DETERMINATION OF PHOTOMETRIC PARAMETERS OF LONG-PERIOD COMETS AT LARGE HELIOCENTRIC DISTANCES. II. COMETS OBSERVED IN THE YEARS 1947 - 1976

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Received 20 September 1984

ABSTRACT. Based on collected photometric observations of long-period comets, their photometric parameters at large distances from the Sun have been determined. This paper covers the years 1947 - 1976. The last section contains some qualitative conclusions obtained by investigating instrumental effects on the accuracy of comet brightness data, as well as a comparison of the brightness variations for various parts of the comets. An interesting result, for example, is the finding that the value of the instrumental correction also depends on the apparent brightness of the comet and may take positive and negative relative values for the same pair of observers. A large difference in the values of photometric exponents was reliably determined in some comets for the total brightness and for the brightness of the central condensation. Large systematic differences (as much as 7.5 stellar magnitudes) were found to exist between individual observers and methods of estimation. In comparison with the data on the brightness of the central condensation, the data on the total brightness are less sensitive to change of instrument, provided objects of large areas, comparable with the dimensions of the instrument viewing field, are not involved.

ОПРЕДЕЛЕНИЕ ФОТОМЕТРИЧЕСКИХ ПАРАМЕТРОВ ДОЛГО-ПЕРИОДИЧЕСКИХ КОМЕТ НА БОЛЬШИХ ГЕЛИОЦЕНТРИЧЕСКИХ РАССТОЯНИЯХ. КОМЕТЫ НАБЛЮДАВШИЕСЯ В 1947-1976 ГГ. На основании собранных фотометрических наблюдений долго-периодических комет в работе определены их фотометрические параметры на больших расстояниях от

Солнца. Представлена работа охватывает период 1947-1976 гг. В последней части приведены некоторые качественные заключения, полученные расследованием влияния приборных аффектов на точность величин блеска комет и сравнением кривой блеска для разных частей комет. Интересным результатом является обнаружение, что величина приборной поправки зависит также от видимой звездной величины кометы и для той же самой пары наблюдателей может достичь положительных и отрицательных относительных величин. Для некоторых комет была достоверно получена большая разница величин фотометрических показателей степени для общего блеска и блеска центрального сгущения. Обнаружено присутствие больших систематических разниц (вплоть до 7,5 звездных величин!) между отдельными наблюдателями и методами оценок. Изменения приборов оказывают меньше влияние на интегральный блеск кометы чем на блеск центрального сгущения, если не наблюдаем больших объектов, сравнительных по размерам дуги с полем зрения приборов.

URČENIE FOTOMETRICKÝCH PARAMETROV DLHOPERIODICKÝCH KOMÉT VO VEĽKÝCH HELIOCENTRICKÝCH VZDIALENOSTIACH. KOMÉTY POZOROVANÉ V ROKOCH 1947-1976. Na základe zozbieraných fotometrických pozorovaní dlhoperiodických komét sú v práci určované ich fotometrické parametre vo veľkých vzdialenostiach od Slnka. Predložená práca zahŕňa obdobie rokov 1947-1976. V poslednej časti sú uvedené niektoré kvalitatívne závery získané vyšetrovaním vplyvu prístrojových efektov na presnosť údajov o jasnosti komét ako aj porovnaním chodu jasnosti pre rôzne časti komét. Zaujímavým výsledkom je napr. zistenie, že veľkosť prístrojovej korekcie závisí aj od zdanlivej jasnosti kométy a môže pre tú istú dvojicu pozorovateľov nadobúdať kladné i záporné relatívne hodnoty. U niektorých komét sa spoľahlivo zistil veľký rozdiel v hodnotách fotometrických exponentov pre celkovú jasnosť a pre jasnosť centrálnej kondenzácie. Zistila sa prítomnosť veľkých systematických rozdielov (až 7,5 hviezdnych veľkostí!) medzi jednotlivými pozorovateľmi a metódami odhadov. Údaje o celkovej jasnosti komét sú v porovnaní s údajmi o jasnosti centrálnej kondenzácie menej citlivé na zmenu prístroja, pokiaľ sa nejedná o veľké plošné objekty porovnateľné s rozmermi zorných polí prístrojov.

1. INTRODUCTION

The photometric observations of long-period comets at large distances from the Sun, already published in three parts (Svoreň, 1983; 1984a; 1985) were used to determine the photometric parameters of comets at large r's. The photometric parameters involved are: M, n - the absolute brightness and photometric exponent which is obtained by reducing Holetschek's relation (1893) to stellar magnitude:

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

These parameters have the advantage of being simple as compared to the parameters suggested by Vsekhsvyatskij (1936) who used an empirical law with three independent parameters to describe brightness changes. Although Eq. (1) is an interpolational relation, it is given preference even to Levin's relation (1943) based on interpreting physical processes which take place on the surface of the comet's nucleus and within the coma. The reasons for this are mainly historical because, in the past, the parameters M and n were used to analyse extensive photometric data sets.

This paper is the second part of a study which deals with determining the photometric parameters of long-period comets at large heliocentric distances. In the first part (Svoreň, 1984b) in which comets whose perihelion passage occured in the years 1861-1946 were analysed, also the factors affecting the accuracy in determination of the visual magnitude were given.

2. METHOD USED

In determining the parameters, the following procedure was adopted: for each series of observations we attempted to select an observer who was able to cover by observations the whole time interval and who was also able to observe in the region of extreme distances. The last condition is important for obtaing the most faithful determination of changes of the comet's brightness at large distances from the Sun. If such an observer was available, the parameters were calculated from his observations and the observations of the other observers were only used to calculate the correction for the scale of the primary observer. If observations of no observer were sufficient on their own to determine the photometric parameters, these were determine from the observations of observers who covered the larger range of heliocentric distances on their own. If the slopes of the regression lines and, consequently, also the photometric exponents differed by a small value only, mutual corrections were determined and the observations were reduced to a uniform scale, as a rule of the observer who observed at extreme distances from the Sun. Only after all the possibilities of determining the parameters exclusively from the data of the comet itself had been exhausted, were the corrections, determined for the appropriate pair of observers used for the other comets. Nevertheless, for some of the comets the existing photometric data were insufficient to determine the parameters in the region $r > 2.5$ AU. For comets, for which the data enabled the calculation, the photometric parameters n and M , derived from Eq. (1), together with the appropriate mean square deviations are given. Also the coefficient of correlation s between the quantities m_{Δ} and $2.5 \log r$ is given. Together with the values of M, n and s , the value m_m is given for all comets, i.e. the median of apparent magnitudes used in calculating the parameters. This value is important in assessing the actual observational conditions for the individual objects. In the preliminary processing of the material, all instrumental corrections, which the data enabled to be determined, were calculated. Since the use of an instrumental correction, derived for a single comet, for another object is only possible after a thorough analysis of the data, in this paper we only give the determinations of those instrumental corrections which were utilized in further processing.

If an absolute value of a correction was determined as equal to or smaller than $0\overset{m}{.}25$ for an individual comet, these observations were considered to have been made on a uniform scale with a view to the accuracy of the input photometric data.

3. CALCULATION OF PHOTOMETRIC PARAMETERS FOR INDIVIDUAL COMETS AND CONSTRUCTION OF PHOTOMETRIC CURVES FOR SELECTED OBJECTS WITH SUFFICIENT NUMBER OF RELIABLE DATA

The sets of brightness values were divided into five groups according to the quality of the basic photometric data and the possibility of determining the representative parameters:

Group A - The parameters can be determined from the observations of a single observer or from the data of several observers, but the corrections have only been determined from the data for the particular comet itself (pre- and post-perihelion observations of a same comet are formally considered to be observations of two different comets) and corrections, derived for other comets, were not used. The parameters are characteristic for the behaviour of the brightness in the region of extreme observations.

Group B - The parameters were determined as in Group A, the only difference being that, for some reasons, they are not characteristic for the behaviour of the brightness in the region of extreme observation.

Group C - The parameters were determined by combining the observations of a number of observers, all suitable corrections determined for groups A and B being applied. The parameters are characteristic for the brightness variation in the region of extreme observation.

Group D - the parameters were determined using the same procedure as in group C, the only difference being that they are not characteristic for brightness variations in the region of extreme observation.

Group E - The representative parameters could not be calculated.

The photometric parameters were determined from the pairs log r, m_Δ , which are given in the whole of this section together with the number N, i.e. the ordinal number of observation in agreement with the list of observations. The list of observations have already been published separately for comets up to 1955 (Svoreň, 1984a) and up to 1976 (Svoreň, 1985). In these two papers, further data concerning the observations and references to the literature used can be found by referring to the numbers N .

GROUP A

Comet 1947 I (Bester) - after perihelion

Three observers were considered with the largest number of observations and the best coverage of the interval (Van Biesbroeck, Boyer and Jeffers).

Beyer's observations were not considered because they only cover 0.035 AU. First, the photometric exponents were determined independently for each observer:

Table 1
Boyer's observations

N	log r	m_Δ
1	0.451	10.6
3	0.475	11.2
17	0.556	11.9
18	0.557	12.0
24	0.576	12.3
26	0.622	12.8

n = 4.8 ± 0.4 s = 0.99

Table 2
Jeffers' observations

N	log r	m_Δ
2	0.451	12.6
6	0.504	11.9
23	0.576	12.8
28	0.716	14.6
29	0.764	15.0

n = 3.8 ± 0.8 s = 0.94

Van Biesbroeck recorded an outburst of $1^m.9$ after July, 25, 1947, and a rapid decrease in brightness between Sept. 14 and Oct. 9, 1947 ($1^m.4$). This brightness behaviour is also substantiaied by Jeffers' observations, although the changes he observed were smaller either way. The parameters were, therefore, calculated from Van Biesbroeck's observations made only after this period of activity, i.e. beginning with Oct. 9, 1947.

Table 3
Van Biesbroeck's observations

N	log r	m_Δ
15	0.549	12.1
22	0.571	12.3
25	0.602	14.0
27	0.632	13.7
30	0.800	14.5

n = 3.4 ± 1.5 s = 0.81

With a view to the similarity of the inclinations of the regression lines, Boyer's and Jeffers' observations can be reduced to Van Biesbroeck's scale.

Table 4
Reduction of Boyer's observations to Van Biesbroeck's scale

log r	m_{Bo}	m_{Bi}	$m_{Bi} - m_{Bo}$
0.556	11.9	12.7	+ 0.8
0.557	12.0	12.7	+ 0.7
0.576	12.3	12.8	+ 0.5
0.622	12.8	13.2	+ 0.4

Average correction = + $0^m.60$.

Table 5
Reduction of Jeffers' observations to Van Biesbroeck's scale

log r	m_J	m_{Bi}	$m_{Bi} - m_J$
0.576	12.8	12.8	0.0
0.716	14.6	14.1	- 0.5
0.764	15.0	14.5	- 0.5

Average correction = $- 0\overset{m}{.}33$.

The resultant parameters were determined from Van Biesbroeck's original data, Jeffers' values corrected by $-0\overset{m}{.}3$ and Boyer' values corrected by $+ 0\overset{m}{.}6$ for the period after Oct. 9, 1947:

Table 6
Van Biesbroeck's, Boyer's and Jeffers' observations

N	log r	m_Δ	N	log r	m_Δ	N	log r	m_Δ
15	0.549	12.1	23	0.576	12.5	27	0.632	13.7
17	0.556	12.5	24	0.576	12.9	28	0.716	14.3
18	0.557	12.6	25	0.602	14.0	29	0.764	14.7
22	0.571	12.3	26	0.622	13.4	30	0.800	14.5

Resultant parameters:

$n = 3.9 \pm 0.6$ $\qquad s = 0.90$

$M = 7.2 \pm 0.9$ $\qquad m_m = 15.8$

Comet 1947 VI (Wirtanen) - after perihelion

Only Van Biesbroeck's and Jeffers' observations were considered in calculating the parameters, all the other observations being in the interval of 0.001 AU. Since Van Biesbroeck's private communication to Bobrovnikoff (Bobrovnikoff, 1941) indicates that all Van Biesbroeck's unmarked observations are total brightness determined by the extrafocal method, the unmarked observations were taken to be m_1 . First, the photometric exponents for Van Biesbroeck and Jeffers were determined independently:

Table 7
Van Biesbroeck's observations

N	log r	m_Δ	N	log r	m_Δ	N	log r	m_Δ
11	0.452	11.7	24	0.690	15.5	26	0.706	16.4
17	0.461	13.1	25	0.691	14.5	27	0.706	16.4
23	0.689	15.5						

$n = 5.6 \pm 1.0$ $\qquad s = 0.92$

Table 8
Jeffers' observations

N	log r	m_Δ	N	log r	m_Δ	N	log r	m_Δ
4	0.452	13.2	15	0.453	13.1	20	0.612	15.5
5	0.452	13.2	16	0.454	13.5	21	0.633	15.0
13	0.452	13.2	19	0.484	14.9	22	0.665	15.7

$n = 4.4 \pm 0.8$ $s = 0.90$

With a view to the similarity of the photometric exponents, the linear correction for reducing Jeffers' observations to Van Biesbroeck's scale was determined.

Table 9
Reduction of Jeffers' observations to Van Biesbroeck's scale

log r	m_J	m_{Bi}	$m_{Bi} - m_J$
0.452	13.2	12.3	- 0.9
0.452	13.2	12.3	- 0.9
0.452	13.2	12.3	- 0.9
0.453	13.1	12.3	- 0.8
0.454	13.5	12.3	- 1.2
0.484	14.9	12.7	- 2.2
0.612	15.5	14.5	- 1.0
0.633	15.0	14.8	- 0.2
0.665	15.7	15.2	- 0.5

Average correction = $- 0\overset{m}{.}96$.

The resultant parameters were determined from Van Biesbroeck's original observations and Jeffers' observations corrected by $- 1\overset{m}{.}0$:

Table 10
Van Biesbroeck's and Jeffers' observations

N	log r	m_Δ	N	log r	m_Δ	N	log r	m_Δ
4	0.452	12.2	17	0.461	13.1	23	0.689	15.5
5	0.452	12.2	19	0.484	13.9	24	0.690	15.5
11	0.452	11.7	20	0.612	14.5	25	0.691	14.5
13	0.452	12.2	21	0.633	14.0	26	0.706	16.4
15	0.453	12.1	22	0.665	14.7	27	0.706	16.4
16	0.454	12.5						

Resultant parameters:

$n = 5.2 \pm 0.5$ $s = 0.93$

$M = 6.5 \pm 0.8$ $m_m = 17.8$

Comet 1948 I (Bester) - after perihelion

The parameters were calculated from two Jeffers' values; consequently, they are very unreliable.

Table 11
Jeffers' observations

N	log r	m_Δ
1	0.599	14.6
2	0.689	14.4

Resultant parameters:
$n = -0.9$
$M = 15.9$ $m_m = 17.6$

Comet 1948 II (Mrkos) - after perihelion

The photometric exponents were first calculated separately for Boyer, Van Biesbroeck and Mrkos, and for the observations with the 0.91-m reflector (Jeffers, Mayall, Sill) - Fig. 1.

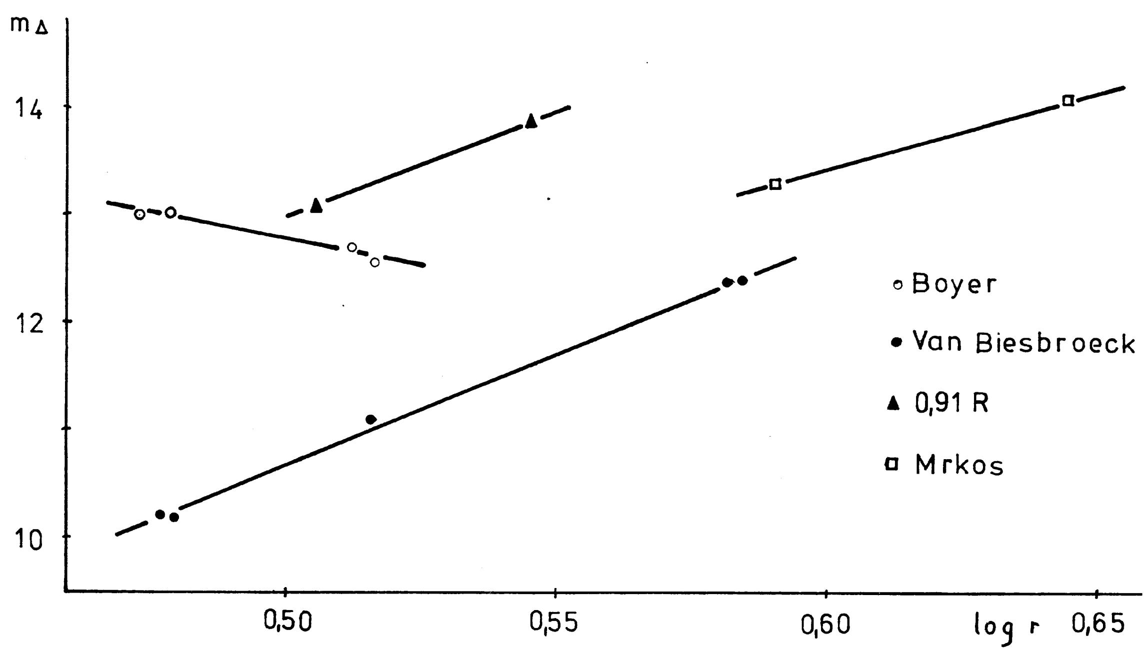

Fig. 1 : The changes of the brightness of Comet 1948 II after perihelion.

Table 12

Boyer's observations

N	log r	m_Δ
1	0.473	13.0
4	0.479	13.0

N	log r	m_Δ
6	0.513	12.7
8	0.517	12.6

$n = -3.6 \pm 0.4$ $s = 0.99$

Table 13

Mrkos' observations

N	log r	m_Δ
12	0.591	13.3
13	0.645	14.1

$n = 5.9$

Table 14

Observations of Jeffers et al.

N	log r	m_Δ
5	0.506	13.1
9	0.546	13.9

$n = 8.0$

Table 15

Van Biesbroeck's observations

N	log r	m_Δ
2	0.477	10.2
3	0.479	10.2

N	log r	m_Δ
7	0.516	11.1
10	0.582	12.4

N	log r	m_Δ
11	0.585	12.4

$n = 8.3 \pm 0.2$ $s = 1.00$

From the tables given above, one can see that the inclinations Van Biesbroeck's line and of the line derived from observations with the 0.91-m reflector are practically identical, and that Boyer's observations cannot be used because of the large difference in "n". Mrkos' values, which are at the limit of usability (again because of the large difference in "n") were taken into account as they contain extreme observation. The correction was determined from the interval log r = 0.585 - 0.591 by determining the extrapolated values for both lines and for the middle of this interval, i.e. log r = 0.588. This yielded the value $13\overset{m}{.}26$ for Mrkos and $12\overset{m}{.}51$ for Van Biesbroeck, the resultant correction being $m_{Bi} - m_M = -0\overset{m}{.}8$.

Table 16

Reduction of observations of Jeffers et al. to Van Biesbroeck's scale

log r	$m_{0.91}$	m_{Bi}	$m_{Bi} - m_{0.91}$
0.506	13.1	10.8	- 2.3
0.546	13.9	11.6	- 2.3

Average correction = $- 2\overset{m}{.}3$.

Table 17
Reduction Boyer's observations to Van Biesbroeck's scale

log r	m_{Bo}	m_{Bi}	$m_{Bi} - m_{Bo}$
0.479	13.0	10.2	- 2.8
0.513	12.7	11.0	- 1.7
0.517	12.6	11.0	- 1.6

The resultant parameters were determined from Van Biesbroeck's original values, Mrkos' data corrected by $- 0\overset{m}{.}8$ and the observations of Jeffers et al. corrected by $- 2\overset{m}{.}3$:

Table 18
Observations on Van Biesbroeck's scale

N	log r	m_Δ	N	log r	m_Δ	N	log r	m_Δ
2	0.477	10.2	7	0.516	11.1	11	0.585	12.4
3	0.479	10.2	9	0.546	11.6	12	0.591	12.5
5	0.506	10.8	10	0.582	12.4	13	0.645	13.3

Resultant parameters:

$n = 7.7 \pm 0.3$ $s = 1.00$

$M = 1.1 \pm 0.4$ $m_m = 12.4$

Comet 1948 V (Pajdušáková-Mrkos) - after perihelion

Observations of the nucleus were used for calculating the parameters, i.e. Beyer's values and Jeffers' and Sill's data containing extreme observation. The photometric parameters were first determined separately for both series of observations:

Table 19
Jeffers' and Sill's observations

N	log r	m_Δ	N	log r	m_Δ
89	0.551	13.4	110	0.822	15.2
109	0.777	14.5			

$n = 2.4 \pm 0.6$ $s = 0.97$

Table 20
Beyer's observations

N	log r	m_Δ	N	log r	m_Δ	N	log r	m_Δ
2	0.398	11.1	12	0.412	10.9	20	0.422	11.1
4	0.399	10.9	14	0.413	11.1	22	0.425	11.4
7	0.400	10.9	16	0.418	11.4	27	0.430	11.4
10	0.411	10.9	18	0.421	11.1	29	0.435	11.0

Table 20 (cont.)

N	log r	m_Δ	N	log r	m_Δ	N	log r	m_Δ
31	0.436	11.0	56	0.492	12.0	82	0.544	11.5
33	0.442	11.5	58	0.494	12.0	84	0.545	12.5
35	0.461	11.4	60	0.497	12.0	86	0.549	13.0
37	0.462	11.5	62	0.508	12.4	88	0.551	12.7
39	0.464	11.7	64	0.512	12.3	91	0.552	12.7
41	0.479	11.5	66	0.514	11.9	93	0.553	12.6
43	0.480	12.0	68	0.515	11.9	95	0.554	12.9
45	0.482	12.0	70	0.518	11.8	97	0.555	12.9
47	0.483	12.5	72	0.519	11.8	100	0.573	13.6
49	0.484	12.5	74	0.520	12.3	102	0.574	13.1
52	0.490	12.5	76	0.521	12.0	104	0.582	13.0
54	0.491	11.9	78	0.524	12.3			

$n = 4.6 \pm 0.4$ $s = 0.89$

With a view to the difference in the inclinations of the regression lines, it would be incorrect to reduce one series to the other using a single value (Sill's observation of Jan. 28, 1949). Therefore, the values derived from the data in Tab. 19, which also contain extreme observation, were adopted as the parameters:

$n = 2.4 \pm 0.6$ $s = 0.97$

$M = 10.0 \pm 1.1$ $m_m = 18.0$

Comet 1951 I (Minkowski) - before perihelion

The parameters were determined from Beyer's estimates m_1 which, like Van Biesbroeck's data, cover the whole interval of observations with the exception of narrow margins. They were preferred to Van Biesbroeck's data because there are more of them, absolutely and in the region of extreme observation (Fig. 2).

Table 21
Beyer's observations

N	log r	m_Δ	N	log r	m_Δ	N	log r	m_Δ
5	0.535	9.1	29	0.513	9.2	54	0.491	8.9
6	0.533	9.1	31	0.512	9.1	56	0.491	9.0
8	0.532	9.1	35	0.509	9.2	58	0.490	8.7
12	0.532	9.1	37	0.508	9.1	62	0.489	8.9
14	0.530	9.4	41	0.502	9.3	64	0.488	9.0
15	0.527	9.4	43	0.500	9.2	66	0.487	9.0
19	0.527	9.3	45	0.496	9.3	68	0.487	9.1
21	0.525	9.3	46	0.495	8.9	70	0.486	9.2
23	0.518	9.4	50	0.494	9.0	72	0.485	9.3
27	0.513	9.1	52	0.492	8.7	74	0.483	9.0

Table 21 (cont.)

N	log r	m_Δ
77	0.480	8.7
84	0.411	9.1

Resultant parameters:

$n = 1.2 \pm 0.5$ $\qquad s = 0.39$

$M = 7.6 \pm 0.7$ $\qquad m_m = 11.2$

The photometric exponent for Beyer's estimates m_2 is very similar ($n = 1.1 \pm 0.8$). To determine the correction, the regression line was computed

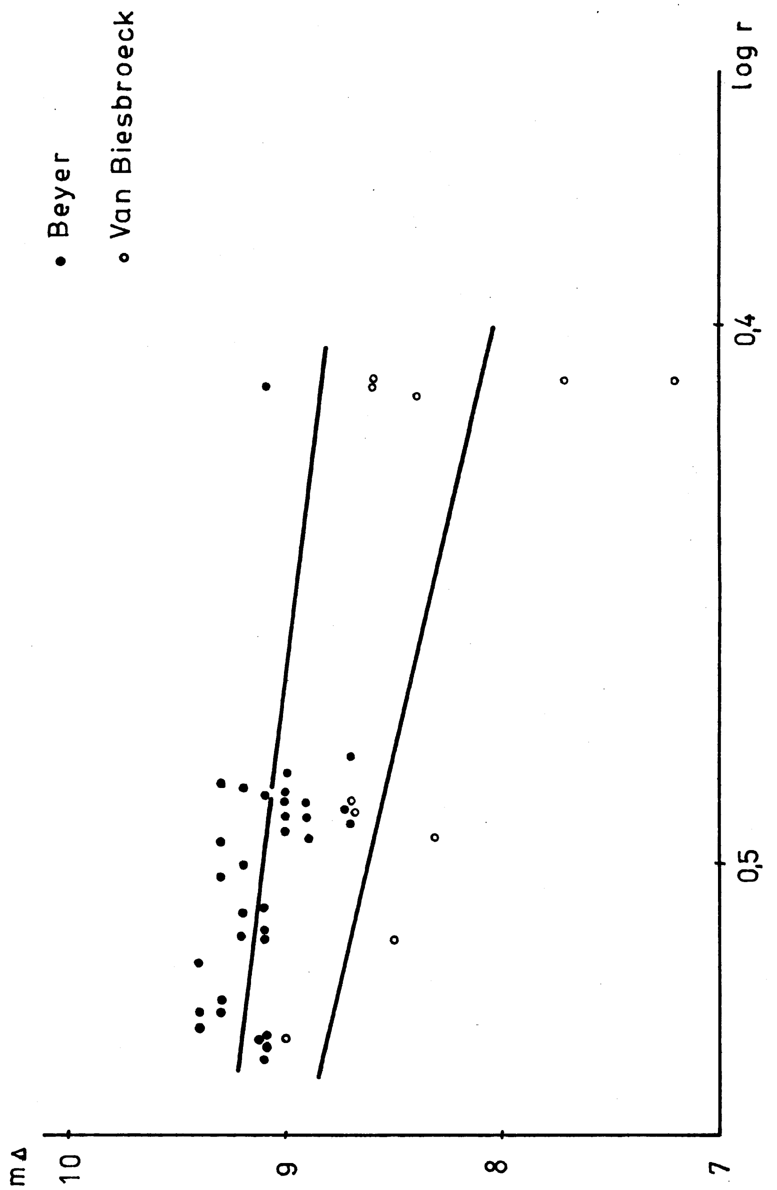

Fig. 2 : The changes of the brightness of Comet 1951 I before perihelion

separately for Van Biesbroeck's observations.

Table 22
Van Biesbroeck's observations

N	log r	m_Δ	N	log r	m_Δ	N	log r	m_Δ
11	0.532	9.0	61	0.489	8.7	83	0.411	8.6
26	0.514	8.5	80	0.413	8.4	86	0.410	7.7
48	0.495	8.3	82	0.411	8.6	87	0.410	7.2
60	0.490	8.7						

$n = 2.4 \pm 1.2$ $\quad M = 5.6 \pm 1.4$ $\quad s = 0.57$

Table 23
Reduction Boyer's observations to Van Biesbroeck's scale

log r	m_{Bo}	m_{Bi}	$m_{Bi} - m_{Bo}$
0.527	9.0	8.8	- 0.2
0.512	8.8	8.7	- 0.1

Table 24
Reduction of the observations of Hirose and Tomita to Van Biesbroeck's scale

log r	m_{H+T}	m_{Bi}	$m_{Bi} - m_{H+T}$
0.505	8.9	8.7	- 0.2
0.482	9.1	8.5	- 0.6
0.413	8.4	8.1	- 0.3

Comet 1955 VI (Baade) - after perihelion

For further processing, observations of 3 observers were chosen with the largest number of observations (Roemer, Beyer and Van Biesbroeck). Roemer's coverage of the interval proved to be most equable. The graphical representation in Fig. 3 can be used to decide about the character of Van Biesbroeck's data. The data from Aug. 14 and Oct. 12 and 13, 1955 are m_1 , whereas all the others are m_2 . As regards the m_2-values, the photometric exponents were first determined separately for each observer:

Table 25
Beyer's observations

N	log r	m_Δ	N	log r	m_Δ	N	log r	m_Δ
8	0.590	11.0	41	0.605	11.2	59	0.618	11.3
15	0.592	11.2	44	0.609	11.5	62	0.618	11.2
19	0.596	11.4	46	0.609	11.7	66	0.619	11.7
21	0.597	11.3	51	0.612	11.4	68	0.621	11.4
24	0.597	11.4	53	0.613	11.4	70	0.621	11.4
30	0.603	11.4	55	0.617	11.3	76	0.630	11.4
32	0.603	11.4	57	0.617	11.3	78	0.632	10.8

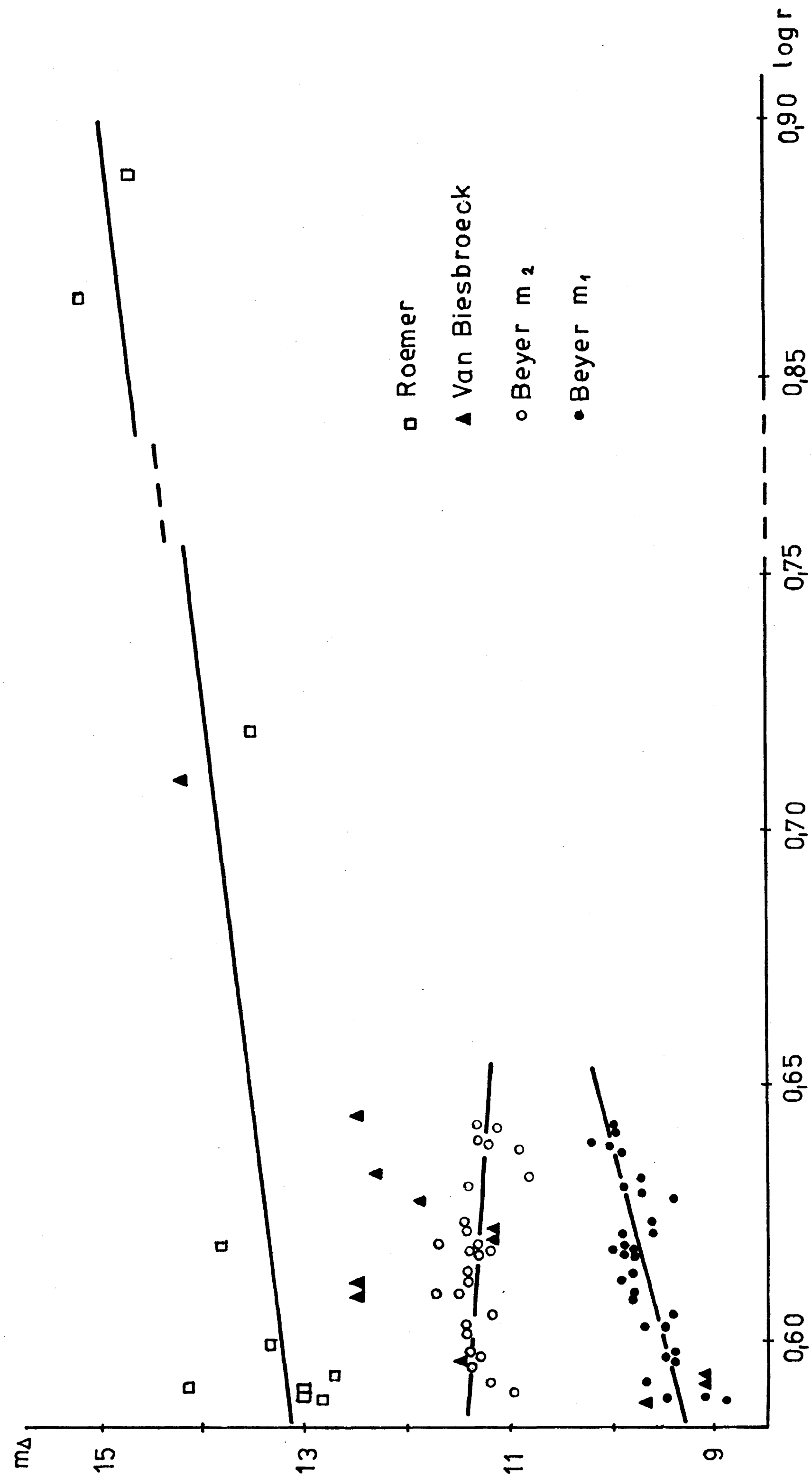

Fig. 3 : The changes of the brightness of Comet 1955 VI after perihelion

Table 25 (cont.)

N	log r	m_Δ	N	log r	m_Δ	N	log r	m_Δ
81	0.637	10.9	85	0.639	11.3	89	0.642	11.3
83	0.638	11.2	87	0.641	11.1			

n = - 1.3 ± 1.0   s = 0.25

Table 26
Van Biesbroeck's observations

N	log r	m_Δ	N	log r	m_Δ	N	log r	m_Δ
17	0.596	11.4	63	0.619	11.2	79	0.632	12.3
48	0.609	12.5	64	0.619	11.2	90	0.644	12.5
49	0.611	12.5	72	0.627	11.9	91	0.710	14.2

n = 9.2 ± 2.5   s = 0.81

Table 27
Roemer's observations

N	log r	m_Δ	N	log r	m_Δ	N	log r	m_Δ
3	0.588	12.8	16	0.593	12.7	92	0.720	13.5
7	0.589	13.0	26	0.599	13.3	94	0.865	15.2
9	0.590	13.0	27	0.599	13.3	96	0.889	14.7
10	0.591	14.1	60	0.618	13.8			

n = 2.3 ± 0.5   s = 0.84
M = 9.7 ± 0.8 m_m = 16.0

With a view to the difference in the inclinations of the regression lines, the observations were not reduced to one another. The values derived from Roemer's observations, containing extreme observation and providing best coverage of the whole interval, were adopted as the resultant parameters.

For comparison, the regression line was also computed from Beyer's m_1-values from the region of log r = 0.588 - 0.642 - and plotted in the graph (n = 5.0 ± 0.9 , s = 0.72).

Comet 1956 I (Haro-Chavira) - after perihelion

The observations of Roemer, Van Biesbroeck and Jeffers were taken into account. Apart from them, only Waterfield observed (once). The photometric exponents were first determined separately for each observer:

Table 28
Jeffers' observations

N	log r	m_Δ	N	log r	m_Δ
9	0.642	12.7	26	0.806	14.8
24	0.793	14.0			

n = 4.4 ± 1.4   s = 0.95

Table 29
Van Biesbroeck's observations

N	log r	m_Δ	N	log r	m_Δ	N	log r	m_Δ
2	0.610	12.0	10	0.643	12.2	16	0.745	12.4
4	0.620	12.8	11	0.652	12.6	17	0.747	13.4
5	0.620	12.8	12	0.653	12.6	18	0.747	13.4
7	0.627	11.7	14	0.696	12.4	21	0.779	14.2
8	0.632	11.7	15	0.734	13.4	23	0.781	14.2

$n = 4.0 \pm 0.8$ $s = 0.80$

Table 30
Roemer's observations

N	log r	m_Δ	N	log r	m_Δ	N	log r	m_Δ
1	0.610	11.6	20	0.770	15.5	27	0.861	15.6
3	0.613	10.9	22	0.780	15.5	28	0.881	15.8
13	0.660	13.1	25	0.805	15.4	29	0.891	16.7
19	0.761	14.9						

$n = 7.0 \pm 0.9$ $s = 0.95$

By comparing the inclinations of the regression lines, one can see that Jeffers' as well as Van Biesbroeck's observations cannot be reduced to Roemer's observations which contain the extreme observation. Therefore, only Roemer's observations were considered. A more detailed analysis of these observations indicated that the observations after June 5, 1957 inclusive were made in Flagstaff (probably with the 1.02-m reflector), whereas the first three with the 0.51-m astrograph. When the last 7 observations were taken into account, the following parameters were obtained:

$n = 3.1 \pm 1.1$ $s = 0.79$
$M = 9.2 \pm 2.2$ $m_m = 19.5$

These values were also considered for further processing. The difference is an illustration of the influence of instrumental effects on the resultant photometric parameters, in particular on exponent n .

Comet 1957 III (Arend-Roland) - after perihelion

The parameters were determined from Roemer's m_2-estimates which give the best coverage of the observation interval and contain extreme observation:

Table 31
Roemer's observations

N	log r	m_Δ	N	log r	m_Δ
6	0.479	15.3	12	0.653	15.4
9	0.592	16.0	15	0.729	17.3

$n = 2.6 \pm 1.6$ $s = 0.76$

$M = 12.0 \pm 2.5$ $m_m = 18.6$

Comet 1957 V (Mrkos) - after perihelion

The parameters were determined from Roemer's observations which include extreme observation and give a relatively good coverage of the interval.

Table 32
Roemer's observations

N	log r	m_Δ	N	log r	m_Δ	N	log r	m_Δ
4	0.536	13.9	9	0.645	15.3	11	0.702	15.8
7	0.626	15.3	10	0.688	15.8			

$n = 4.7 \pm 0.9$ $s = 0.98$
$M = 7.8 \pm 0.5$ $m_m = 18.0$

Comet 1957 VI (Wirtanen) - after perihelion

This comet belongs to the rare cases of the splitting of the nucleus into two parts, both the parts having long lifetimes. The brighter nucleus was chosen for the reduction, because a substantial parts of the data concerns this part of the comet. Figure 4 clearly shows that the rate of brightness decrease for the interval January-December 1958 differs from that for April 11, 1959 and beyond. Roemer's observations made in 1959 and containing extreme observation, were used to determine the parameters:

Table 33
Roemer's observations

N	log r	m_Δ	N	log r	m_Δ	N	log r	m_Δ
45	0.806	15.0	49	0.824	15.2	55	0.835	15.1
46	0.808	15.1	51	0.825	15.2	61	0.974	15.5
47	0.817	15.1						

$n = 1.0 \pm 0.2$ $s = 0.93$
$M = 13.1 \pm 0.4$ $m_m = 19.2$

Comet 1959 I (Burnham-Slaughter) - after perihelion

All the observations, including the extreme, were made by Roemer.

Table 34
Roemer's observations

N	log r	m_Δ	N	log r	m_Δ	N	log r	m_Δ
1	0.560	16.7	4	0.620	16.9	7	0.689	16.5
2	0.589	16.5	5	0.641	16.3	8	0.692	16.5
3	0.614	17.0	6	0.666	16.6			

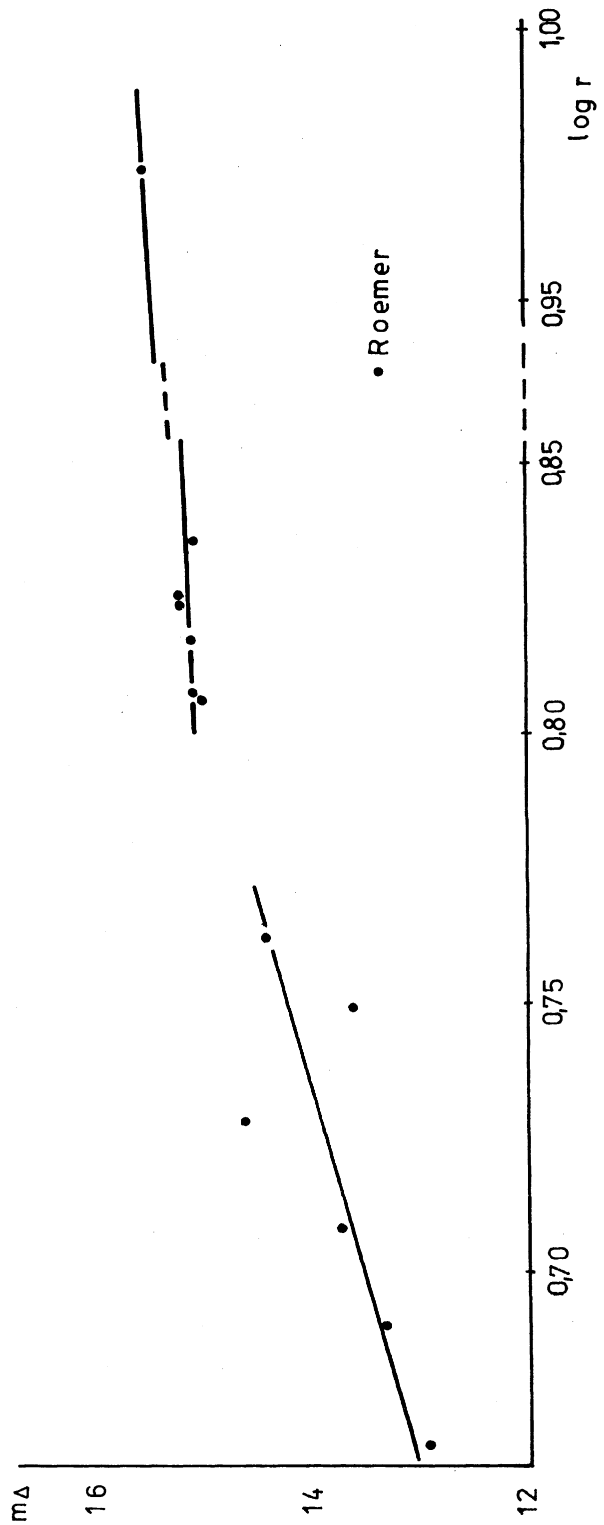

Fig. 4 : The changes of the brightness of Comet 1957 VI after perihelion

$n = -0.7 \pm 0.7$ $s = 0.37$

$M = 17.8 \pm 1.2$ $m_m = 19.5$

Comet 1959 IX (Mrkos) - after perihelion

The parameters were again determined from Roemer's observations:

Table 35
Roemer's observations

N	log r	m_Δ	N	log r	m_Δ	N	log r	m_Δ
1	0.410	16.0	5	0.509	15.2	7	0.583	16.0
3	0.463	15.7	6	0.563	15.6	8	0.626	16.1
4	0.505	16.0						

$n = 0.3 \pm 0.8$ $s = 0.16$

$M = 15.4 \pm 1.0$ $m_m = 17.8$

Comet 1962 III (Seki-Lines) - after perihelion

All the observations, including the extreme, were made by Roemer with a 1.02-m reflector.

Table 36
Roemer's observations

N	log r	m_Δ	N	log r	m_Δ
1	0.584	17.2	3	0.624	16.9
2	0.585	17.2	4	0.689	17.4

$n = 0.7 \pm 1.1$ $s = 0.41$

$M = 16.1 \pm 1.7$ $m_m = 20.2$

Comet 1962 VIII (Humason) - before perihelion

The observations of the comet before perihelion passage fall into two well-defined intervals (Fig. 5). From the point of view of the development of the comet's brightness in the region of extreme observation, the interval between Sept. 1, 1961 and Feb. 8, 1962 is important. The observations of Roemer and Beyer provide the most continuous coverage of this interval. The photometric exponents were determined for each of them separately.

Table 37
Roemer's observations

N	log r	m_Δ	N	log r	m_Δ	N	log r	m_Δ
2	0.718	12.9	26	0.693	12.5	49	0.654	12.7
8	0.714	12.8	32	0.691	12.1	59	0.635	12.4
9	0.712	12.6	41	0.677	12.8	65	0.607	12.5
11	0.702	12.1	46	0.670	12.0	71	0.600	12.4

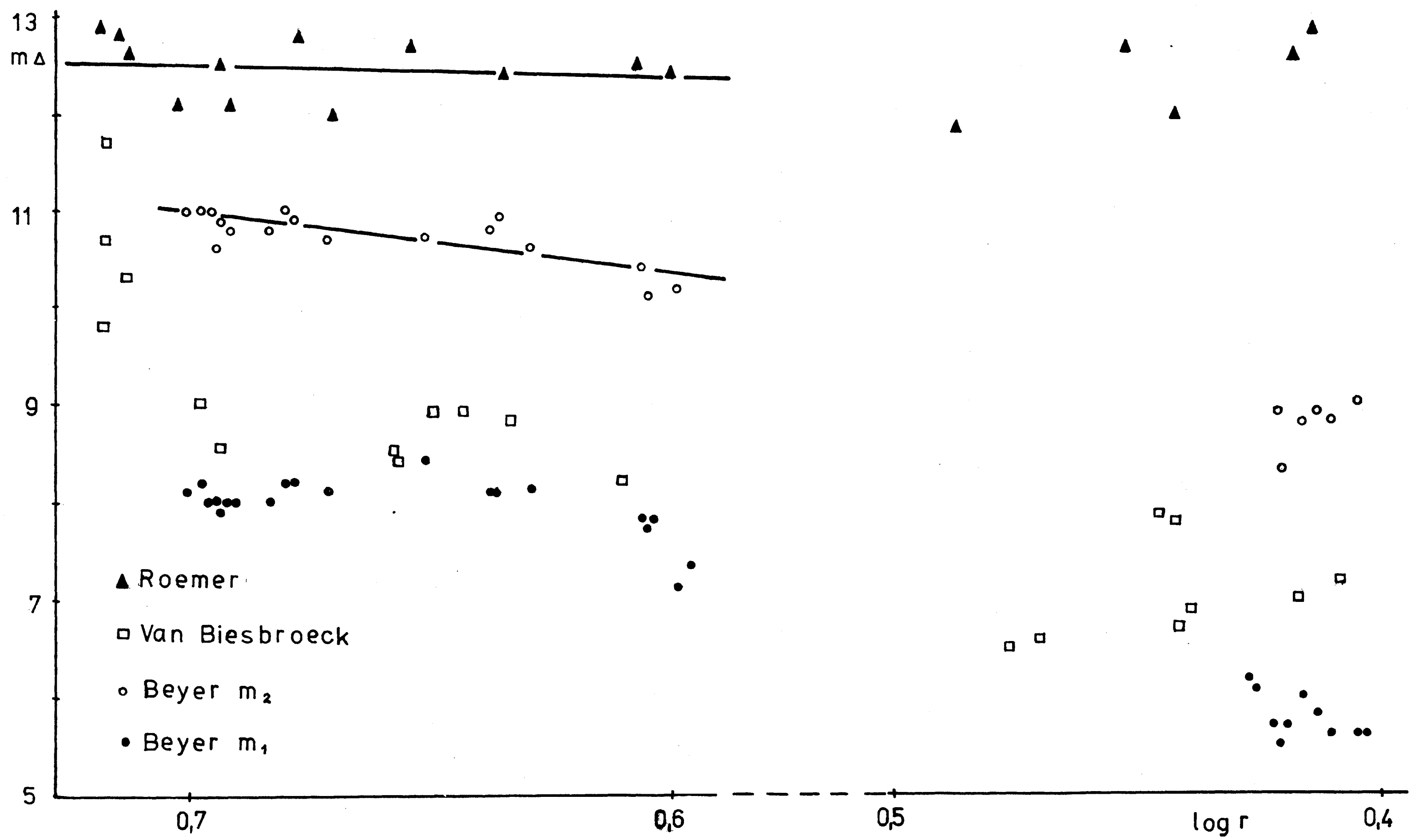

Fig. 5 : The changes of the brightness of Comet 1962 VIII before perihelion

$n = 0.6 \pm 0.9$ $s = 0.19$

Table 38
Beyer's observations m_2

N	log r	m_Δ	N	log r	m_Δ	N	log r	m_Δ
13	0.700	11.0	35	0.683	10.8	58	0.636	10.9
15	0.697	11.0	37	0.680	11.0	63	0.629	10.6
21	0.695	11.0	40	0.678	10.9	67	0.606	10.4
23	0.694	10.6	44	0.671	10.7	69	0.605	10.1
28	0.693	10.9	51	0.651	10.7	73	0.599	10.2
31	0.691	10.8	56	0.637	10.8			

$n = 2.5 \pm 0.5$ $s = 0.80$

With a view to the completely different inclination of the regression line, Van Biesbroeck's observations are not suitable even for determining the correction. His data also display an exceptionally large scatter. The difference in the inclinations of Beyer's and Roemer's lines is due to Beyer's values of Jan. 28 and 30, and Feb. 5, 1962. The sudden outburst in this interval is also documented well by Beyer's m_1-values (Fig. 5). Without these three values the photometric exponent of Beyer's observations would be considerably smaller: $n = 1.0 \pm 0.6$ ($s = 0.45$). Roemer's values are considered to be the resultant parameters; they extend closer to extreme observation and, in spite of the larger interval scatter, they do not display sudden changes with r as was the case with Beyer's series. As regards this comet, the extent of the systematic differences between the individual observers and between m_1 and m_2 are remarkable: at the end of the series they exceed 7^m !

$n = 0.6 \pm 0.9$ $s = 0.19$
$M = 11.6 \pm 1.5$ $m_m = 15.8$

Comet 1963 I (Ikeya) - after perihelion

The photometric exponents were first determined separately for Beyer and Roemer.

Table 39
Beyer's observations

N	log r	m_Δ	N	log r	m_Δ	N	log r	m_Δ
2	0.404	9.4	7	0.436	8.9	12	0.469	9.9
3	0.415	8.6	8	0.456	10.6	13	0.471	10.4
4	0.417	8.4	9	0.460	10.1	14	0.473	10.1
5	0.428	8.1	11	0.462	9.6	15	0.475	9.7
6	0.434	8.9						

$n = 9.6 \pm 2.6$ $s = 0.75$

Table 40

Roemer's observations

N	log r	m_Δ	N	log r	m_Δ
1	0.402	16.2	16	0.517	16.7
10	0.460	16.4	17	0.534	16.5

$n = 1.2 \pm 0.5$ $s = 0.87$

With a view to the different inclinations of the regression lines, one set of observations cannot be directly reduced to the other. Therefore, the parameters were determined only from Roemer's observations covering the whole interval, albeit sparsely.

$n = 1.2 \pm 0.5$ $s = 0.87$

$M = 15.0 \pm 0.6$ $m_m = 18.6$

Comet 1964 VI (Tomita-Gerber-Honda) - after perihelion

All the observations, including the extreme, were made by Roemer.

Table 41

Roemer's observations

N	log r	m_Δ	N	log r	m_Δ
1	0.443	16.5	3	0.512	16.1
2	0.457	15.7	4	0.536	17.2

$n = 3.3 \pm 3.4$ $s = 0.57$

$M = 12.4 \pm 4.1$ $m_m = 18.1$

Comet 1969 I (Thomas) - after perihelion

Roemer's observations with the 2.29- and 1.54-m reflectors (possibility of internal correction) and Waterfield's observations provide a good coverage of the interval as a whole.

Only Roemer's observations, made in the years 1970-71, were taken into account in calculating n for the following reasons:

- there are no observations between July 5, 1969 and Jan. 5, 1970, i.e. exactly half a year,
- however, there are indications that the comet was still active in May and June 1969 (Roemer's observations of Apr. 20, May 18 and June 23), so that it would have been very difficult to reduce these observations over a whole half a year and to interpolate some brightness curve,
- the observations of Waterfield and Giclas, although undescribed, are apparently m_1 ; since the inclinations of their regression lines and of Roemer's line are different, the former cannot be used,
- Seki's observations cover a too narrow interval of r .

Since Roemer used two different telescopes for her observations, the correction between these two instruments was determined first. The same method was used as had been used several times in reducing the observations of one observer to the scale of another. The larger series of observations comes from the 1.54-m reflector and for this series the photometric parameters were determined:

Table 42

Roemer's observations with the 1.54-m reflector

N	log r	m_Δ	N	log r	m_Δ	N	log r	m_Δ
19	0.667	14.3	21	0.701	14.9	23	0.732	15.3
20	0.686	14.9	22	0.717	15.1	24	0.764	15.4

n = 4.2 ± 0.9 M = 7.5 ± 1.6

These parameters were used to extrapolate the values for the times at which observations with the 2.29-m reflector were made, and the two were compared:

Table 43

Reduction of Roemer's observations to the uniform scale

log r	$m_{2.29}$	$m_{1.54}$	$m_{1.54} - m_{2.29}$
0.880	16.9	16.8	- 0.1
0.888	16.9	16.8	- 0.1
0.902	16.7	17.0	+ 0.3
0.902	16.7	17.0	+ 0.3

Since the average correction comes out as $+ 0\overset{m}{.}1$, the observations made with both the instruments are considered to have been made on the same scale. Consequently, Roemer's observations, made with both intruments, were used without any correction to calculate the parameters.

Table 44

Roemer's observations

N	log r	m_Δ	N	log r	m_Δ	N	log r	m_Δ
19	0.667	14.3	23	0.732	15.3	26	0.888	16.9
20	0.686	14.9	24	0.764	15.4	27	0.902	16.7
21	0.701	14.9	25	0.880	16.9	28	0.902	16.7
22	0.717	15.1						

n = 4.0 ± 0.2 s = 0.98

M = 7.9 ± 0.5 m_m = 19.0

Comet 1970 II (Bennett) - after perihelion

To cover the whole interval of observations, it is necessary to tie in Roemer's and Beyer's observations (Fig. 6). The photometric exponents were first determined separately from Beyer's m_2- observations and from Roemer's observations.

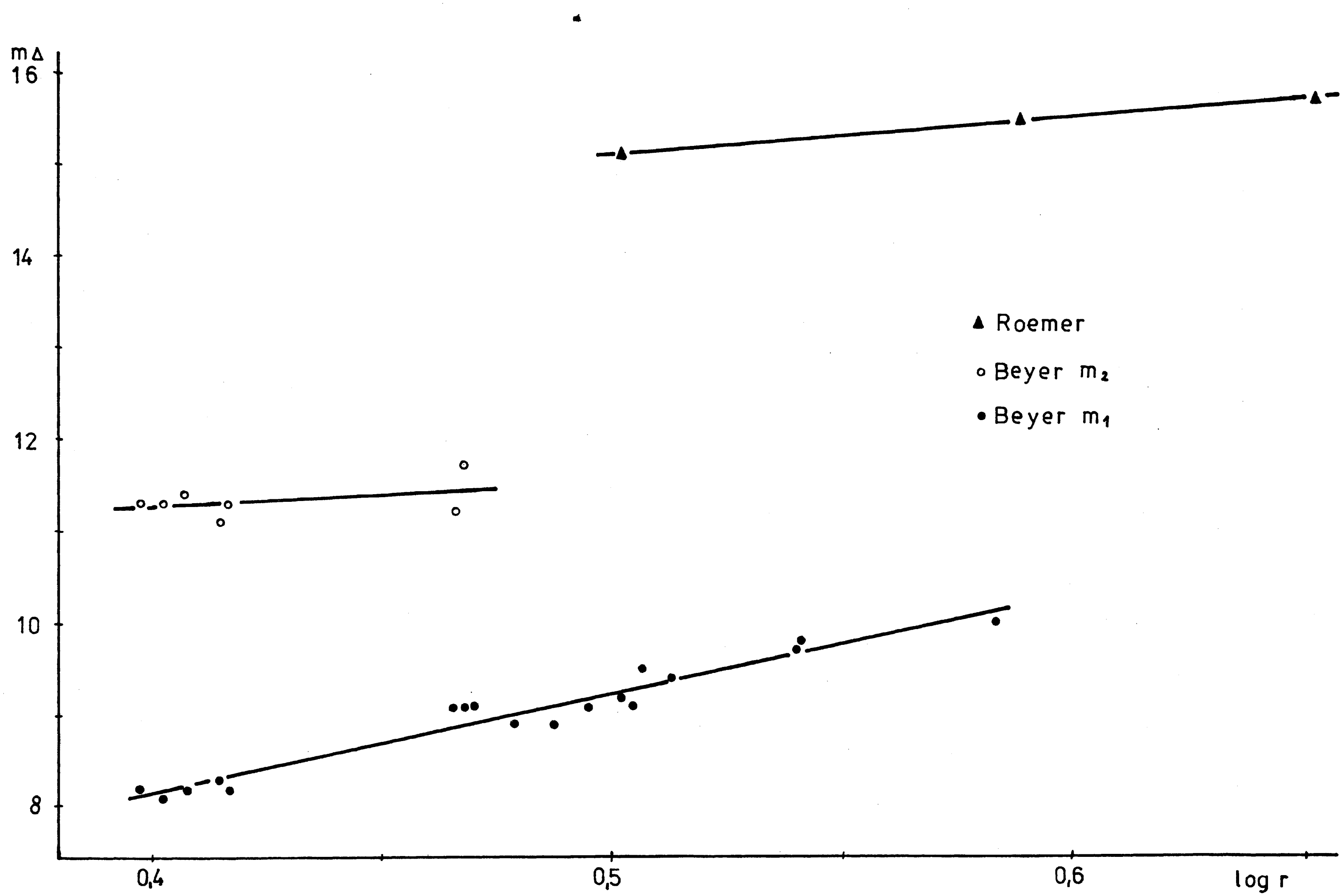

Fig. 6 : The changes of the brightness of Comet 1970 II after perihelion

Table 45
Beyer's observations

N	log r	m_{Δ}
2	0.398	11.3
5	0.403	11.3
7	0.408	11.4
9	0.415	11.1
11	0.417	11.3
14	0.466	11.2
16	0.468	11.7

n = 1.0 ± 1.1 s = 0.40

Table 46
Roemer's observations

N	log r	m_{Δ}
23	0.502	15.1
31	0.589	15.5
32	0.653	15.7

n = 1.6 ± 0.2 s = 0.99

Since the inclinations of the regression lines were similar, the observations could be tied in with one another. Beyer's m_1-observations, which show that no sudden changes in brightness occurred between the times of Roemer's observations and Beyer's m_2-observations, justify interpolation.

Table 47
Reduction of Beyer's observations to Roemer's scale

log r	m_B	m_R	$m_R - m_B$
0.398	11.3	14.7	+ 3.4
0.403	11.3	14.7	+ 3.4
0.408	11.4	14.7	+ 3.3
0.415	11.1	14.8	+ 3.7
0.417	11.3	14.8	+ 3.5
0.466	11.2	15.0	+ 3.8
0.468	11.7	15.0	+ 3.3

Average correction = + $3^{\mathrm{m}}.49$.

The resultant parameters were determined from Roemer's original values and Beyer's data corrected by + $3^{\mathrm{m}}.5$. The large systematic scatter in the m_1-, m_2 and m_2-values of various observers is remarkable also in this case.

Table 48
Beyer's and Roemer's observations

N	log r	m_{Δ}
2	0.398	14.8
5	0.403	14.8
7	0.408	14.9
9	0.415	14.6
11	0.417	14.8
14	0.466	14.7
16	0.468	15.2
23	0.502	15.1
31	0.589	15.5
32	0.653	15.7

n = 1.5 ± 0.2 s = 0.92

$M = 13.2 \pm 0.3$ $m_m = 13.6$

Comet 1970 III (Kohoutek) - before perihelion

Waterfield's and Milet's observations provide the best coverage of the interval. The photometric exponents were determined for each of them separately.

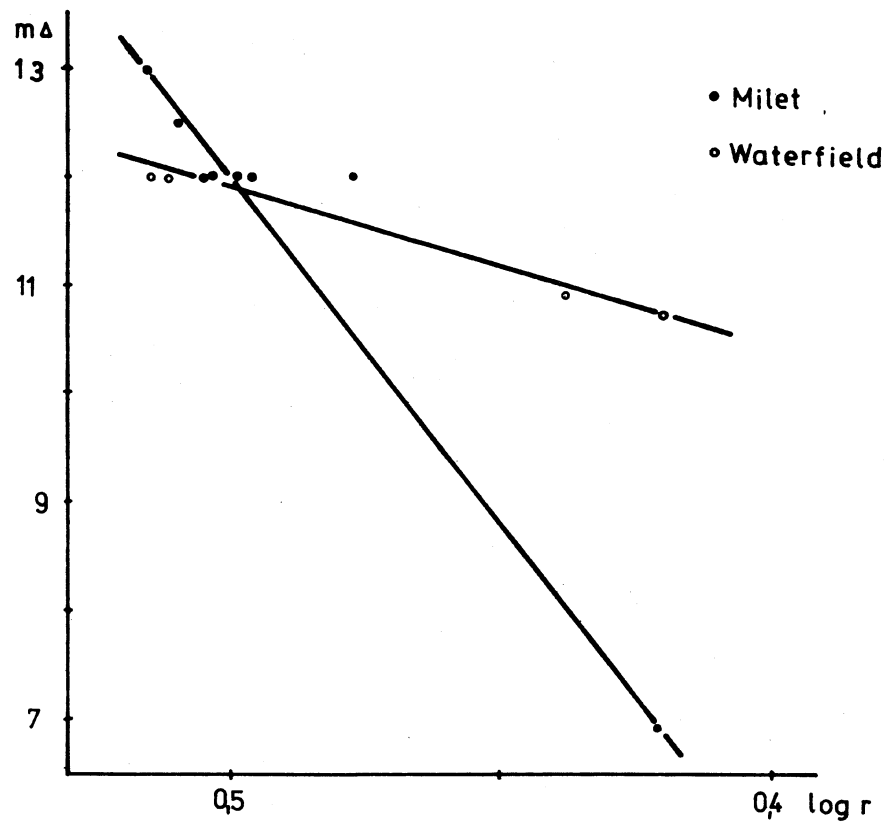

Fig. 7 : The changes of the brightness of Comet 1970 III before perihelion

Table 49
Milet's observations

N	log r	m_Δ	N	log r	m_Δ	N	log r	m_Δ
6	0.515	13.0	16	0.504	12.0	21	0.496	12.0
14	0.510	12.5	19	0.499	12.0	30	0.421	6.9
15	0.505	12.0						

$n = 25.4 \pm 1.1$ $s = 0.99$

Table 50
Waterfield's observations

N	log r	m_Δ	N	log r	m_Δ	N	log r	m_Δ
7	0.515	12.0	23	0.477	12.0	31	0.420	10.7
13	0.512	12.0	28	0.438	10.9			

n = 5.8 ± 1.3 s = 0.94

The inclinations of these two regression lines are so different that they cannot be used to calculate the correction. Waterfield's values were used for further computations, because Milet's inclination is improbably large and essentially determined by a single value of Oct. 13, 1969; moreover, Waterfield, for example, observed no substantial increase in brightness during this period (Fig. 7). It seems there is a mistake in Milet's results, or that m_1 was estimated using a different instrument. On the side of the larger r's, the set was expanded by adding Kohoutek's values of Aug. 5 and 6, 1969. Waterfield's interpolated value came out as $12\overset{m}{.}1$ so that no correction was necessary. The resultant parameters were determined from Waterfield's and Kohoutek's values.

Table 51
Observations of Waterfield and Kohoutek

N	log r	m_Δ	N	log r	m_Δ	N	log r	m_Δ
1	0.530	11.9	7	0.515	12.0	23	0.477	12.0
2	0.529	11.9	10	0.514	12.0	28	0.438	10.9
3	0.520	12.0	11	0.513	12.0	31	0.420	10.7
4	0.516	12.0	13	0.512	12.0			

n = 4.7 ± 0.7 s = 0.91
M = 5.9 ± 0.9 m_m = 14.0

Comet 1971 I (Gehrels) - after perihelion

The parameters were determined from Roemer's observations which contain the extreme observation and cover the whole interval relatively well.

Table 52
Roemer's observations

N	log r	m_Δ	N	log r	m_Δ
5	0.724	15.4	7	0.741	15.9
6	0.727	15.8	11	0.851	16.9

n = 4.1 ± 0.8 s = 0.96
M = 8.3 ± 1.5 m_m = 19.2

The correction of Pereyra's observation relative to Roemer's scale was also determined. Pereyra's value of $15\overset{m}{.}5$ for log r = 0.766 corresponds to Roemer's interpolated value of $16\overset{m}{.}1$, so that the correction $m_R - m_P = + 0\overset{m}{.}6$.

Comet 1972 VIII (Heck-Sause) - after perihelion

Four observers made observations in the region of the extreme observation after the observations had been interrupted from May to December 1973. Of these Shao's and Furuta's observations are the only observations of the comet, and Heck's estimate of the brightness of the central condensation cannot be tied in with his two estimates of the total brightness made at the time of the comet's discovery. Only Roemer's values could be used to calculate the parameters (two from this period and two observed earlier):

Table 53

Roemer's observations

N	log r	m_{Δ}	N	log r	m_{Δ}
27	0.453	14.3	64	0.723	15.7
54	0.500	14.5	66	0.746	16.0

$n = 2.2 \pm 0.1$ $\quad s = 0.99$

$M = 11.7 \pm 0.2$ $\quad m_m = 17.8$

The extension of the observations towards smaller values of r (application of Seki-Roemer's correction) will not improve the values in the interval of large heliocentric distances.

Comet 1972 IX (Sandage) - after perihelion

The whole interval is covered relatively well by Roemer. The coverage of the interval cannot be extended towards smaller values of r because only Seki and Urata observed at smaller heliocentric distances. Their observations cannot be reduced to Roemer's scale as they made no observations after Feb. 4, 1973 (the date of Roemer's first observation). The parameters were therefore determined from Roemer's observations.

Table 54

Roemer's observations

N	log r	m_{Δ}	N	log r	m_{Δ}	N	log r	m_{Δ}
8	0.636	13.2	19	0.670	14.6	26	0.846	16.5
13	0.647	13.5	24	0.800	16.9	27	0.854	16.4
16	0.659	15.1	25	0.833	17.0			

$n = 5.7 \pm 1.0$ $\quad s = 0.92$

$M = 4.9 \pm 1.9$ $\quad m_m = 19.4$

Comet 1973 II (Kojima) - after perihelion

The parameters were determined from Roemer's observations which cover the largest part of the interval.

Table 55
Roemer's observations

N	log r	m_Δ
3	0.497	14.3
9	0.724	15.7
10	0.738	16.0

$n = 2.7 \pm 0.3$ $s = 0.99$
$M = 11.0 \pm 0.5$ $m_m = 19.3$

Although Shao's extreme observation has not been tied in, the parameters can be considered as characteristic also for this region.

Comet 1973 XII (Kohoutek) - before perihelion

Mrkos (Mar. 23 - May 3) and Kohoutek (Jan. 28 - Mar. 26) have covered the interval best. The photometric exponents were determined separately for each of them:

Table 56
Kohoutek's observations

N	log r	m_Δ
1	0.713	12.9
2	0.677	13.0
3	0.675	13.0
4	0.663	12.0
9	0.657	12.0

$n = 6.4 \pm 4.2$ $s = 0.66$

Table 57
Mrkos' observations

N	log r	m_Δ
6	0.660	12.4
17	0.647	12.2
23	0.617	11.4
24	0.613	11.7

$n = 7.5 \pm 1.9$ $s = 0.94$

Since the calculated inclinations of the regression lines are similar, the two series of observations were tied in with each other in the interval where they overlap, i.e. log r = 0.657 - 0.660. Mrkos' value of $12\overset{m}{.}4$ for log r = 0.660 corresponds to Kohoutek's interpolated value of $12\overset{m}{.}3$, and Kohoutek's value of $12\overset{m}{.}0$ for log r = 0.657 corresponds to Mrkos' interpolated value of $12\overset{m}{.}4$. Since the average correction $m_K - m_M = -0\overset{m}{.}25$, the observations were considered to have been carried out on a uniform scale. The resultant parameters were determined from all the values in Tabs 56 and 57:

$n = 6.5 \pm 1.5$ $s = 0.85$
$M = 1.6 \pm 2.4$ $m_m = 15.2$

Comet 1973 XII (Kohoutek) - after perihelion

Both observations were made by Roemer with a 2.29-m reflector.

Table 58
Roemer's observations

N	log r	m_Δ
1	0.402	15.7
2	0.697	18.8

n = 4.2
M = 11.5 m_m = 20.1

The comparison of absolute brightnesses before and after perihelion passage shows an exceptionally large decrease in brightness. Part of this difference is due to the different scales. Since only Roemer observed at $r > 2.5$ AU after perihelion passage, also the observations made before perihelion passage were reduced to her scale as far as possible. Both Mrkos (brightness $15\overset{m}{.}2$) and Roemer (brightness $17\overset{m}{.}0$) observed on Apr. 4, 1973 before perihelion passage, from which one may assume that the value of M prior to perihelion passage on Roemer's scale was approximately $M = 3\overset{m}{.}4$. However, even after this reduction, there remains a difference of 8 stellar magnitudes. Whipple (1978) explained these large changes in brightness as being due to the release of exceptionally active ice, characteristic of new comets, and also to the inclination of the axis of rotation of the cometary nucleus.

Comet 1975 VIII (Lovas) - before perihelion

The parameters were determined from Seki's observations which cover the interval of larger r-values well.

Table 59
Seki's observations

N	log r	m_Δ	N	log r	m_Δ	N	log r	m_Δ
4	0.749	11.7	8	0.740	12.7	26	0.568	12.0
7	0.747	11.7	24	0.571	12.0			

n = 0.0 ± 1.0 s = 0.01
M = 12.0 ± 1.7 m_m = 15.0

The resultant photometric exponent, as well as the sudden decrease in brightness, observed by Seki between Mar. 29 and Apr. 12, 1974, are also evidence of the comet's activity.

For the purpose of determining the corrections, the regression line was also calculated for Gilmore's and Kilmartin's observations.

Table 60
Observations of Gilmore and Kilmartin

N	log r	m_Δ	N	log r	m_Δ	N	log r	m_Δ
23	0.571	13.3	28	0.514	13.3	33	0.489	12.6
25	0.569	13.2	29	0.502	13.0	35	0.483	12.8
27	0.529	13.6	30	0.498	13.2			

$n = 2.2 \pm 1.2$ $s = 0.59$

The corrections required to reduce Bruwer's observations to Gilmore's and Kilmartin's scale were also determined:

Table 61
Reduction of Bruwer's observations to Gilmore's and Kilmartin's scale

log r	m_B	m_{G+K}	$m_{G+K} - m_B$
0.492	11.0	13.0	+ 2.0
0.490	11.0	13.0	+ 2.0
0.484	10.9	12.9	+ 2.0

Comet 1975 VIII (Lovas) - after perihelion

The parameters were determined from Gilmore's and Kilmartin's observations with an 0.41-m reflector; they cover the whole interval including the extreme observation.

Table 62
Observations of Gilmore and Kilmartin

N	log r	m_Δ	N	log r	m_Δ	N	log r	m_Δ
1	0.479	12.5	5	0.661	12.6	8	0.695	12.7
2	0.490	11.8	6	0.679	13.1	9	0.717	12.7
3	0.501	12.2						

$n = 1.2 \pm 0.4$ $s = 0.76$
$M = 10.8 \pm 0.7$ $m_m = 15.5$

Comet 1976 VI (West) - before perihelion

All three observations, including the extreme, were made in La Silla with a 1.00-m Schmidt camera.

Table 63
Observations of Pizarro et al.

N	log r	m_Δ	N	log r	m_Δ
1	0.552	14.4	3	0.474	12.6
2	0.548	13.9			

$n = 8.2 \pm 1.9$ $\qquad$ $s = 0.97$

$M = 2.8 \pm 2.5$ $\qquad$ $m_m = 16.0$

GROUP B

Comet 1949 I (Wirtanen) - before perihelion

There were considerable difficulties with determining the parameters because the corrections between no pair of observers were known and the r-interval for calculating the parameters from the observations of any of the observers was not sufficiently large. Jeffers' observations, made with an 0.91-m reflector, cover the largest interval of r-values:

Table 64
Jeffers' observations

N	log r	m_Δ
4	0.580	13.9
12	0.482	13.7

$n = 0.8$

$M = 12.7$ $\qquad$ $m_m = 16.4$

The observation of July 15, 1948 was not included in the calculation because Jeffers does not mention the instrument he used and there is reason to believe that an 0.50-m camera was used.

Within Jeffers' interval, Van Biesbroeck observed an increase in brightness of $1^m.0$ between Aug. 11 and Sept. 2, 1948. Boyer's observations only account for the end of this interval (after Aug. 28), so that it is difficult to tell whether the brightening was real.

Comet 1950 I (Johnson) - after perihelion

The comet was observed in three distinctly different periods. In the first, January - May 1950, it is useless to calculate the parameters (interval r = = 0.28 AU). The observations were then interrupted for 7 months. In the second period, December 1950 - February 1951, the r-interval is also small (only 0.44 AU) and after an intermission of 9 months, there is a single observation in the third period. Two pairs of parameters were determined, i.e. for the 1st + 2nd period and for the 2nd + 3rd period, only the observations of Van Biesbroeck, who observed in all three periods and is also the author of the extreme observation, were taken into account.

Table 65
Van Biesbroeck's observations (1st + 2nd)

N	log r	m_Δ	N	log r	m_Δ	N	log r	m_Δ
34	0.418	10.0	67	0.451	11.2	72	0.627	14.2
54	0.433	10.7	70	0.453	11.2	73	0.641	13.7

Table 65 (cont.)

N	log r	m_Δ	N	log r	m_Δ
74	0.643	13.6	76	0.664	14.4
75	0.646	14.1	78	0.667	14.3

$n = 6.3 \pm 0.4$ $\qquad$ $s = 0.99$

The corrections of Cunningham's and Boyer's observations required to reduce them to Van Biesbroeck's scale were determined in the interval log r = 0.418 - - 0.667 .

Table 66

Reduction of Cunningham's observations to Van Biesbroeck's scale

log r	m_C	m_{Bi}	$m_{Bi} - m_C$
0.624	14.2	13.7	- 0.5
0.665	15.6	14.3	- 1.3

Boyer's value of $10^m.5$ for log r = 0.418 corresponds to Van Biesbroeck's interpolated value of $10^m.4$, so that $m_{Bi} - m_{Bo} = - 0^m.1$.

Table 67

Van Biesbroeck's observations (2nd + 3rd)

N	log r	m_Δ	N	log r	m_Δ	N	log r	m_Δ
72	0.627	14.2	75	0.646	14.1	78	0.667	14.3
73	0.641	13.7	76	0.664	14.4	79	0.823	16.1
74	0.643	13.6						

$n = 4.7 \pm 0.7$ $\qquad$ $s = 0.95$

$M = 6.5 \pm 1.2$ $\qquad$ $m_m = 17.0$

The parameters determined from these two periods were used for further processing because they contain the extreme observation. However, because of the 9-month intermission, these parameters are not particularly characteristic of the region of the extreme observation.

The correction of Cunningham's observation required to reduce it to Van Biesbroeck's scale was also determined for this new regression line. Cunningham's value of $15^m.6$ for log r = 0.665 was found to correspond to Van Biesbroeck's interpolated value of $14^m.3$, so that the difference of $- 1^m.3$ is the same as in the preceding case.

Comet 1951 I (Minkowski) - after perihelion

The parameters were first determined from Van Biesbroeck's observations containing the extreme observation and covering the whole interval, although not completely.

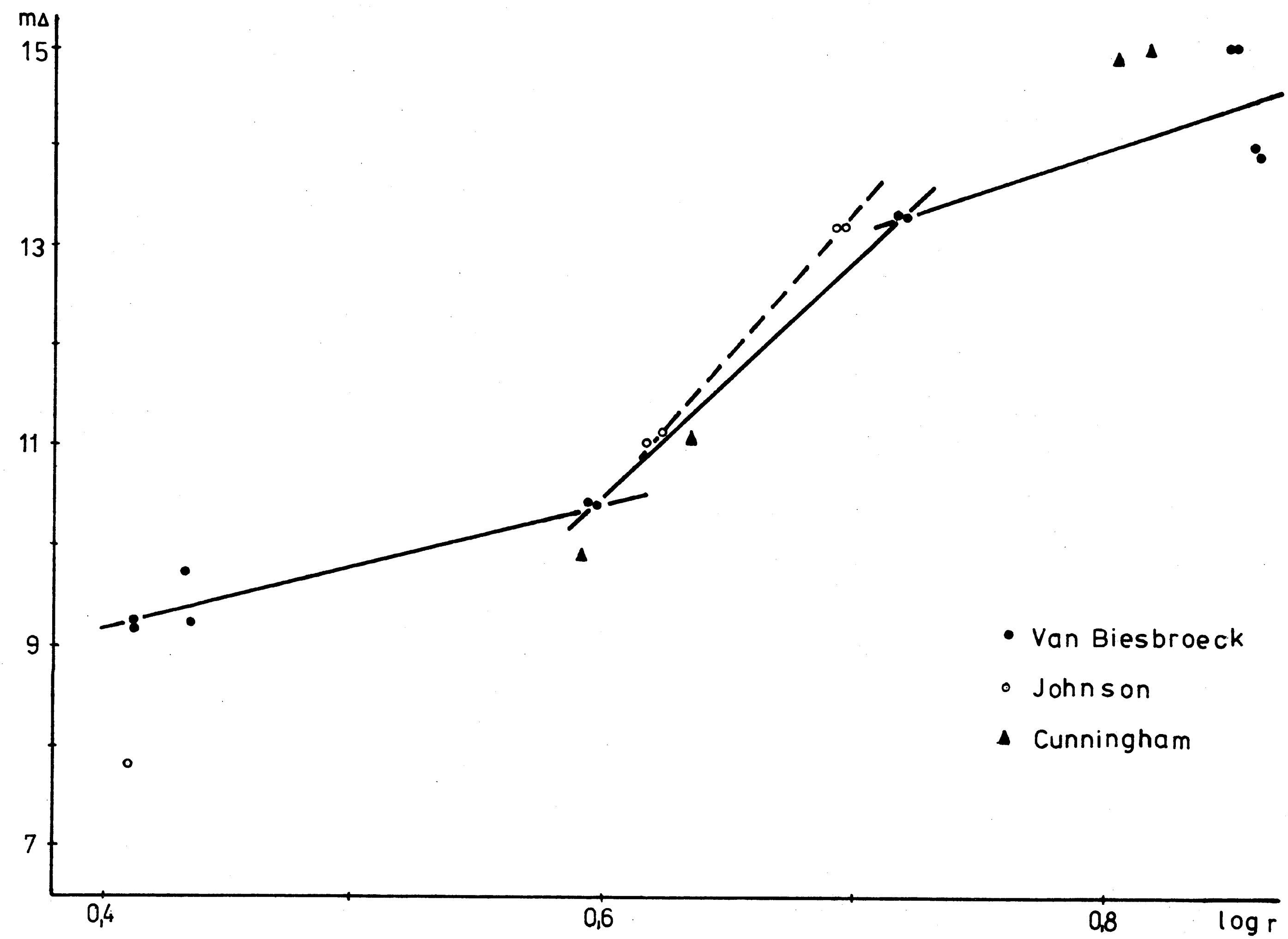

Fig. 8 : The changes of the brightness of Comet 1951 I after perihelion

Table 68

Van Biesbroeck's observations

N	log r	m_{Δ}	N	log r	m_{Δ}	N	log r	m_{Δ}
5	0.412	9.1	19	0.595	10.4	30	0.848	15.0
6	0.412	9.2	20	0.597	10.4	31	0.849	15.0
12	0.432	9.7	26	0.718	13.3	32	0.859	14.0
14	0.434	9.2	27	0.720	13.3	33	0.861	13.9

$n = 5.0 \pm 0.4$ $\qquad$ $s = 0.97$

The observations of Cunningham and E. L. Johnson were also included in the graph (Fig. 8). All the other observations are from the region of $\log r < 0.493$ and are not characteristic of the extreme observation. Van Biesbroeck's observations of the comet are concentrated into four isolated intervals: $\log r = 0.412 - 0.434$, $0.595 - 0.597$, $0.718 - 0.720$, $0.848 - 0.861$. In determining the parameters, the use of brightnesses corresponding to two consecutive intervals yielded:

Table 69

The photometric exponents derived from Van Biesbroeck's observations

intervals	n	s
1st + 2nd	2.6 ± 0.4	0.95
2nd + 3rd	9.4 ± 0.1	1.00
3rd + 4th	3.3 ± 1.5	0.74

One can see that a rapid decrease of brightness occurred between the 2nd and 3rd period, i.e. between Dec. 23, 1951 and Mar. 15, 1952. This is also proved by Johnson's observations (dashed line). The parameters determined from Van Biesbroeck's observations made between this decrease and the end of the observation period are considered to be the photometric parameters of the comet:

$n = 3.3 \pm 1.5$ $\qquad$ $s = 0.74$

$M = 7.5 \pm 3.0$ $\qquad$ $m_m = 18.0$

At the end of the period, between Dec. 23, 1952 and Jan. 19, 1953, a sudden outburst occured (Van Biesbroeck recorded $1\overset{m}{.}1$). With o view to this increase in the region of the extreme observation, the parameters were included in Group B.

The correction were determined by reduction to Van Biesbroeck's scale separately in each calculated interval: $\log r = 0.412 - 0.597$, $0.595 - 0.720$, $0.718 - 0.861$.

Table 70

Reduction of the observations of Hirose and Tomita to Van Biesbroeck's scale

log r	m_{H+T}	m_{Bi}	$m_{Bi} - m_{H+T}$
0.412	7.1	9.2	+ 2.1
0.419	8.6	9.3	+ 0.7

Table 71

Reduction of Cunningham's observations to Van Biesbroeck's scale

log r	m_C	m_{Bi}	$m_{Bi} - m_C$
0.591	9.9	10.4	+ 0.5
0.635	11.1	11.3	+ 0.2
0.805	14.9	14.0	- 0.9
0.818	15.0	14.2	- 0.8

Krumpholz's value of $9^m.4$ for log r = 0.444 was found to correspond to Van Biesbroeck's value also of $9^m.4$.

Table 72

Reduction of Johnson's observations to Van Biesbroeck's scale

log r	m_J	m_{Bi}	$m_{Bi} - m_J$
0.617	11.0	10.9	- 0.1
0.623	11.1	11.0	- 0.1
0.694	13.2	12.7	- 0.5
0.694	13.2	12.7	- 0.5

Comet 1954 X (Abell) - before perihelion

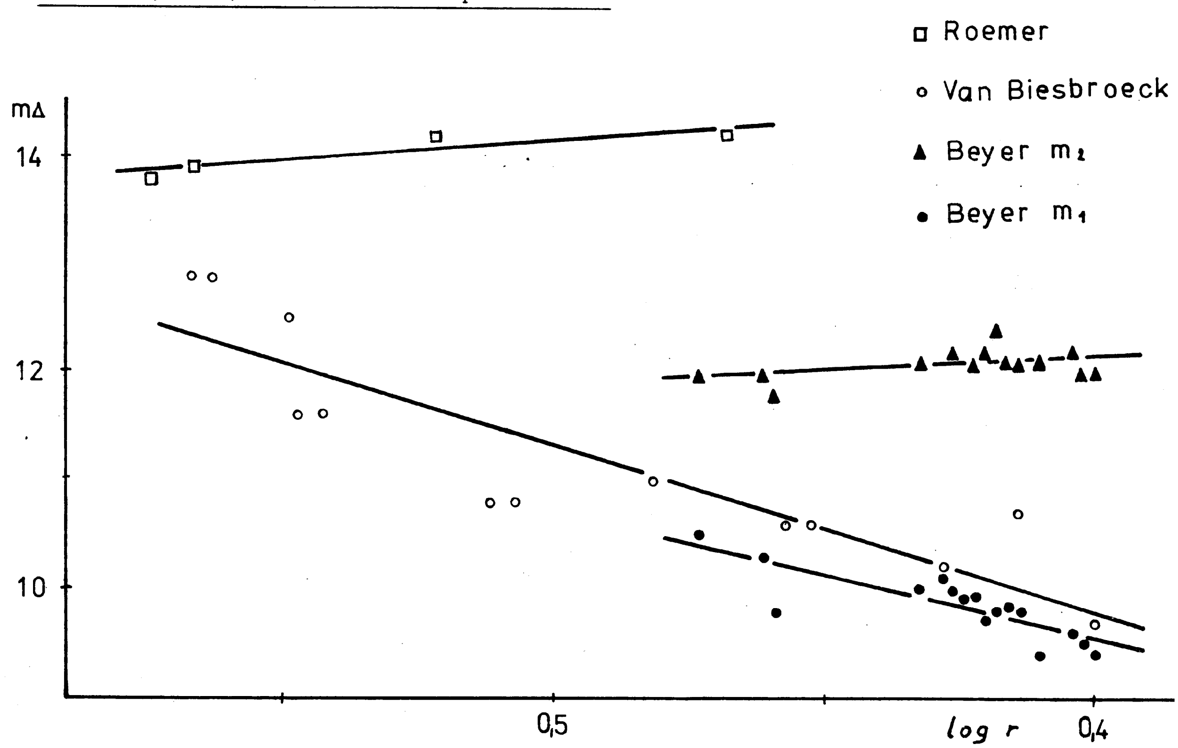

Fig. 9 : The changes of the brightness of Comet 1954 X before perihelion

Van Biesbroeck's observations m_1 provide the most equable coverage of the interval.

Table 73
Van Biesbroeck's observations

N	log r	m_Δ	N	log r	m_Δ	N	log r	m_Δ
3	0.567	12.9	13	0.511	10.8	24	0.452	10.6
5	0.563	12.9	14	0.507	10.8	28	0.428	10.2
9	0.549	12.5	15	0.481	11.0	42	0.414	10.7
10	0.547	11.6	23	0.457	10.6	52	0.400	9.7
11	0.542	11.6						

$n = 6.1 \pm 1.0$ $s = 0.89$
$M = 3.6 \pm 1.2$ $m_m = 13.0$

The correction required to reduced Hirose's and Tomita's observation to Van Biesbroeck's scale was also determined. Hirose's and Tomita's value of $7^m.7$ for $\log r = 0.412$ was found to correspond to Van Biesbroeck's interpolated value of $10^m.0$, so that the difference $m_{Bi} - m_{H+T} = + 2^m.3$.

For comparison, the photometric exponents of other series of observations are plotted in Fig. 9:

Beyer m_1 : 16 values, $\log r = 0.473 - 0.400$, $n = 4.7 \pm 0.8$;
Roemer m_2: 4 values, $\log r = 0.575 - 0.468$, $n = - 1.5 \pm 0.6$;
Beyer m_2 : 14 values, $\log r = 0.473 - 0.400$, $n = - 1.1 \pm 0.6$.

For this comet the difference in the values of the photometric exponents for the total brightness and the brightness of the central condensation is realistic and very large.

Comet 1955 VI (Baade) - before perihelion

Van Biesbroeck's observations (Fig. 10) provide the best coverage of the observation interval. Shortly after discovery (between Aug. 29 and Sept. 22, 1954) he observed a conspicuous outburst ($1^m.9$). There are only Van Biesbroeck's observations at that period. After this outburst, the comet calmed down relatively: for example, Beyer's m_2-values between Feb. 22 and Apr. 18, 1955 varied within the interval of $13^m.9 - 14^m.1$. Just before perihelion passage, the brightness decreased (Van Biesbroeck recorded a decrease of $3^m.4$) and, after perihelion passage, it increased again (Van Biesbroeck recorded $2^m.5$). With a view to the increased activity of the comet shortly after discovery, the parameters representing the variation of the comet's brightness at the time of the extreme observation cannot be calculated. Beyer's observations are not suitable for calculating the parameters (interval of $r = 0.20$ AU) either. The parameters were determined from Van Biesbroeck's observations between the outburst and decrease of brightness, i.e. for the period Sept. 22, 1954 and Apr. 25, 1955.

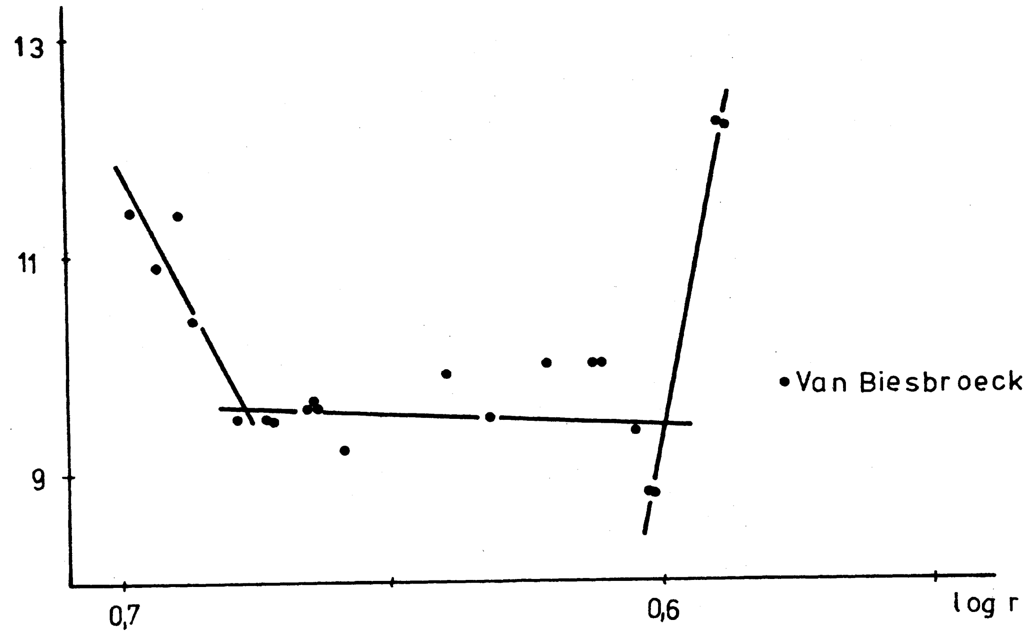

Fig. 10 : The changes of the brightness of Comet 1955 VI before perihelion

Table 74
Van Biesbroeck's observations

N	log r	m_Δ	N	log r	m_Δ	N	log r	m_Δ
9	0.679	9.5	16	0.664	9.6	43	0.612	10.0
11	0.673	9.5	17	0.659	9.2	44	0.612	10.0
12	0.673	9.5	20	0.640	9.9	51	0.605	9.4
13	0.665	9.6	21	0.632	9.5	60	0.602	8.8
14	0.665	9.6	23	0.621	10.0	61	0.601	8.8

$n = 0.7 \pm 1.4$ $\quad s = 0.14$

$M = 8.4 \pm 2.3$ $\quad m_m = 13.0$

Hirose's and Tomita's value of $10\overset{m}{.}0$ for log r = 0.622 was found to correspond to Van Biesbroeck's interpolated value of $9\overset{m}{.}5$, so that the difference $m_{Bi} - m_{H+T} = - 0\overset{m}{.}5$.

Comet 1957 VI (Wirtanen) - before perihelion

A substantial part of the observations is formed by the data of the 0.51-m Carnegie astrograph and Van Biesbroeck's observations. The photometric exponents were determined for the two series separately.

Hirose's and Tomita's value of $8\overset{m}{.}8$ for log r = 0.656 corresponds to Van Biesbroeck's interpolated value of $9\overset{m}{.}5$, so that the difference $m_{Bi} - m_{H+T} = + 0\overset{m}{.}7$.

Table 75
Observations of Wirtanen et al.

N	log r	m_Δ	N	log r	m_Δ	N	log r	m_Δ
1	0.788	11.6	16	0.656	7.3	30	0.650	7.5
2	0.788	11.4	22	0.654	7.7	34	0.648	7.8
3	0.787	11.9	26	0.651	7.6			

$n = 11.9 \pm 0.6$ $s = 0.99$

Table 76
Van Biesbroeck's observations

N	log r	m_Δ	N	log r	m_Δ	N	log r	m_Δ
5	0.783	11.9	8	0.759	12.4	21	0.654	9.2
6	0.778	12.5	12	0.659	10.2	25	0.652	9.2
7	0.760	12.4	20	0.654	9.2			

$n = 9.7 \pm 1.1$ $s = 0.96$

Both series of observations indicate that the comet increased its brightness rapidly as it approached the perihelion. Unfortunately, it is difficult to tell how the brightness changed at large heliocentric distances, because there is a large gap of 10 months in the observations, from June 1956 to April 1957, and the 1956 observations are insufficient on their own to calculate the parameters because of the range of heliocentric distances.

Comparison with post-perihelion brightnesses is also difficult because they are mostly related to the brightness of the brighter nucleus which was not observed in 1956. The first observation of the double nucleus was only made on May 1, 1957 (Van Biesbroeck).

Van Biesbroeck's observations were reduced to the scale of Wirtanen et al., because the latter series has a smaller internal scatter (correlation coefficient 0.99) and contains the extreme observation.

Table 77
Reduction of Van Biesbroeck's observations to scale of Wirtanen et al.

log r	m_{Bi}	m_W	$m_W - m_{Bi}$
0.783	11.9	11.5	- 0.4
0.778	12.5	11.3	- 1.2
0.760	12.4	10.8	- 1.6
0.759	12.4	10.8	- 1.6
0.659	10.2	7.8	- 2.4
0.654	9.2	7.7	- 1.5
0.654	9.2	7.7	- 1.5
0.652	9.2	7.6	- 1.6

Average correction = $- 1\overset{m}{.}48$.

The resultant parameters were determined from the original values obtained with an 0.51-m astrograph and from Van Biesbroeck's data corrected by $- 1\overset{m}{.}5$:

Table 78
Observations of Van Biesbroeck and Wirtanen et al.

N	log r	m_Δ	N	log r	m_Δ	N	log r	m_Δ
1	0.788	11.6	8	0.759	10.9	22	0.654	7.7
2	0.788	11.4	12	0.659	8.7	25	0.652	7.7
3	0.787	11.9	16	0.656	7.3	26	0.651	7.6
5	0.783	10.4	20	0.654	7.7	30	0.650	7.5
6	0.778	11.0	21	0.654	7.7	34	0.648	7.8
7	0.760	10.9						

$n = 10.9 \pm 0.6$ $\quad s = 0.97$

$M = -10.1 \pm 1.1$ $\quad m_m = 12.5$

With a view to the large gap in the observations (10 months) these parameters need not be characteristic of the region of the extreme observation.

Comet 1962 VIII (Humason) - after perihelion

The post-perihelion observations are divided into several independent intervals interrupted by two periods in which no observations were made due to the small angular distance of the comet from the Sun and one mighty outburst (Fig. 11).

I. In the first interval (April - July 1963) Roemer observed with a 1.02-m reflector and Bruwer with a short-focus camera.

Table 79
Roemer's observations

N	log r	m_Δ	N	log r	m_Δ
4	0.454	13.7	8	0.480	14.0
6	0.459	13.3	11	0.485	13.8

$n = 5.1 \pm 4.1$ $\quad s = 0.66$

Table 80
Bruwer's observations

N	log r	m_Δ	N	log r	m_Δ	N	log r	m_Δ
1	0.413	5.7	5	0.455	5.9	10	0.485	6.3
2	0.424	6.2	7	0.478	6.0	12	0.510	6.4
3	0.447	6.0	9	0.483	6.2	13	0.515	6.8

$n = 2.8 \pm 0.8$ $\quad s = 0.79$

The correction for reducing Roemer's observations to Bruwer's scale was determined.

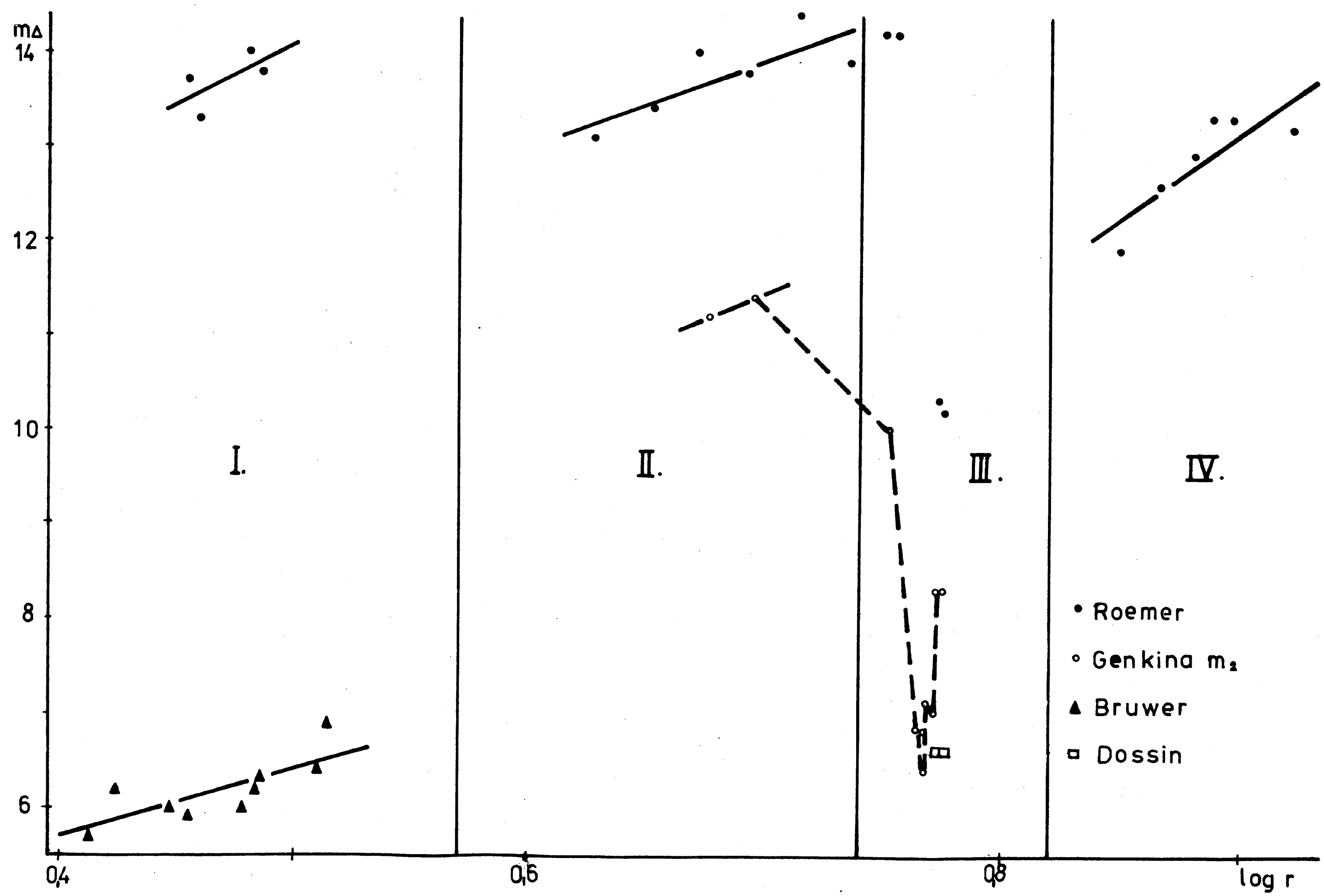

Fig. 11 : The changes of the brightness of Comet 1962 VIII after perihelion

Table 81
Reduction of Roemer's observations to Bruwer's scale

log r	m_R	m_{Br}	$m_{Br} - m_R$
0.454	13.7	6.1	- 7.6
0.459	13.3	6.1	- 7.2
0.480	14.0	6.3	- 7.7
0.485	13.8	6.3	- 7.5

The average correction is unusually large, - $7^m_.5$.

II. The second interval starts with the beginning of observability after conjuction in the summer of 1963 and ends with the beginning of increased activity of the comet in May 1964 (November 1963 - April 1964). Roemer and Genkina observed:

Table 82
Genkina's observations

N	log r	m_Δ
17	0.676	11.2
19	0.695	11.4

n = 4.2

Table 83
Roemer's observations

N	log r	m_Δ
14	0.627	13.1
15	0.652	13.4

n = 3.6 ± 1.4

N	log r	m_Δ
16	0.671	14.0
18	0.692	13.8

s = 0.79

N	log r	m_Δ
20	0.714	14.4
21	0.735	13.9

Table 84
Reduction of Genkina's observations to Roemer's scale

log r	m_G	m_R	$m_R - m_G$
0.676	11.2	13.7	+ 2.5
0.695	11.4	13.9	+ 2.5

Average correction = + $2^m_.5$.

III. The third interval is the period of brightness outburst. It is useless to calculate the photometric parameters in this period. The beginning of the outburst was not determined precisely, because Genkina observed an increase in brightness already on May 7, 1964 (from $11^m_.4$ to $10^m_.0$ in reduced values) whereas Roemer only observed an increase in brightness beginning with May 12, 1964. The difference in the estimates is $4^m_.2$ which is higher than the correction determined for the preceding interval, $1^m_.7$. The last observations prior to conjuction with the Sun show better agreement: a difference of $2^m_.0$ as compared to $2^m.5$ before the outburst.

With a view to the increased activity of the comet, no conclusion can be drawn concerning the development of the comet's brightness in the interval of July - October 1964.

IV. Roemer's observations with the 1.02-m reflector can be used to determine the photometric exponent for the interval from November 1964 to April 1965.

Table 85

Roemer's observations

N	log r	m_Δ	N	log r	m_Δ	N	log r	m_Δ
37	0.849	11.9	39	0.880	12.9	41	0.897	13.3
38	0.866	12.6	40	0.888	13.3	42	0.922	13.2

n = 7.3 ± 2.3 s = 0.85

To be able to judge to what extent the parameters changed after the outburst, the values of the photometric exponents were first determined for the 1st and 2nd intervals using all observations reduced to Roemer's uniform scale.

Table 86

Roemer's and Bruwer's observations

N	log r	m_Δ	N	log r	m_Δ	N	log r	m_Δ
1	0.413	13.2	6	0.459	13.3	10	0.485	13.8
2	0.424	13.7	7	0.478	13.5	11	0.485	13.8
3	0.447	13.5	8	0.480	14.0	12	0.510	13.9
4	0.454	13.7	9	0.483	13.7	13	0.515	14.3
5	0.455	13.4						

n = 3.0 ± 0.8 s = 0.75

Table 87

Roemer's and Genkina's observations

N	log r	m_Δ	N	log r	m_Δ	N	log r	m_Δ
14	0.627	13.1	17	0.676	13.7	20	0.714	14.4
15	0.652	13.4	18	0.692	13.8	21	0.735	13.9
16	0.671	14.0	19	0.695	13.9			

n = 3.7 ± 1.1 s = 0.80

By comparing n of the 4th interval (7.3) with those of the 1st and 2nd (3.0 and 3.7, respectively) one can see that the exponent after the outburst is considerably larger than before it. One is justified in assuming that this change is not realistic but that it is due to the end of the more rapid decrease of brightness after the outburst. Evidence of this is the gradual diminishing of n, provided the exponents for the sets of values are calculated omitting the value of Nov. 5, 1964 (n = 4.2 ± 2.3) and the values of Nov. 5 and Dec. 11, 1964 (n = 1.7 ± 2.7).

However, the parameters of any of these three sets of the 4th interval can hardly be considered as representative of the characteristic of the region of large r for the following reasons:

- small range of r of the last 5 or 4 values,
- the end of the outburst which overlaps the normal behaviour of the brightness,
- observations missing after April 30, 1965, which would enable a definitive decision to be made whether the change in the brightness curve since the beginning of 1965 is realistic. This is the more important because the change in brightness as a whole is essentially due to the one observation on Apr. 30, 1965.

On the whole, it can be concluded that the comet was constantly active from April 1964 to the day of the extreme observation, so that the values of the 2nd interval, i.e. prior to the outburst, can be considered as the photometric parameters:

$n = 3.7 \pm 1.1$ $s = 0.80$

$M = 7.5 \pm 1.9$ $m_m = 16.9$

Due to their extremely narrow range of r, Dossin's observations have no significance in determining the parameters.

Comet 1968 I (Ikeya-Seki) - after perihelion

Since the Roemer-Tomita correction is not known, the parameters were calculated using Roemer's m_2-data only.

Table 88

Roemer's observations

N	log r	m_Δ	N	log r	m_Δ
4	0.523	13.8	12	0.825	17.7
9	0.564	12.8			

$n = 6.0 \pm 2.0$ $s = 0.95$

$M = 5.2 \pm 3.2$ $m_m = 16.2$

With a view to the large intermission in Roemer's observations (nearly one year), the parameters need not be characteristic also of the region of extreme observation.

Comet 1976 VI (West) - after perihelion

Bortle's observations (m_1), covering the whole interval with the exception of the region of extreme observation relatively well, were used to calculate the parameters.

Table 89
Bortle's observations

N	log r	m_Δ	N	log r	m_Δ	N	log r	m_Δ
3	0.404	7.0	12	0.453	7.0	24	0.485	8.0
4	0.407	7.1	15	0.455	7.1	26	0.511	8.2
8	0.419	7.1	16	0.463	7.7	27	0.512	8.2
10	0.424	7.1	19	0.469	7.1	28	0.514	8.4
11	0.426	7.0	20	0.471	7.8	30	0.524	8.7

$n = 5.4 \pm 0.7$ $s = 0.90$

$M = 1.4 \pm 0.8$ $m_m = 8.8$

GROUP C

Comet 1947 VIII (Wirtanen) - after perihelion

The comet was observed in three distinctly different intervals: from Oct. 7 to Dec. 2, 1948, from June 25 to Sept. 24, 1949, and a single observation on Sept. 11, 1950. To be able to determine the parameters, Van Biesbroeck's observations have to be tied in with Cunningham's. The corrections used to reduce Cunningham's observations to Van Biesbroeck's scale, determined in Groups A and B, are given in Tab. 90 whose first column gives the apparent brightness of the comet according to Cunningham's observations, the second column the difference of values m_Δ , and the third the designation of the comet for which the value was derived.

Table 90
Corrections Van Biesbroeck - Cunningham

m_p	$m_{Bi} - m_C$	comet
13.0	+ 0.5	1951 I after perihelion
14.0	+ 0.2	1951 I after perihelion
19.0	- 0.9	1951 I after perihelion
19.0	- 0.8	1951 I after perihelion
17.0	- 0.5	1950 I after perihelion
18.7	- 1.3	1950 I after perihelion

The average value $m_{Bi} - m_C = - 0^m.47$. The graphical representation alone (Fig. 12) indicates that there is some dependence of the correction on the apparent brightness. Calculations proved that the 6 values given above satisfy the following linear relation very well (correlation coefficient $s = 0.96$):

$$m_{Bi} - m_C = \frac{m_p - 15.05}{- 3.71} \tag{2}$$

For Comet 1947 VIII $m_p = 18^m.0$, so that the correction is $- 0^m.8$ and the corrected value of Cunningham's observation reduced to Van Biesbroeck's scale is $12^m.5$.

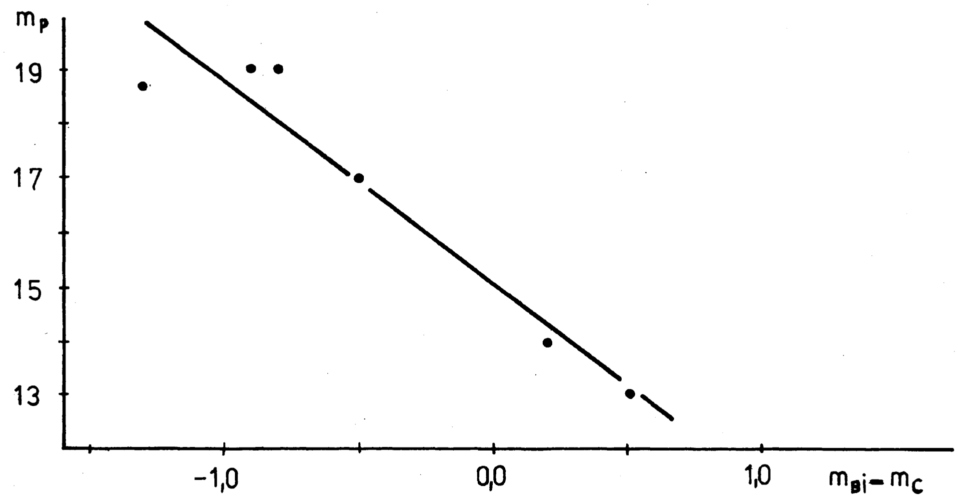

Fig. 12 : Corrections of Cunningham to Van Biesbroeck

The resultant parameters were determined from Van Biesbroeck's observations (he was the only one to observe in two intervals) and from Cunningham's corrected value given above:

Table 91
Van Biesbroeck's and Cunningham's observations

N	log r	m_Δ	N	log r	m_Δ
8	0.718	11.3	14	0.980	12.5
11	0.838	12.2			

$n = 1.8 \pm 0.6$ $\quad s = 0.95$

$M = 8.2 \pm 1.3$ $\quad m_m = 16.0$

Comet 1949 I (Wirtanen) - after perihelion

Based on Van Biesbroeck's observations, one may assume that the brightness suddenly decrease by $2^m_.2$ between Apr. 17 and May 14, 1950. Consequently, the parameters had to be determined separately for the interval before the brightness decrease and after it. The interval before the sudden decrease is covered well by Johnson's observations.

Table 92
Johnson's observations

N	log r	m_Δ	N	log r	m_Δ
2	0.426	11.4	4	0.576	11.1
3	0.574	11.1	5	0.619	11.8

$n = 0.2 \pm 1.1$ $\quad s = 0.15$

The interval after the decrease is not covered sufficiently by any observer. Equation (2), derived for reducing Cunningham's observations to Van Biesbroeck's scale in the case of Comet 1947 VIII, was used. For $m_p = 19.0$, the correction comes out at $-1^m\!.1$. The parameters for the interval after the sudden brightness decrease were determined from Van Biesbroeck's observations and Cunningham's corrected observations:

Table 93
Van Biesbroeck's and Cunningham's observations

N	log r	m_Δ
9	0.660	13.2
10	0.661	13.2
11	0.794	14.1
12	0.824	14.1
13	0.833	14.0

$n = 2.1 \pm 0.3$
$M = 9.7 \pm 0.6$
$s = 0.97$
$m_m = 19.0$

Comet 1949 IV (Bappu-Bok-Newkirk) - after perihelion

To determine the characteristic parameters, it is necessary to reduce Cunningham's observations to the scale of one of the observers from the interval before May 15, 1950. Using Eq. (2), Cunningham's observations were reduced to Van Biesbroeck's scale. For the observation of Dec. 16, 1950 ($m_p = 18^m\!.0$) the correction came out as $-0^m\!.8$ and the corrected value on Van Biesbroeck's scale as $14^m\!.1$. For the observation of Mar. 4, 1951 ($m_p = 19^m\!.0$) the correction came out as $-1^m\!.1$ and the corrected value on Van Biesbroeck's scale as $14^m\!.5$. The resultant parameters were determined from Van Biesbroeck's original values and from Cunningham's corrected values.

Table 94
Van Biesbroeck's and Cunningham's observations

N	log r	m_Δ
16	0.455	12.9
20	0.490	12.9
21	0.689	14.1
22	0.743	14.5

$n = 2.3 \pm 0.2$
$M = 10.2 \pm 0.3$
$s = 0.99$
$m_m = 16.8$

Comet 1955 III (Mrkos) - after perihelion

To determine the characteristic parameters, it was necessary to reduce Jeffers' extreme observation to Van Biesbroeck's scale. The lists of observations (Groups A and B) contain a total of 10 observations with the 0.51-m astrograph, which were within the intervals of Van Biesbroeck's observations with 0.61-m and 2.08-m reflectors, and for which the corrections have been determined. The symbols in Tab.95 are analogous to those in Tab. 90; in this case m_p represents the apparent brightness of the comet according to Jeffers' observations.

Table 95

Corrections Van Biesbroeck - Jeffers

m_p	$m_{Bi} - m_J$	comet
14.5	- 0.9	1947 VI after perihelion
14.5	- 0.9	1947 VI after perihelion
14.5	- 0.9	1947 VI after perihelion
14.5	- 0.8	1947 VI after perihelion
15.0	- 1.2	1947 VI after perihelion
17.5	- 2.2	1947 VI after perihelion
18.5	- 1.0	1947 VI after perihelion
16.0	- 0.4	1956 I after perihelion
10.0	+ 2.2	1957 VI before perihelion
10.5	+ 1.8	1957 VI before perihelion

The average value $m_{Bi} - m_J = -0\overset{m}{.}43$. The linear dependence of the correction on the comet's apparent brightness, with a coefficient of correlation of 0.88, was calculated in very much the same way as for the $m_{Bi} - m_C$ -values:

$$m_{Bi} - m_J = \frac{m_p - 13.81}{-1.71} \tag{3}$$

For Jeffers' extreme observation, $m_p = 17\overset{m}{.}5$, so that the correction came out as $-2\overset{m}{.}2$ and the corrected value of Jeffers' observation on Van Biesbroeck's scale as $12\overset{m}{.}5$. One can also compare the error which would be generated if the average correction of $-0\overset{m}{.}4$ were used instead. The photometric parameters were determined from Van Biesbroeck's original data and Jeffers' corrected value.

Table 96

Van Biesbroeck's and Jeffers' observations

N	log r	m_Δ		N	log r	m_Δ
1	0.408	9.3		3	0.662	12.5
2	0.412	9.3				

$n = 5.1 \pm 0.1$ $\quad s = 1.00$

$M = 4.1 \pm 0.1$ $\quad m_m = 12.0$

Comet 1970 III (Kohoutek) - after perihelion

The parameters were determined from the changes in brightness of the brighter nucleus. All observations, with the exception of the extreme, were made by Roemer with a 1.54-m reflector. Pereyra's values were reduced to Roemer's scale, $m_P - m_R = -0\overset{m}{.}6$, using the observations of Comet 1971 I. By correcting the observation of Feb. 21, 1971 by this value, we obtaine $17\overset{m}{.}8$. The resultant parameters were determined from Roemer's original values and Pereyra's corrected value.

Table 97

Roemer's and Pereyra's observations

N	log r	m_Δ	N	log r	m_Δ	N	log r	m_Δ
1	0.469	14.8	4	0.542	14.3	7	0.629	17.8
2	0.507	14.6	6	0.572	16.5			

$n = 8.3 \pm 3.0$ $\quad s = 0.85$

$M = 4.3 \pm 4.1$ $\quad m_m = 17.5$

The scatter is smaller than for the uncorrected values for which $n = 6.9 \pm 2.7$, $s = 0.82$.

GROUP D

Comet 1950 I (Johnson) - before perihelion

It proved most convenient to reduce all observations to Van Biesbroeck's scale. Schmitt's observations were omitted because no correction could be derived for them in the whole data set relative to any other observer of this comet (Johnson, Merton, Van Biesbroeck, Hirose and Tomita, Boyer).

Johnson's observations were reduced first. Four difference values between Johnson's observations and Van Biesbroeck's scale were determined in the observations of Comet 1951 I after perihelion. They are given in the following table which is arranged analogously to Tabs 90 and 95 (m_p is the apparent brightness according to Johnson):

Table 98

Corrections Van Biesbroeck - Johnson

m_p	$m_{Bi} - m_J$	comet
14.0	- 0.1	1951 I after perihelion
14.0	- 0.1	1951 I after perihelion
16.5	- 0.5	1951 I after perihelion
16.5	- 0.5	1951 I after perihelion

The following linear dependence can be fitted to these points:

$$m_{Bi} - m_J = \frac{m_p - 13.38}{- 6.25} \qquad (4)$$

For $m_p = 12\overset{m}{.}5$ and $m_p = 13\overset{m}{.}0$ the correction came out at $+ 0\overset{m}{.}1$. By comparing Van Biesbroeck's observations and Johnson's observations, reduced to a uniform scale, it is possible to infer that a conspicuous decrease of brightness ($1\overset{m}{.}4$) occured between discovery and June 18, 1949, and an outburst occured between June 22 and Aug. 24, 1949 ($2\overset{m}{.}1$). For these reasons the parameters representative of the period of the extreme observation cannot be determined.

Using the observations of Comet 1925 VII (Svoreň, 1984b), the correction Van Biesbroeck (0.61-m reflector) - Merton (short-focus camera) was determined from three values as $-0^m.17$; consequently the correction did not have to be applied in this case because the observation may be considered to have been made on the same scale.

The corrections derived for reducing Hirose's and Tomita's observations to Van Biesbroeck's scale, as can be seen from the attached table, display a considerable scatter (m_p is the apparent brightness of the comet according to the observations of Hirose and Tomita):

Table 99

Corrections Van Biesbroeck - Hirose + Tomita

m_p	$m_{Bi} - m_{H+T}$	comet
9.5	+ 2.3	1954 X before perihelion
11.0	- 0.2	1951 I before perihelion
11.5	- 0.6	1951 I before perihelion
11.0	- 0.3	1951 I before perihelion
9.0	+ 2.1	1951 I after perihelion
10.0	+ 0.7	1951 I after perihelion
11.5	+ 0.7	1957 VI before perihelion
13.0	- 0.5	1955 VI before perihelion

The average value of the correction is $+0^m.5$. However, it was found that there is a close linear dependence between the correction and apparent brightness according to Hirose and Tomita. Calculations yielded the relation

$$m_{Bi} - m_{H+T} = \frac{m_p - 11.30}{-0.92} \qquad (5)$$

with a coefficient of correlation of as much as 0.83. For $m_p = 12^m.5$ the correction came out as $-1^m.3$ and the corrected value reduced to Van Biesbroeck's scale as $9^m.1$.

The same large scatter is displayed by the values of the corrections used to reduced Boyer's observations to Van Biesbroeck's scale. Since not even the linear dependence could be derived in this case, Boyer's observation of Jan. 16, 1950 was not used.

The resultant parameters were determined from the observations of Johnson, Merton, and Hirose and Tomita, made on or after Aug. 24, 1949 and reduced using the corrections given above to Van Biesbroeck's uniform scale:

Table 100

Reduction of observations to Van Biesbroeck's scale

N	log r	m_Δ	N	log r	m_Δ
8	0.477	9.9	10	0.407	9.1
9	0.411	10.0	12	0.407	10.2

$n = 0.9 \pm 3.9$ $\qquad$ $s = 0.16$

$M = 8.9 \pm 4.2$ $\qquad$ $m_m = 12.5$

These parameters are not representative, on the one hand, because of the small range of r (0.45 AU) and, on the other, because they refer to the opposite end of the interval (the region of small r's) than the extreme observation.

Comet 1972 XII (Araya) - after perihelion

The Bruwer (short-focus camera) - Gilmore (0.41-m reflector) correction of $-2^{m}_{.}0$ was derived from the observations of Comet 1975 VIII. The parameters were derived from two of Gilmore's values and Bruwer's value to which the above correction was applied.

Table 101
Gilmore's and Bruwer's observations

N	log r	m_Δ	N	log r	m_Δ
1	0.707	11.8	4	0.843	14.7
3	0.833	14.1			

$n = 8.0 \pm 1.1$ $s = 0.99$
$M = -2.4 \pm 2.1$ $m_m = 18.0$

The disadvantage of these parameters is that they are not based on the extreme observation.

GROUP E

For completeness, we give the list of comets of the selected set for which the photometric parameters could not be derived using the methods described above:

- 1947 I (Bester) before perihelion - range of r = 0.12 AU;
- 1956 I (Haro-Chavira) before perihelion - very active comet;
- 1957 III (Arend-Roland) before perihelion - range of r = 0.33 AU;
- 1959 I (Burnham-Slaughter) before perihelion - range of r = 0.33 AU;
- 1969 I (Thomas) before perihelion - range of r = 0.008 AU;
- 1972 IX (Sandage) before perihelion - range of r = 0.20 AU;
- 1972 XII (Araya) before perihelion - range of r = 0.07 AU;
- 1974 III (Bradfield) after perihelion - no series of any single observer can be used independently and mutual corrections could not be determined;
- 1974 XII (Van den Bergh) after perihelion - comet constantly active;
- 1975 V (Bradfield) after perihelion - range of r = 0.19 AU.

4. CONCLUSIONS

Apart from the photometric parameters of the studied comets, the following general conclusions were drawn in processing the observational material:

(1) In comparison with the data on the brightness of the central condensation, the data on the total brightness of the comet are less sensitive to change of instrument, provided objects of large area, comparable with the dimen-

sions of the viewing field of the instruments, are not involved.

(2) The values of the brightness of the central condensation, determined by different observers and instruments, cannot be practically compared. The reason is the subjective decision-making of the observer which mainly depends on the parameters of the instrument used, as to the size of the area he considers to be central condensation. This requires the introduction of a standard sequence of the diameter of the surfaces around the optical centre, which would enable visual observations m_2 of various authors to be compared.

(3) The type and size of instrument used has an effect on the resultant photometric parameters, particularly on exponent n. This can also be observed if one observer uses different instruments. This requires the publishing of more complete data on physical observations of comets. Apart from brightness data, also data on the instruments used and method of observation and processing used are very important.

(4) Large systematic differences (as much as 7.5 stellar magnitudes) were found between individual observers and methods of estimation.

(5) An interesting result is that the instrumental correction depends on the apparent brightness and degree of condensation of the comet; it may take positive and negative relative values for the same pair of observers.

(6) By observing the brightness variation of various parts of the comet, a large difference was reliably determined in the values of the photometric exponents for the total brightness (m_1) and for the brightness of the central condensation (m_2). The smaller value of the photometric parameter n for the m_2-values is probably due to the diminishing of the angular dimensions of the coma as the comet recedes, since in fact increasingly larger regions of the comet are considered to be part of the central condensation.

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