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THE CORRELATION BETWEEN WATER PRODUCTION RATES AND VISUAL MAGNITUDES IN COMETS

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Abstract

From the visual magnitudes of the *International Comet Quarterly* data base and the OH radio lines measured at the Nançay radio telescope, the law log $Q[H_2O] = 30.74 (\pm 0.02) - 0.240 (\pm .003)\ m_h$ is derived from a sample of 13 comets.

INTRODUCTION

A fundamental problem in cometary studies is to relate gas production rates and visual magnitudes. If such a problem can be solved, it will be possible to use the large historical data set of visual magnitude measurements to investigate the evolution of gas production along the orbit. It will also be possible to assess the feasibility of spectrocopic observations (from radio to UV) of new comets from their brightness behaviour.

DATA SET AND METHOD

We have now two homogeneous data sets in computer-readable form:
1) The compilation of visual magnitudes of the *International Comet Quarterly*. The base consists of more than 35 000 entries in the 1990 version (Green, 1990), most of them coming from amateur astronomers.
2) The data base of 18-cm OH cometary spectra measured with the Nançay telescope. 35 comets were observed since 1973, and most of the data are now incorporated in a computer base (Gérard *et al.*, 1990).

Water production rates can be derived from the OH radio lines following the model of Bockelée-Morvan *et al.* (1990). The model includes pumping by UV fluorescence, collisional quenching, and a coma expansion velocity deduced from the radio line shapes. The production rates from radio and UV observations of OH are now in agreement when consistent sets of model parameters are used. We assume $Q[H_2O] = 1.1\ Q[OH]$.

We have studied the correlation between the water production rate and the visual magnitude in 13 comets. The water production rates were evaluated for a selection of 81 time-averaged OH spectra which have sufficient signal-to-noise ratios to get reliable results (the corresponding OH data are published in more detail by Bockelée-Morvan *et al.* 1990a, 1990b and 1991). The visual magnitudes m_v were reduced to heliocentric magnitudes m_h according to $m_h = m_v - 5 \log \Delta$ and averaged (or interpolated) over the same time intervals as the OH spectra. This averaging process smoothes the large dispersion of the total visual magnitude measurements. The heliocentric distances of the resulting sample range from 0.32 to 2.8 AU.

RESULTS AND DISCUSSION

$Q[H_2O]$ is plotted as a function of m_v for the whole sample and for different groups of comets in the figures. The error bar on $Q[H_2O]$ is that resulting from the noise in the OH spectrum (it does not include model uncertainties).The error bar on m_h is that resulting from the dispersion on the measurements. The empirical law deduced from a regression analysis applied to the whole sample is:

$$\log Q[H_2O] = 30.74\ (\pm 0.02) - 0.240\ (\pm .003)\ m_h$$

with a regression coefficient of -0.92. We note that:
- there is no strong deviation to this law for individual comets. From first inspection, the law does not depend upon gas-to-dust ratio. Although the sample includes short-period, long-period and new comets, there is no obvious difference between these different classes.
- the slope of the law is steeper for P/Halley (-0.303) than for the set of the 12 other comets (-0.213).

Similar studies were performed in the past: from OH radio measurements by Bockelée-Morvan *et al.* (1981), from UV OH measurements by Festou (1986) and Roettger *et al.* (1990), for comet P/Halley alone by Sekanina (1989) and many others. Our regression law is intermediary between those of Bockelée-Morvan *et al.* and of Festou; it is in agreement with the one Sekanina proposed for P/Halley (which may be fortuitous). When comparing these studies, one must have in mind that they use gas production rates estimated with different models. We believe that our work is an improvement over the preceding ones, owing to the larger size of our sample.

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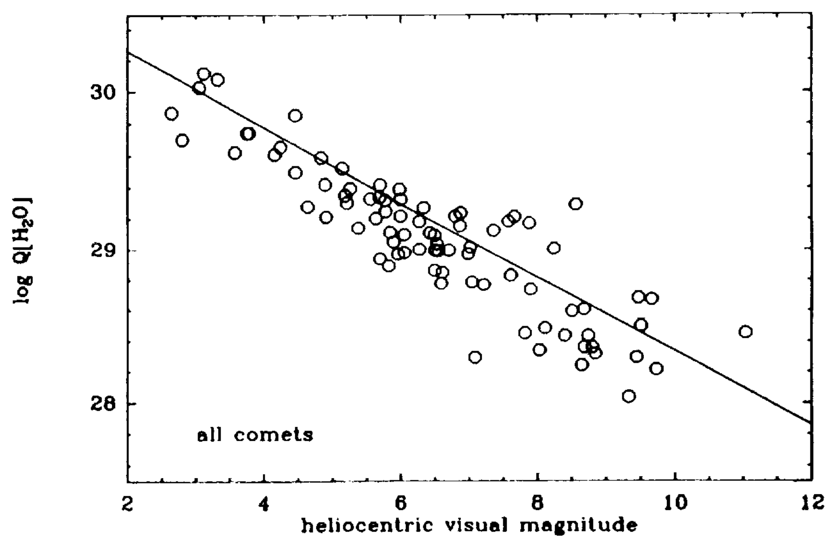
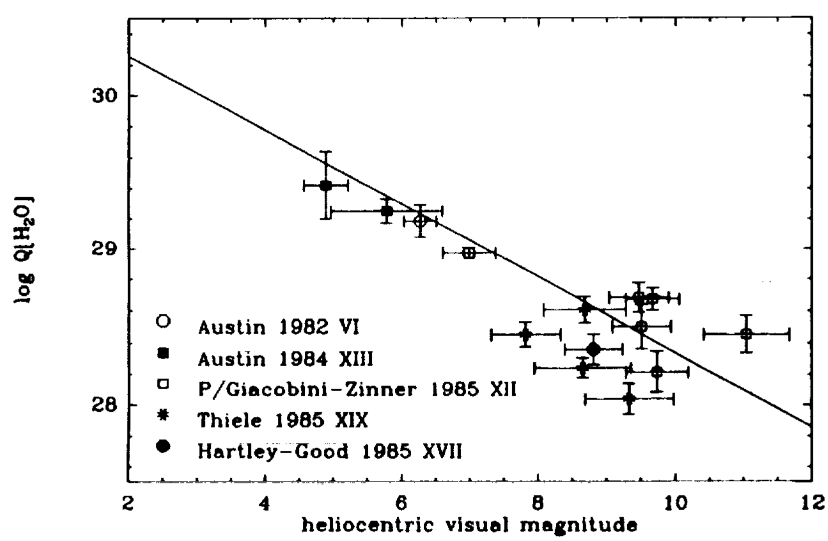
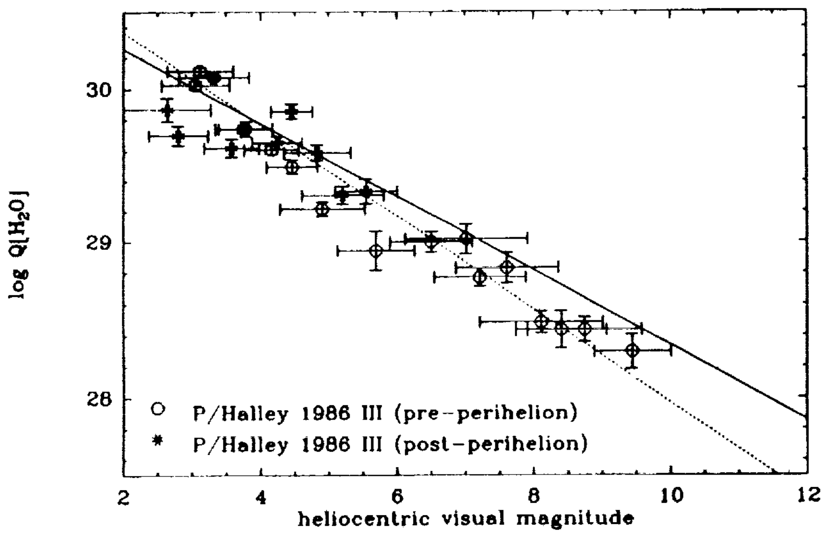
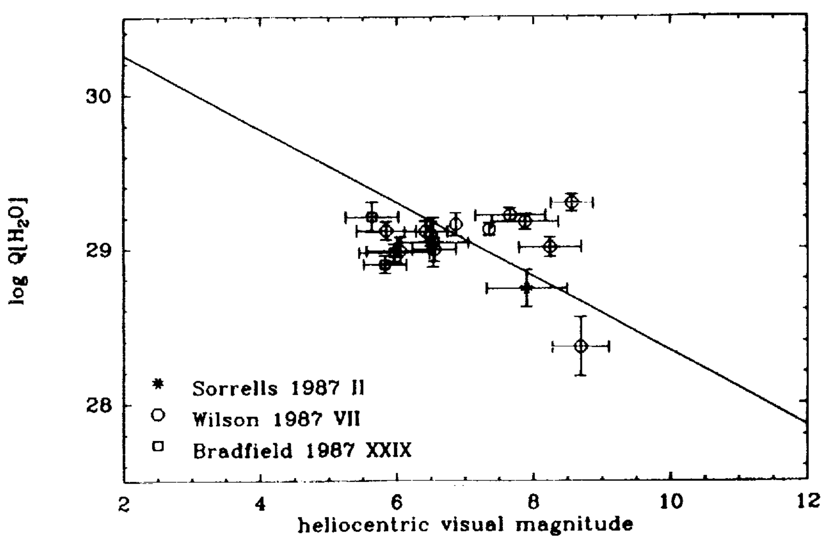
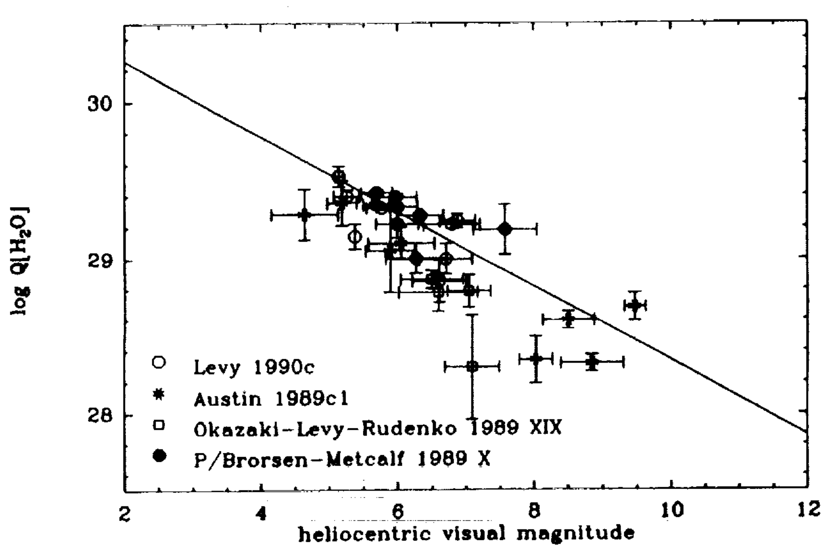
Figures: Water production rates derived from the OH 18-cm lines observed at Nançay, as a function of heliocentric visual magnitudes derived from the ICQ archives. The error bars are ±1 σ. The full line shows the least-square linear fit to the whole sample and is repeated on each figure. The dashed line is the fit to P/Halley data alone.






log Q[H_2O]
30
29
28
2
4
6
8
10
12
heliocentric visual magnitude
P/Halley 1986 III (pre-perihelion)
P/Halley 1986 III (post-perihelion)


log Q[H_2O]
30
29
28
2
4
6
8
10
12
heliocentric visual magnitude
Sorrells 1987 II
Wilson 1987 VII
Bradfield 1987 XXIX


log Q[H_2O]
30
29
28
2
4
6
8
10
12
heliocentric visual magnitude
Levy 1990c
Austin 1989c1
Okazaki-Levy-Rudenko 1989 XIX
P/Brorsen-Metcalf 1989 X