RAPID CHANGES OF BRIGHTNESS IN P/HALLEY

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(Received 25 June, 1986)

Abstract. The results of photometric measurements (in *UBV* filters) of Comet P/Halley during four nights in January 1986 have been presented. Rapid recurring increases of P/Halley's brightness were observed during these four nights. This phenomenon seemed to occur at a time interval of about 23.7 ± 0.3 hr. The maximum variation of brightness during an individual night amounts to $\Delta U \sim 0^m.70$; $\Delta B \sim 0^m.65$, and $\Delta V \sim 0^m.66$ in *U, B,* and *V* filters, respectively. Rapid irregular short-lived fluctuations of brightness of the order of $0^m.1$ were also found present during an individual night. The present observations show the active nature of P/Halley.

1. Introduction

Halley's comet is the most famous of its breed, inspite of the fact that it is not the brightest. It is our guest, visiting us approximately every seventy-six years and is the brightest of all-short period comets (Littmans and Yeomans, 1985). During its recent visit it was recovered on 16 October 1982 ($r_H = 11.04$ AU; $V = 24.2$) by Jewitt and Danielson (1982), more than three years before its perihelion (Feb. 9, 1986). This is the earliest recovery ever made on a periodic comet. Halley's comet is of such a scientific importance and is so dependable, pre-preparations for its return were made years in advance. Thousands of amateur and professional astronomers throughout the world have joined together in the largest programme of international cooperation, International Halley Watch (IHW), ever undertaken in astronomy.

Since its present recovery observations of the comet have continued to be extremely challenging. Astronomers have scrutinized Comet Halley with a variety of sophisticated instruments that were not available during its last passage. The astronomers were eagerly awaiting the brightening of the comet from August 1985 to May 1986.

In the present investigation we report the photometric behaviour of P/Halley during the pre-perihelion period when the comet was considerably bright in January 1986. The three colour (*UBV*) observations of P/Halley during four nights show the rapid recurring and erratic variability.

2. Observations

Comet P/Halley was observed during four nights in January 1986 with the 38-cm reflector of the Uttar Pradesh State Observatory, Naini Tal, using the 1P21

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Earth, Moon, and Planets **38** (1987) 53–58.

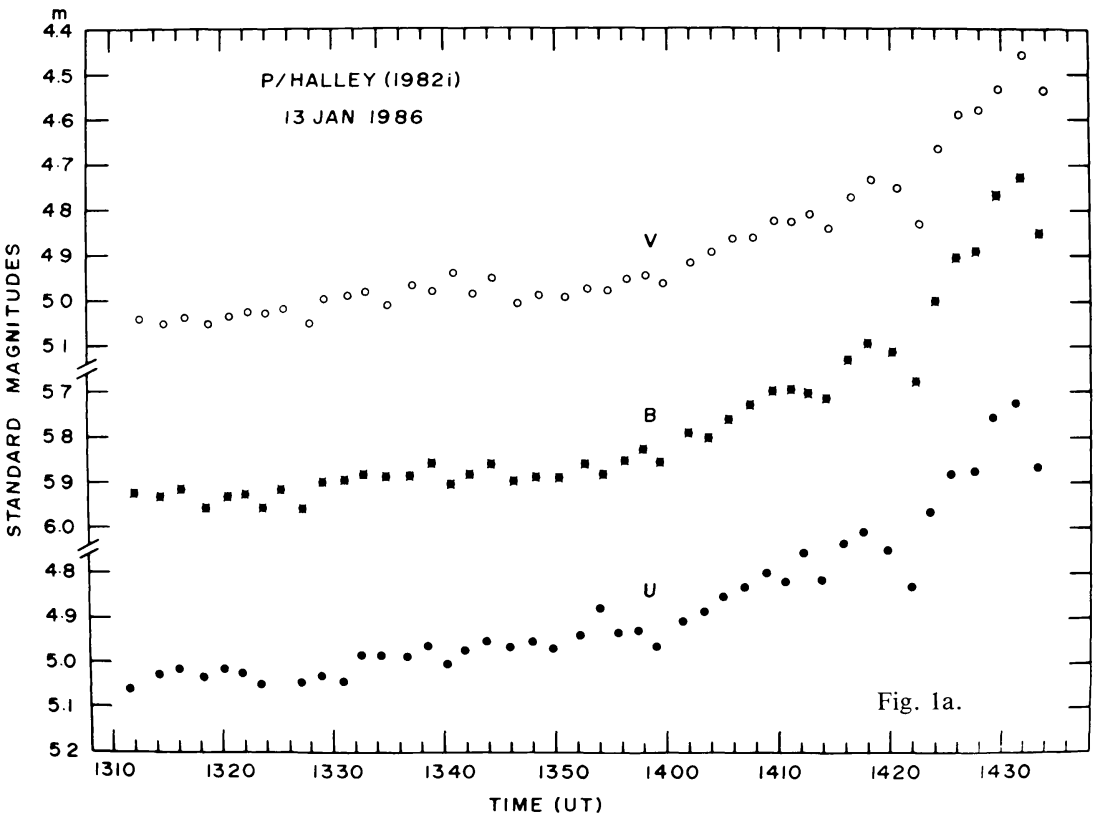

Fig. 1a.

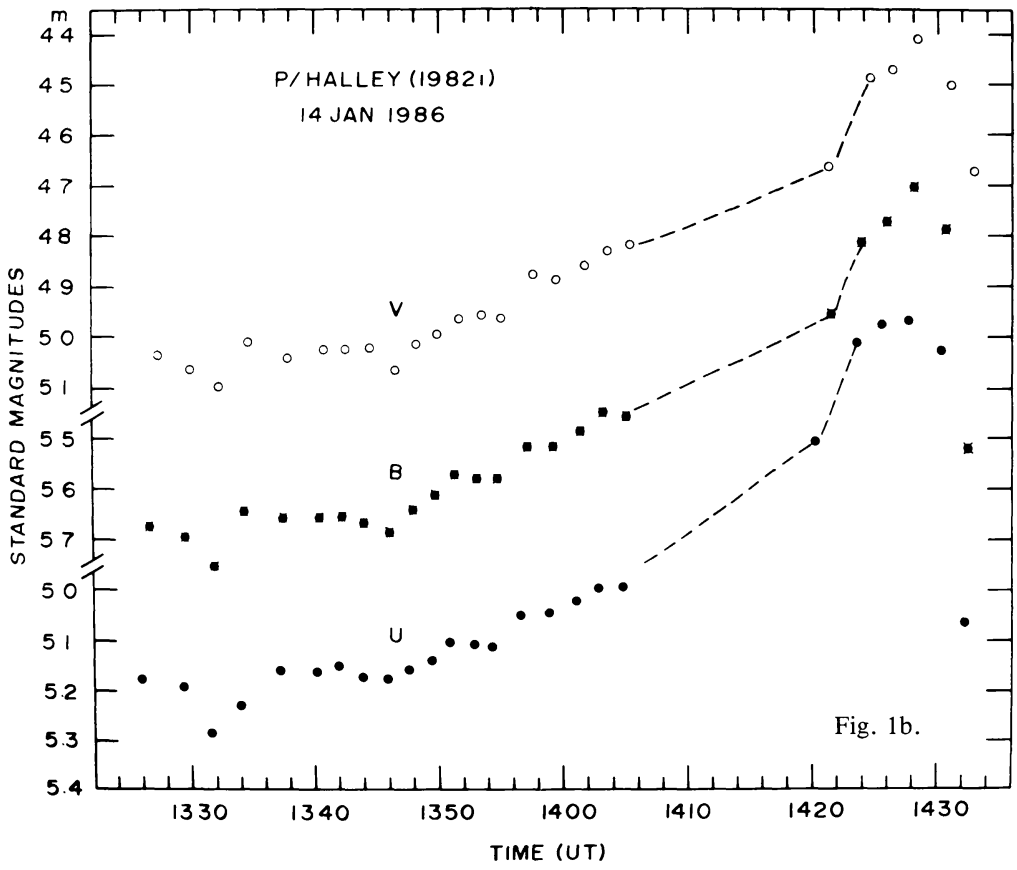

Fig. 1b.

Fig. 1a–d. Light curves of Comet P/Halley in three colours during four nights.

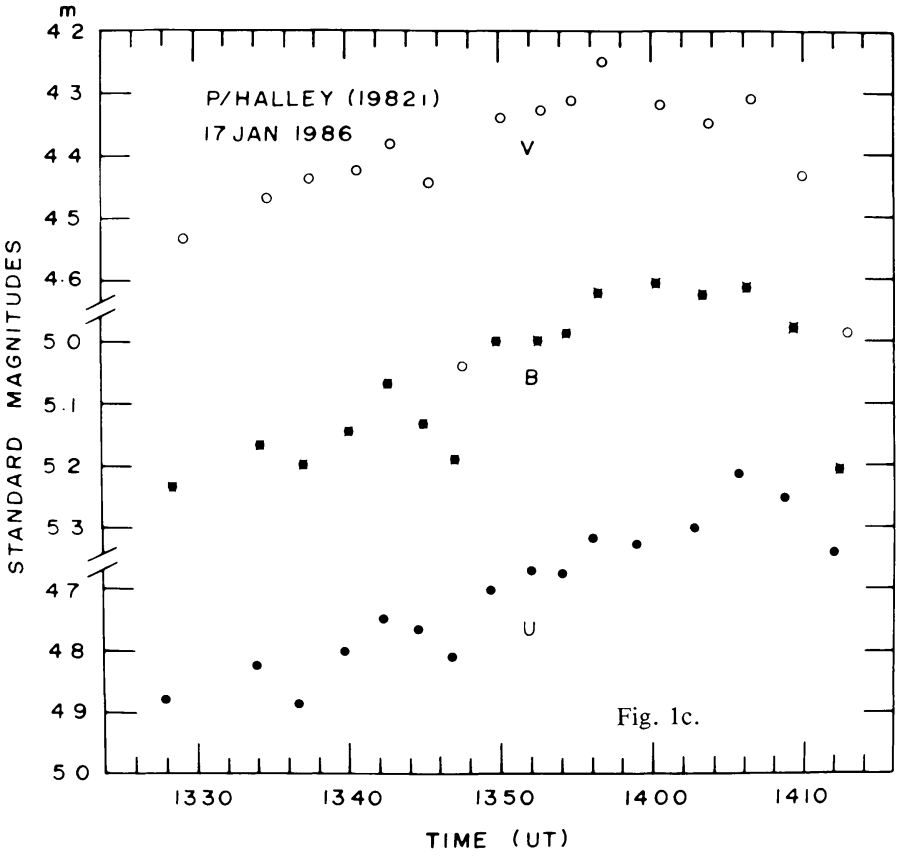

Fig. 1c.

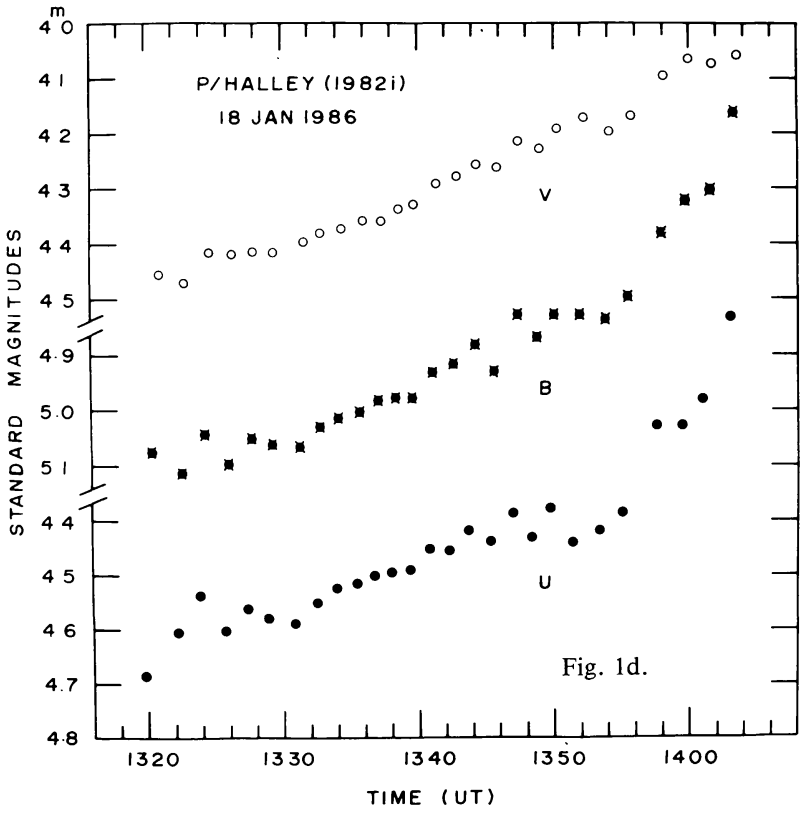

Fig. 1d.

TABLE I

The maximum variations of brightness of P/Halley during individual nights

Jan. 1986 Date (UT) (Mean)	Total observing time	Amplitude of variations			Total number of measured magnitudes in each filters	Trend of variations
		ΔU	ΔB	ΔV		
13.56	01^h22^m	$0^m.65$	$0^m.60$	$0^m.55$	43	Rapid increase in brightness
14.58	01^h07^m	0.70	0.65	0.66	25	Rapid increase in brightness
17.58	00^h45^m	0.35	0.30	0.25	16	Rapid increase in brightness
18.56	00^h43^m	0.60	0.60	0.40	27	Rapid increase in brightness

photomultiplier thermoelectrically cooled to $-20\,^\circ$C. The dates of observations are given in Table I alongwith the total observing time. The standard d.c. techniques were employed for taking the observations. An entrance diaphragm of 75 arc sec allowing the whole head of the comet to fall on the photomultiplier was used while securing the observations.

The comparison stars η Aqr and 10 Tau were observed alongwith the comet for determining the extinction coefficients and differential magnitudes of the comet. The differential magnitudes were converted to the standard *UBV* system with the help of the standard stars and following the usual standard method used in photometry. The total standard *UBV* magnitudes of Comet P/Halley thus obtained by us on different dates are displayed in Figures 1a–d. The standard deviation of the observations does not exceed $\pm\, 0^m.06$.

3. Results and Discussion

Figures 1a–d display the standard total magnitudes of Comet P/Halley in three colours as measured by us on four nights in January 1986. If one examines the *U, B,* and *V* light curves of P/Halley during individual nights, one finds that the comet displayed recurrent brightening in all the three colours during each of the four nights. A careful examination of these light curves shows that during an individual night the brightening began at the same time in all the three colours. The amplitudes of brightness variation are given in Table I. The amplitude of variation is quite large and is maximum in *U* filter and minimum in the *V* filter. An important and interesting feature to be noted from Figures 1a–d is that the brightening did not begin at the same time in all the four nights. There is a gradual shift in time of about 15 min per day for the beginning of brightness. For every preceding night the brightening started earlier by about 15 min. This type of phenomenon indicates that the variation is more or less periodic in nature, having a period less than 24 hr. The

present observations show that the variability has a period of approximately 23.7 ± 0.3 hr. However, at present it is not possible to derive the exact period of variability due to the lack of observations and less time coverage. We could observe the comet for about 1.2 hr and even less out of 24 hr. This short coverage of time did not allow us to give precise period of variability.

The light curves in Figures 1a–d also show that the Comet P/Halley exhibit short-lived irregular fluctuations having an amplitude of about $0^m.1$ in brightness. Such fluctuations are clearly seen during every individual night. At present, we are arrived at the conclusion that all the observed light curves of Comet P/Halley are a composite of periodic and erratic variations.

The periodic brightness variations in comets very likely reflect the rotation of the nucleus. We suggest two explanations both relying upon the spin of the nucleus, for such variations: (a) In the first case we expect that the nucleus is not spherical but dumbbell-shaped (elongated) and has a nearly uniform albedo. In this case the observed brightness is simply proportional to the area of cross-section as projected to the observer. If this is the case, the rotational period of the comet may be sub-multiples and multiples of 23.7 hr; the period 47.4 hr is most likely expected. (b) The second possibility is that the nucleus is nearly spherical in shape but the surface is quite inhomogeneous so that the albedo varies remarkably over the surface.

The short-lived erratic variations may be due to great inhomogeneity of dust emission. The dust outflow may take place in the form of jets. Such jets could arise from the active zones on the rotating nucleus producing a burst of gas and dust as they are heated-up by the Sun. Such phenomenon can occur at any time producing temporary irregular variations of brightness. The complicated jets and fan-like structures have already been seen in the inner comas of comets (Hughes, 1985).

The present investigation shows that the Comet P/Halley was very active near perihelion. However, the observations made by West & Pedersen in December 1982 and January 1983 showed the evidence that the comet was variable by about $0^m.5$ even at larger heliocentric distances ($\Upsilon_H \sim 10$ AU) indicating the active nature of P/Halley (Wychoff and Wehinger, 1985). Jewitt and Danielson (1984) observed P/Halley during October 1982 and December 1984 ($\Upsilon_H = 11.0$ AU and 8.2 AU)) with CCD camera and noticed that the brightness of the comet varied by about 1 magnitude on a time scale of one day (at $\Upsilon_H = 8$ AU). Sekanina (1984) examined the observed data on P/Halley from the period, October 1982 to February 1984. The data showed variations of upto 5:1 in the intrinsic brightness. It was found that the observed light curve is a composite of periodic and erratic variations.

Further evidences of the active nature of P/Halley at larger heliocentric distances can be found from the observations made by West and Pedersen (1984) and Le Fevre *et al.* (1984). They have reported the photometric variability of about $1^m.0$ to $1^m.7$ in P/Halley during January 1984 to February 1984. The recent photometric observations secured by Hendrie and Keitch (1985) showed that the comet was unexpectedly bright during early November and mid-November 1985. They found that the comet was brighter than expected by about 1.5 to 2 magnitudes. The more

recent observations taken by SUISEI, the first Japanese Interplanetary Spacecraft during November and December 1985 showed that the comet was active at a heliocentric distance of 1.5 AU (Kaneda *et al.*, 1986). These observations showed the periodic activity of the comet.

4. Conclusions

The present discussion shows that the Comet P/Halley possesses intrinsic variations of brightness through the wide range of heliocentric distances, indicating its active nature. The variations are a composite of regular and erratic outbursts. It is concluded that the regular variations are due to the rotation of the nucleus and the erratic variations are due to ejectas of gas and dust from the surface of the nucleus.

Acknowledgement

The authors are thankful to Dr S. K. Gupta for discussions and help during observations.

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