The total magnitude \( m_1 \) of a comet, generally defined today as the integrated brightness of the coma, is a concept with an evolving history that arguably began in the early-modern era with Isaac Newton (1687, see also Cohen et al. 1999), though this concept was not analysed in detail until late in the 19th century (cf. Green 1996a). The quantity \( m_1 \) gives information about the activity of comets and for many comets it provides virtually the only information on such activity, as spectrophotometric or spectroscopic information is not available for most of the historic comets (or even for most of the modern-day fainter comets). While there has been some debate about how to link \( m_1 \) data to modelling of sublimation and dust release from the cometary nucleus, there is a continuing effort at seeking correlations between \( m_1 \) data and flux information gathered in specific bandpasses at both optical and non-optical wavelengths.

The simple power-law formula, essentially introduced (as we now use it) by Orlov (1911), is still the most widely used equation for representing and predicting comet brightness (see the historical review by Green 1997). When a comet is first discovered, the standard time-tested practice is to use the power-law formula in the form \( m_1 = H + 5 \log \Delta + 2.5n \log r \), where \( \Delta \) and \( r \) are the comet's geocentric and heliocentric distances (in AU), \( H \) is the so-called absolute magnitude, and \( n \) is conventionally taken to be 4 (when \( n = 4 \) is assumed, \( H \) is often called \( H_{10} \)). Early work assumed that \( n = 2 \), and although Holetschek (1894) apparently first introduced the variable \( n \) while noting that comet 2P/Encke did not follow an inverse-square heliocentric relation, he curiously did not really deviate from assuming \( n = 2 \) for other comets in his extensive later work on cometary brightness (notwithstanding Hughes’ 1998 work).
inference to the contrary). Work by Sergej Veškhišvantsjš (1928) suggested that the average power-law exponent for comets tended toward $n = 4$, and this value has traditionally been taken as the default when calculating ephemerides of newly discovered comets (in which there is little or no known brightness history) for several decades now. This policy, in turn, led to the prediction in mid-1973 that comet C/1973E1 (Kohoutek, old-style 1973 XII = 1973h) should become a bright naked-eye object as the year 1974 opened.

A well-known study by Oort and Schmidt (1951), which had found that dynamically “newer” comets from the Oort cloud rise less steeply in brightness than short-period comets, was supported by Meisel and Morris (1982), who found that $n = 1$ less for comets with nearly parabolic orbits than for comets of short period. In a study of 41 fairly bright long-period comets, Green (1995) further found that pre-perihelion values of $n$ for comets with original semi-major axis ($a_{0,0} > 10000$ AU) are lower by a value of nearly 2 than are comets with $a_{0,0} = 10000–100000$ AU. We now know that there was nothing particularly unusual about the evolving brightness of comet C/1973E1, which did not brighten as predicted according to 10log$r$; it was a new comet with $2.5n = 7.0–7.5$ and $H = 5.5–6.3$ spanning nearly its entire apparition.

When the discovery of comet C/1999S4 (LINEAR) was announced, the remark on IAU Circular 726 “that this comet might become a naked-eye object next July” was in line with the wishes of astronomers, who like to be alerted to the reasonable possibility of a newly discovered object becoming bright, so that they can reserve telescope time. IAU 7267 assumed $H_{PA} = 7.0$ from the early-reported CCD magnitudes (a later ephemeris on IAUUC 7449 employed a fainter $H_{PA} = 9.0$). Words of caution concerning C/1999S4, particularly if it should turn out to be “new”, were posted on our Web sites early on, including the Press Information Sheet that has been available since February 2001, Vol 42

In recalling the suggestion by Öpik (1963) that the coefficient of log $\Delta$ in the magnitude formula should be taken as $2.5k$, where $k = 1$ (instead of $k = 2$ for the standard inverse-square relationship), McFarland (2000) does not seem aware of the discussions on this so-called “Delta effect” over the past few decades (e.g. Meisel 1970, Meisel and Morris 1976, Marcus 1986, Kamel 1991, Green and Morris 1991, Jewitt 1991, Green 1996b, Morris 2000). Proponents have suggested that the Delta effect can be seen in the light curves of comets that come close to the Earth ($\Delta < AU$). However, of the cases proposed, not one is clear-cut, and several such comets that came very close to the Earth in the past two decades have failed to show any such effect. Comet C/1999S4 certainly would not be a good candidate to use in studying this effect (its closest approach to the Earth, at $\Delta < 0.4$ AU, came about the time that it was showing signs of breaking up in July 2000). Any such study would need to assess carefully such issues as how cometary outbursts and nuclear breakup might affect light curves. Neither does McFarland give any indication as to where he obtained the magnitude data or how he reduced that data; if one does not choose visual and CCD magnitude estimates obtained by experienced observers and understand the instrumental/data-reduction intricacies, the computed light curve will include larger scatter and perhaps will lead to erroneous conclusions. The realization that C/1999S4 was very probably new in January 2000 (Nakano 2000). And indications that comet C/1999S4 was not brightening as rapidly as an inverse-fourth-power law ($n = 4$) would suggest, but rather more along the lines of $n = 2.5$ (and $H = 8.0$), was noted on our Web sites from about this same time in January. In fact, photometric observations from September 1999 to July 2000 (the greatest number of which are published in the International Comet Quarterly) reveal just such a light curve that needs no recourse to a Delta effect, because the proper parameter to vary is $n$ (which indicates the comet’s output of dust and gas as a function of distance from the sun), not $k$ (which is a function only of observing distance here on the Earth).

Thanks mostly to an armada of eager amateur astronomers worldwide (with a smaller contribution from professional astronomers), and in the absence of dedicated professional
time-observing programmes with large telescopes that might observe all comets brighter than (say) $m_{V} = 20$ every night, the ongoing acquisition of $m_{V}$ data continues to represent the only coma-activity observational measurements for most comets on most nights. Furthermore, there will always be a need to represent coma activity for historical comets through the $m_{V}$ data (lacking anything else), and $m_{V}$ data (with subsequent $m_{V}$-based ephemeris predictions of brightness) also aid astronomers greatly in planning their observing programmes. For these reasons, the acquisition and archiving of $m_{V}$ values will continue to have high value in cometary astronomy.

Daniel W E Green and Brian G Marsden, Maryland-Smithsonian Center for Astrophysics; Charles S Morris, International Comet Quarterly.

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In response…
John McFarland writes: I thank Drs Green, Marsden and Morris for the above comments. The observational magnitudes I used were those reported in IAU Circulars, and on the Web sites cfa-www.harvard.edu/icq/CometMags.htm and encke.jpl.nasa.gov/RecentObs.html.
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Discussion

February 2001 Vol 42

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