanding feature is the gradual increase in the $m_0$-value also for pre-perihelion observations. With a view to the smaller number of photometric data of this kind, a faster increase can only be observed in the second of the periods mentioned above. The figure shows that the $m_0$-values are concentrated into a relatively narrow interval of 3-4 magnitudes in each time interval. This can be used to predict, fairly reliably, the duration of the period of observability of the individual objects. During the last decade, the middle of this interval has shifted to the value of $20^m$, reducing the number of comets which stopped being observable due to their small angular distance from the Sun considerably, because they can mostly be observed during the next suitable observation period. Three values of the post-perihelion observations (indicated by arrows in Fig. 2) deviate distinctly from the general tendency, because the comets stopped being observable much sooner than the other comets of this set in the appropriate period. This discrepancy is the larger since the observations were concluded under relatively favourable geometrical conditions (angular distance from the Sun, etc.). It was found that the probable cause in two cases was the larger negative declination of the object (1914 V (Delavan) had a declination of $-51^{\circ}$ and 1972 XII (Araya) $-24^{\circ}$ at the time of extreme observations) which prevented the objects from being observed by large telescopes from the Northern Hemisphere. The reason why these comets were not observed from the Southern Hemisphere is not the lack of large instruments, but rather that these instruments began to be used regularly also for observing faint comets only recently. In the third case, comet 1975 VIII (Lovas), the reason is that the plotted value refers to the last brightness data recorded on Nov. 21, 1976. Nearly a year later (Sep. 11, 1977) Shao et al. (1977) obtained its precise position photographically with a 1.55-m reflector at a distance of $r$ = 7.26 AU, however, they gave no brightness data.

These conclusions are also supported by the statistics of extreme observations processed separately for the Southern and Northern Hemispheres. Of the total number of 92 extreme observations used in this study, 81 originate from

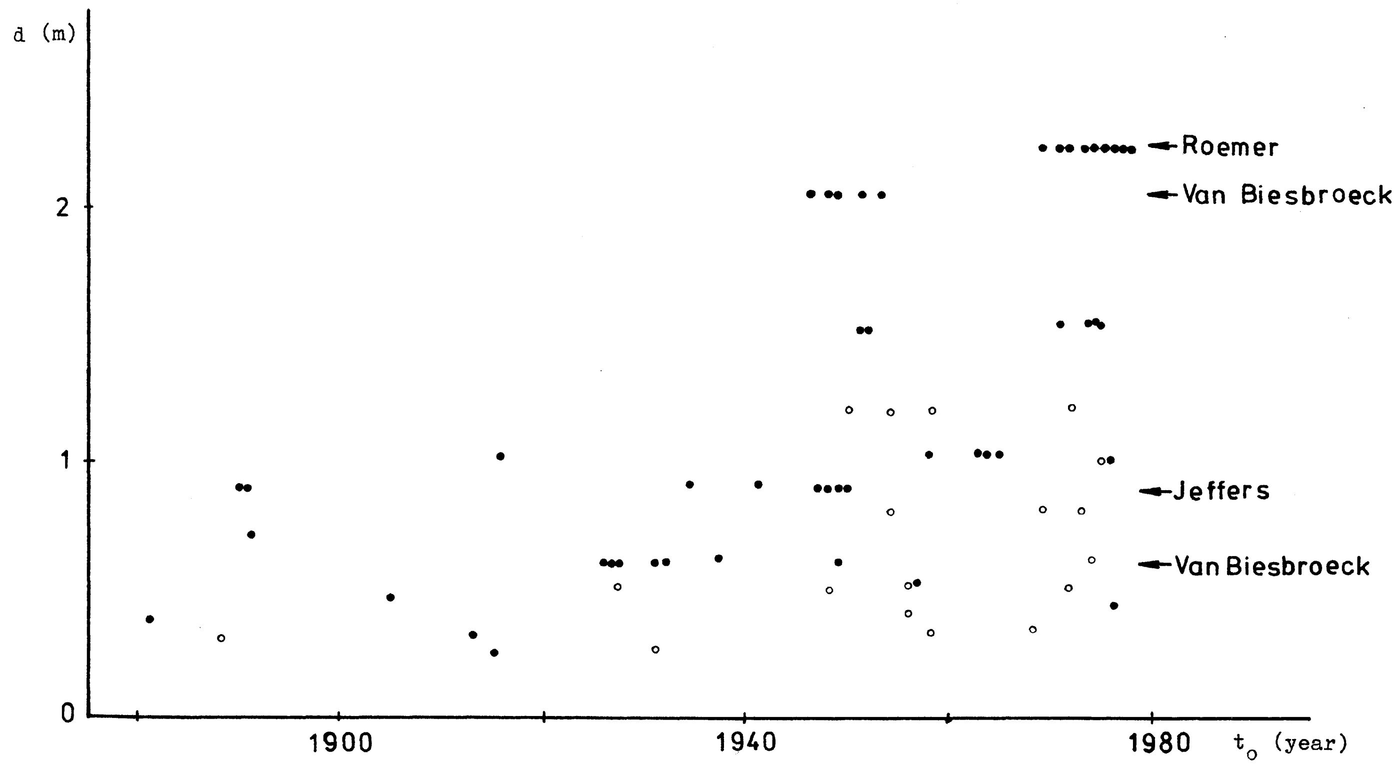


Fig. 3: The increase in the diameters of telescope objectives, used in making extreme observations

• post-perihelion

o pre-perihelion

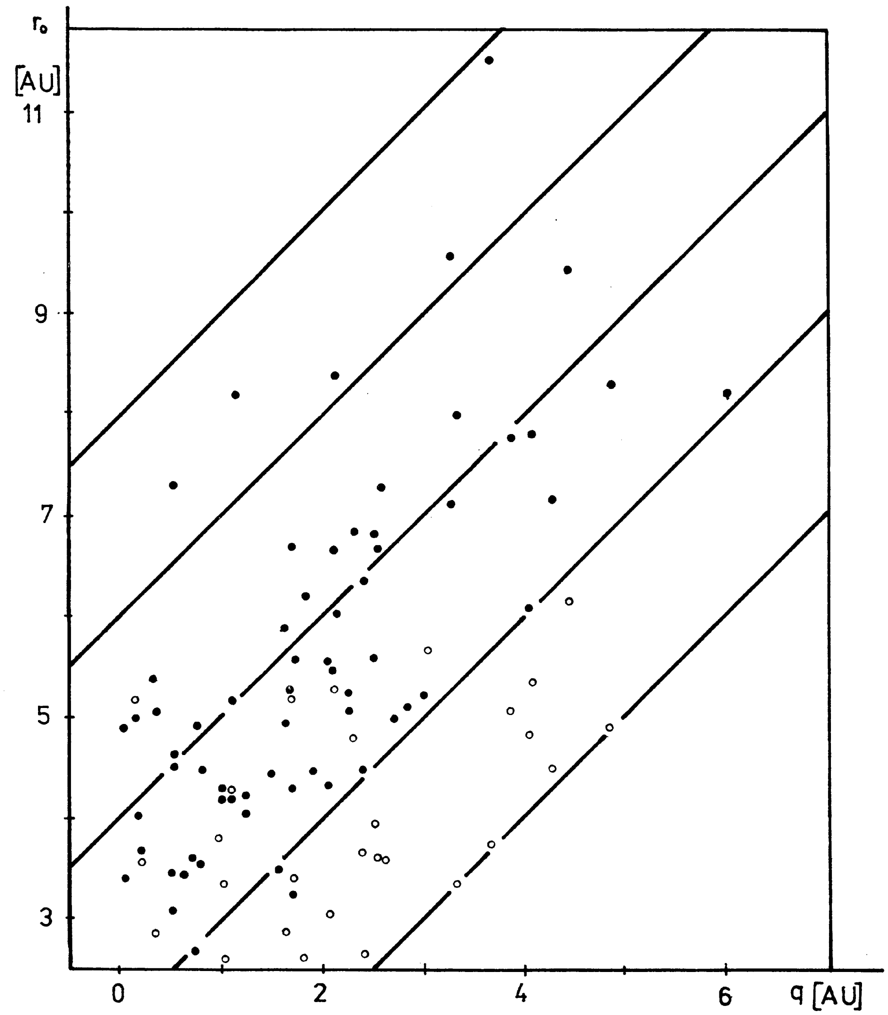


Fig. 4: The extreme distances $r_o$ plotted against the perihelion distance q

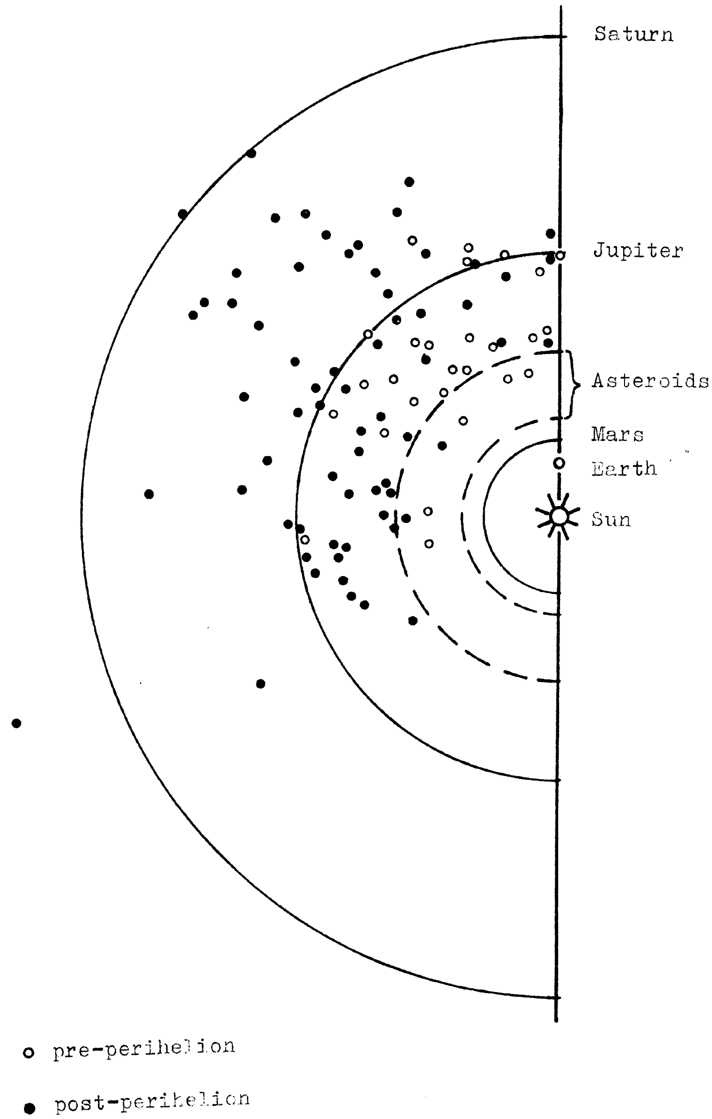


Fig. 5: The positions of the comets at the time of extreme observations

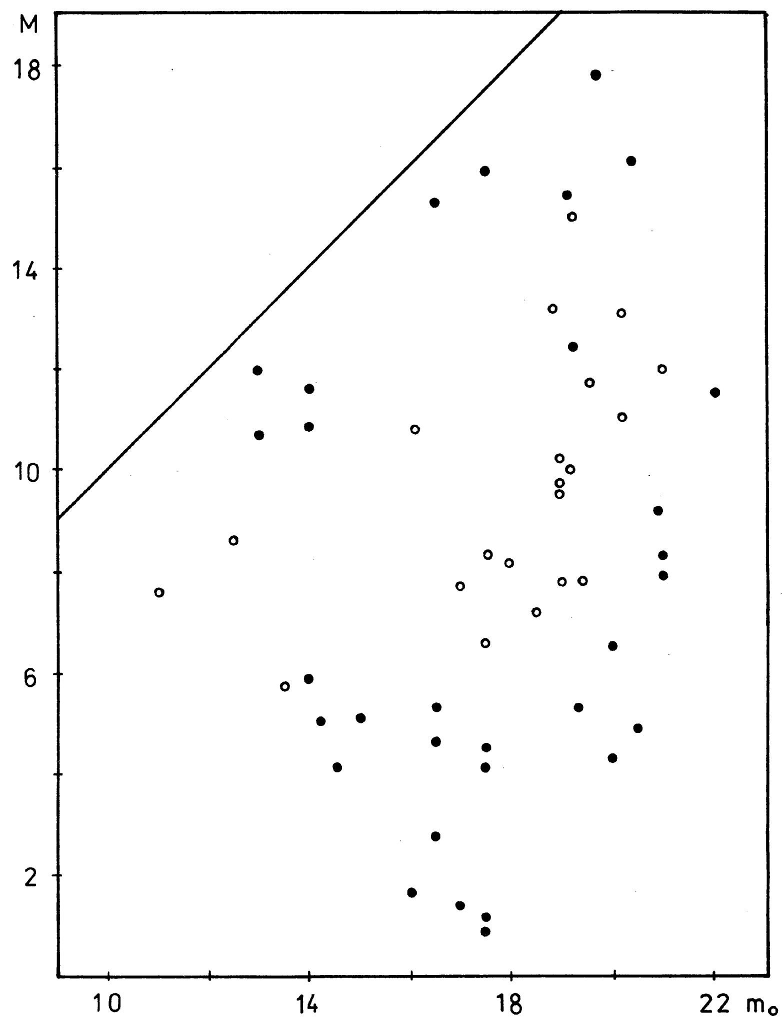


Fig. 6: The dependence of the absolute brightness M and the apparent brightness $m_o$

observatories in the Northern Hemisphere and only 11 (14%) from the Southern Hemisphere. The median of $m_o$ is $17.0^m$ for the Northern and $13.0^m$ for the Southern Hemisphere. The pre-perihelion observations are apparently less affected by the absence of observations with large instruments. If only the post-perihelion observations are compared, the difference is even larger: of the 60 extreme observations only 5 were made in the Southern Hemisphere.

Figure 4 shows the extreme distances $r_o$ plotted against the perihelion distance q . The oblique lines are equidistant relative to the perihelion (0, 2, 4, 6 and 8 AU). Since objects at $r_o > 2.5$ AU were studied, some of the physical processes, in particular the onset of the main molecular emissions, discovered by Kresák (1973) in short-period objects, could not be investigated.

Figure 5, constructed in very much the same way as Kresák's (1973) figure for short-period comets, shows the positions of 92 comets at the time of extreme observation, relative to the fixed positions of the Sun and Earth folded into the half-plane. The figure enables the heliocentric and geocentric distances as well as phase angles to be read directly. Mars, Jupiter and Saturn are plotted at mean distances, the asteroids in the main belt (1.8 - 3.2 AU). As compared to the short-period comets, one can see that in this case a considerable number of comets is in region $\varepsilon_o > 90^o$. Due to the preferred discovery of comets at large heliocentric distances using the photographic method, the pre-perihelion observations are concentrated more at the opposition than the post-perihelion values, which are distributed more uniformly in dependence on $\varepsilon_o$.

The dependence of the absolute brightness $M$ and apparent brightness $m_o$ at the time of extreme observation is shown in Fig. 6. The third parameter is the exponent $n$. The comets whose brightness variation is close to the brightness variation of the inactive nucleus, i.e. $n \in \langle 1.0, 3.0 \rangle$, are marked by white circles. Comets with the photometric exponent $n < 1.0$ are above this group, and comets whose exponent is larger than 3 below it. The objects with the largest values of $n$ being in the lower right-hand corner. The groups of comets, distributed with regard to $n$, form areas in the graph, whose longer axes are roughly parallel with the line $m_o = M$ (the plotted oblique line). The formation of these groups has no physical base, but is the result of the method used to process the data. The "width" of the area, reckoned perpendicular to line $m_o = M$, is directly proportional to the variability of the geometrical conditions of the various objects at the time of observation at maximum heliocentric distance (Fig. 5). In determining the absolute brightness, only linear dependence was considered, and the figure discussed contains only the parameter characteristic of the region of extreme observation. It is thus evident that the areas mentioned above would reduce to lines parallel with line $m_o = M$, if all the comets were at the same geocentric and heliocentric distances at the time of extreme observation.

## 3. APPLICATION TO P/HALLEY

Of the values of the apparent brightness of the comets $m_o$ at the time of observation at maximum heliocentric distance, the smallest brightness observed in each quarter of a century in the interval 1850-1975 was chosen. The discovery observation of P/Halley, satisfying the above condition, was taken for the current quarter century. The resultant regression line of this empirical dependence is

$$\text{magnitude} = -177.1289 + 0.1013 \cdot \text{year} \qquad (2)$$

For the time of the nearest aphelion passage of P/Halley, i.e. the year 2024, the brightness comes out as $27.9^m$, which should be sufficient for detection with the observation instruments to be used at that time.

The fact that this estimate of our possibilities is realistic is supported by the plan to have 3 cameras, fixed to the 2.4-m f/24 RC Space Telescope (Giacconi, 1982), operating even above this magnitude limit of $28^m$ much sooner than the year 2024.

Under the assumption that the brightness will change between heliocentric distance $r_o = 11.04$ and the aphelion with the photometric exponent $n = 2$ and neglecting the effect of the phase angle, which is justified at these heliocentric distances, the brightness at the time of discovery comes out as

$$m_o = M + 5 \log \Delta_o + 5 \log r_o \qquad (3)$$

and the brightness in the aphelion as

$$m_a = M + 5 \log \Delta_a + 5 \log r_a \, . \qquad (4)$$

This yeilds

$$m_a = m_o + 5 \log \frac{\Delta_a \, r_a}{\Delta_o \, r_o} \qquad (5)$$

After substituting the data from the catalogue of cometary orbits (Marsden, 1986) and $m_o = 24.1^m$ , we arrive at $m_a = 29.1^m$ .

In other words, P/Halley will only be 1.1 magnitude weaker in the year 2024 than the present capability of the Space Telescope. We are thus justified in assuming that the improvement of observation equipment, which is probably progressing faster than linearly, wil enable this comet to be observed out to the aphelion and continually after that.

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