COMETARY BRIGHTNESS VARIATION AND
NUCLEUS STRUCTURE*

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Abstract. The Bobrovnikoff and Beyer photometric data for more than 100 comets have been
analyzed for intrinsic brightness variations, before and after perihelion, according to the $r^{-n}$ law,
where $r$ is solar distance. The Oort and Schmidt classification of comet ‘age’ has been extended
and applied with Marsden’s new determinations of inverse semi-major axis, $1/a$, original. All
classes of comets with $P > 25$ yr show statistically the same value of $n$ after perihelion. New comets
approach perihelion with smaller values of $n$ and older comets with increasingly larger values
(Table II). For comets of $P < 25$ yr, $n$ is larger and erratic.

A physical interpretation involves the quick loss of a frosting of super-volatile materials from
new comets; then, for all comets, the development of an insulating crust after perihelion. The crust
also includes ‘globs’ of meteoroidal and icy material. The crust tends to be purged near perihelion
but generally to grow in a spotty fashion with cometary age. The orientation of the axes of rotating
comets is shown to be an important unknown factor in cometary brightness variations. A specula-
tion is made concerning the axis of rotation for C/Kohoutek, 1973 XII.

1. Introduction

The purpose of this paper is to refine the statistical observational relationships between
comet ‘ages’, in the Oort (1950) sense, and their luminosity variations with solar
distance, before and after perihelion separately. From these new observational correla-
tions some qualitative understanding of the changes in the surface structures with
cometary age emerges. Attention is also given to certain photometric effects that may
be expected from the orientation of the rotation axes of cometary nuclei. A relevant
suggestion is made with regard to the rotation axis and photometric behavior of
C/Kohoutek, 1973 XII. Specifically, the marked difference in the intrinsic light curve
of this ‘new’ comet compared to that of ‘old’ P/Halley is shown in Figure 1.

It becomes clear that many questions about comets and their origin must await a
space mission, particularly a rendezvous mission, to a comet.

Oort (1950) first classified comets by means of their ‘original’ orbits, at great helio-
centric distances before they enter the planetary regions. He designated ‘new’ comets
as those that make their first entrance into the inner solar system from the great
solar-bound cloud. From Schmidt’s (1950) study of cometary brightness variations,
Oort and Schmidt (1950) then found that ‘new’ comets show a less rapid increase of

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intrinsic brightness with decreasing heliocentric distance than older comets. They also found that new comets are statistically more dusty, showing a stronger continuous to band spectrum ratio than older and shorter-period comets while simultaneously displaying tails of different types.

Regarding the physical nature of comets, Oort and Schmidt concluded that newer comets show a more rapid rate of deterioration than older comets and that they must contain more volatile gases. Hruška and Vanýsek (1958) extended the photometric studies of comets both on the basis of Levin’s photometric parameters and also with the classical parameters, ‘absolute’ magnitude $H$ and the exponent $n$ of the solar radius vector $r$, coupled with an inverse square law of geocentric distance $\Delta$, all related by

$$H_0 = H + 5 \log \Delta + 2.5n \log r,$$

where $H_0$ is the observed magnitude.

Hruška and Vanýsek found, consistent with the results of Oort and Schmidt, that the average value of $n$ decreases by nearly 50\% from short-period comets to very long-period comets and that comets showing a significant continuous spectrum exhibit an even smaller average value of $n$. Furthermore, the average value of $n$ reaches a peak between 1 and 2 AU. For comets of semi-major axis, $a \geq 500$ AU, the peak value of $\bar{n}$ is reached with $1.5 < r < 2.0$ AU before perihelion, while after perihelion it is reached in the range $1.0 < r < 1.5$ AU. For $r > 2$ AU, $\bar{n}$ is generally smaller after perihelion than before. Hruška and Vanýsek then applied a dust–gas model of a comet in which the dust observed in a comet with a continuous spectrum is the order of $10^{21}$ g and in which the observed dust/gas ratio increases with heliocentric distance.

In a more recent and more complete study, Meisel and Morris (1976) find no correlation of $n$ with $q$ but point out an effect of $q$ on $H_0$, caused by telescope aperture.