POST-PERIHELION SURVIVAL OF COMETS WITH SMALL q

John E. Bortle
W. R. Brooks Observatory, Stormville, NY

Abstract. The absolute magnitudes (H_{10}) of 85 comets with perihelion distances (q) less than 0.51 AU were examined, along with their observational histories. From these data, a formula is derived for the prediction of post-perihelion survival/non-survival of intrinsically faint comets with small values of q.

Those who have carefully studied the observational histories of comets with regard to their so-called absolute magnitudes *vs.* their perihelion distances will likely be aware that there are virtually no examples of long-period comets with absolute magnitudes fainter than 7.5 and perihelion distances less than 0.25 AU that have been observed after perihelion. Clearly, there is a limit to the absolute magnitude required for perihelion survival when the value of q is relatively small.

Utilizing knowledge of this, on several recent occasions the author has expressed published doubts as to perihelion survival of some newly discovered long-period comets. These prognostications came as somewhat a surprise to various colleagues, particularly when the demise of the comets in question were borne out observationally.

More recently the author has endeavored to determine a more definitive relationship between the absolute magnitude of a comet and the odds of its post-perihelion survival. In the process an examination was made of published photometric parameters for all comets observed between 1800 and 1989 whose perihelia carried them relatively close to the Sun. Initially, only comets with q values of 0.3 AU or less were considered, but the study was later expanded to include all objects having perihelia less than 0.51 AU. This upper limit for q was somewhat arbitrarily chosen to reduce the otherwise huge number of cometary apparitions that would need to be examined. However, beyond this value of q, nearly all cases of sudden cometary disappearance are related to violent photometric outbursts rather than to heliocentric proximity.

Since instrument size, magnification, and method used to determine a comet's total magnitude are usually omitted from pre-1950 accounts of cometary apparitions, the bulk of the published magnitude parameters do not take them into account. For this reason, no aperture corrections were applied when calculating the photometric parameters of the recent comets. Likewise, to provide as homogeneous a body of data as possible, the simplest photometric solution was chosen to represent each comet's lightcurve. This assumed that the comet's brightness varied as the inverse 4th power of its heliocentric distance (H_{10}) and generally represented the observations fairly well.

For pre-1955 comets the H_{10} parameters from the extensive listing by S. K. Vsekhsvyatskii were used as a starting point. For comets fainter than $H_{10} = 6.0$, only those were included that had orbital circumstances allowing them to be searched for after passing perihelion, thereby eliminating any whose post-T activity was unknown. After compiling a working list of well-observed comets, reference was made to descriptions of each object's apparition included in the Vsekhsvyatskii catalog. From this it was determined whether an individual comet had passed through T relatively unchanged, showed pronounced brightness changes relative to H_{10}, or totally vanished.

(Continued on next page...)

Table 1. *Fates of 23 long-period comets with absolute magnitudes (H_{10}) at or below the non-survival line. Comets 1979 VII and 1967 II are 'class 2A' Oort Cloud comets; 1961 V is a 'class 2B' comet not from the Oort Cloud (cf. Marsden and Roemer 1982, in Comets, ed. by L. L. Wilkening, U. of Ariz. Press, pp. 718ff).*

No Survival			Unstable Survival			Survived Unchanged		
	q	H_{10}		q	H_{10}		q	H_{10}
1801	0.256	9.3	1859	0.201	7-9½	1988 r	0.428	12.5
1816	0.485	9	1880 I	0.005	7.1			
1870 IV	0.389	11.1	1906 I	0.216	8-5-9			
1872 I	0.045	11.0	1926 III	0.322	7-13			
1887 I	0.005	?	1961 V	0.040	7.5			
1890 I	0.270	8.8	1967 II	0.419	9½-10½			
1902 I	0.451	11.7						
1945 VII	0.008	10.8						
1954 II	0.072	11.1						
1959 VI	0.166	8.8						
1970 I	0.066	9.0						
1978 XVIII	.432	12.0						
1979 VII	0.413	10.5						
1985 e	0.106	9.4						
1987 d_1	0.200	10.0						
1988 j	0.165	8.0						

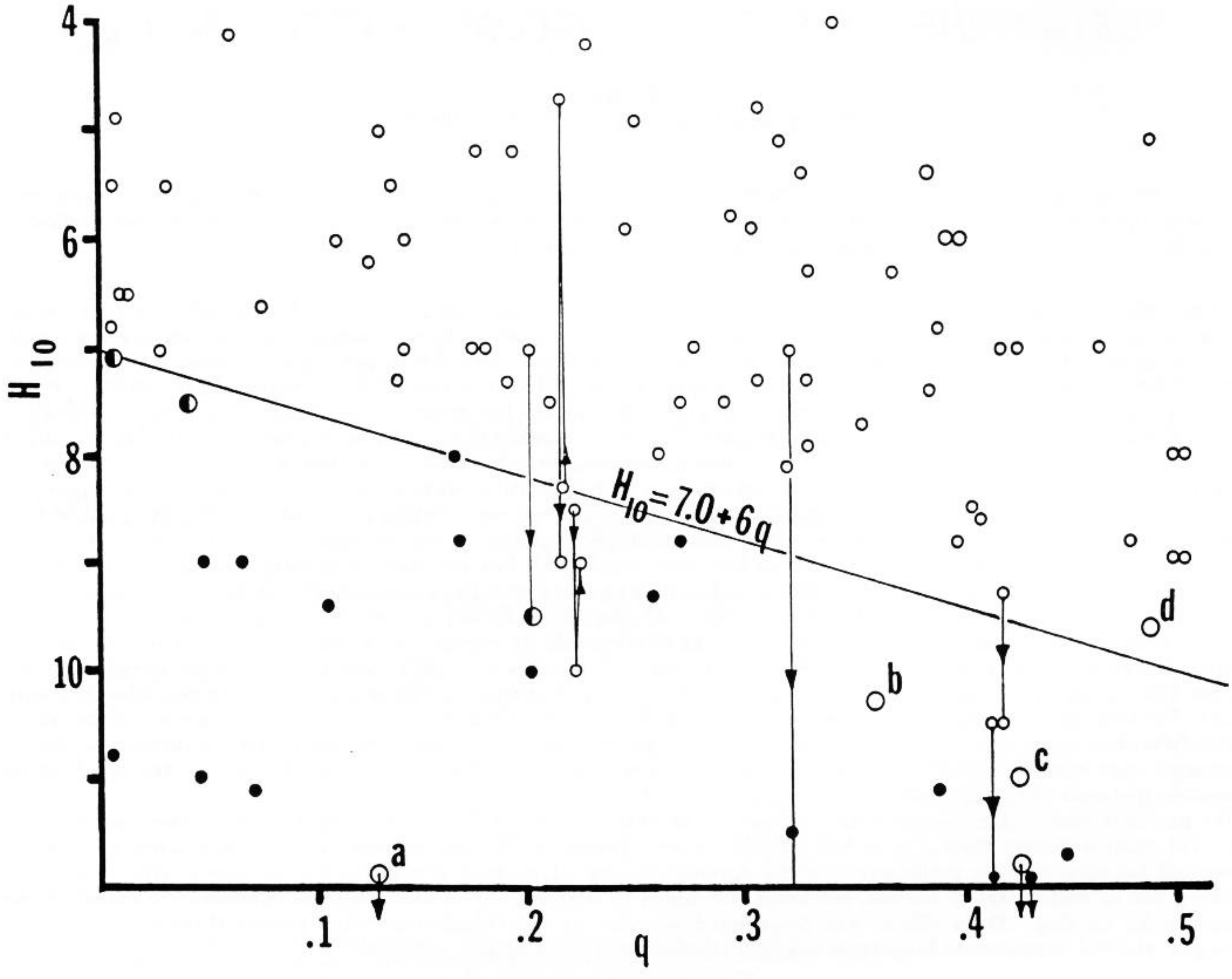

Figure 1. *The absolute magnitudes (H_{10}) of 85 comets are plotted relative to their perihelion distance (q). Open circles indicate post-perihelion survival, half-filled circles a very rapid decrease in brightness following perihelion, and filled circles non-survival. Several cases of dramatic brightness fluctuations are also indicated. The data points marked* a, b, c, *and* d *represent periodic comets Machholz, Encke, Bradfield 2, and Brorsen-Metcalf, respectively.*

(text continued from page 89)

Following this, for each comet with an absolute magnitude fainter than $H_{10} = 6.0$ (q = 0.01-0.30 AU) or $H_{10} = 7.5$ (q = 0.31-0.51 AU), magnitude predictions were calculated covering the object's entire apparition and these were compared with the reported observations. Where necessary, corrections were made to Vsekhsvyatskii's values to bring them into better accord with the observations. To simplify the job of plotting Figure 1, a significant number of comets brighter than $H_{10} = 6.0$ and with q in the range $0.31 < q < 0.51$ AU were omitted.

For post-1955 comets, several descriptive sources were consulted, including *IAU Circulars*, the *ICQ*, and personal observations. Approximate H_{10} values were derived for each object. The comets were then categorized in the same manner as for pre-1955 objects. Whenever it was necessary to generate an ephemeris for a given comet, the orbital elements listed in the *Catalogue of Cometary Orbits* (5th edition) were used.

The final working list included 81 long-period comets and 4 of short-period. The 13 minor sungrazing comets discovered by the *SMM* and *SOLWIND* satellites were not included since they were not observed visually. Of the 85 comets, 16 unquestionably failed to survive their perihelion passages (see Table 1). The data for all 85 objects are plotted in Figure 1, showing the distribution of comets which survived perihelion passage as a function of H_{10} and r. Examination of the plotted data indicates a distinct cutoff, below which the likelihood of a comet surviving perihelion passage becomes drastically reduced.

The formula $H_{10} = 7.0 + 6(q)$, where q is the comet's perihelion distance in AU, is a good approximation of the survival cutoff for comets with perihelia of less than 0.5 AU based on the data examined. For comets whose absolute (H_{10}) magnitudes are fainter than those given by the formula, there is historically a 70-percent chance of non-survival. However, in a closer examination of the distribution of the data, it may be inferred that the actual non-survival rate is much higher since there are significantly fewer datapoints below the line than above. It is possible that, since they would not be expected typically to be very bright when at large solar elongation, a significant percentage of these objects escape detection when approaching the sun.

It is interesting to compare the fate of faint short-period comets with that of long-period objects of similar brightness. Examination of Figure 1 clearly indicates that the formula does not represent activities of periodic comets. Taking each short-period comet in turn, we can see that P/Encke is situated well within the zone of non-survival but has been under regular observation for about two centures. P/Machholz, one of the intrinsically faintest comets, survived its 1986 perihelion passage and remained under observation with large telescopes out to its aphelion. Intrinsically faint P/Bradfield 2 survived its perihelion passage, while P/Brorsen-Metcalf, which has been seen at three apparitions now, has an absolute magnitude that falls just barely above the non-survival line. One possible explanation for the perihelion survival of these four objects is that they evolved from much larger, brighter comets. Brian Marsden notes that, while one cannot be certain (due to poor orbits), one can suggest that most nonsurvival cases were either long-period Oort cloud comets or Kreutz sungrazers.

The foregoing study results in three significant determinations regarding the objects under discussion. It is demonstrated that, in the majority of cases, long-period comets of fainter than average absolute magnitude do not maintain significant continued outgassing post-perihelion if their value of q is much less than 0.5 AU. It is also shown that short-period comets differ from those of long-period in their ability to maintain a continued state of high activity in spite of faint H_{10} values and close approaches to the sun. Finally, the empirical formula presented herein allows observers to predict the perihelion survivability of future intrinsically faint long-period comets of small q with fair reliability.

Φ Φ Φ