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Astrometry of comet Halley during the 1985-86 apparition

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Abstract. Photographs of comet Halley were obtained using the 1m telescope of the Vainu Bappu Observatory, Kavalur, during the 1985-86 apparition, and astrometric measurements carried out. The details of observation and measurement technique adopted are given. The observed apparent positions of the comet are compared with the predicted values. Our results agree well with the revised predictions.

Key words : photographic astrometry—comet Halley

1 Introduction

We obtained photographs of comet Halley using the 1m telescope at the Vainu Bappu Observatory, Kavalur, to evaluate the apparent positions of the comet at regular intervals of time. The results were communicated, each time, to the astrometry network of the international Halley watch (IHW), where the data from a large number of observatories all over the world were regularly pooled and used to evaluate the refined orbit of the comet. In this paper, the details of observation, the measurement technique used and the results obtained are reported.

2. Observation and measurement

In long focus photographic astrometry, a focal ratio of about f/15 is normally used (van de Kamp 1967). We photographed the comet at the Cassegrain focus of the 1m telescope which has a focal ratio of f/13, and a plate scale of 16 arcsec mm^{-1} in the focal plane. These photographs were obtained on Kodak 103 aO plates of size 16 × 16 cm. When the comet was faint, with a predicted total magnitude of about 13, the expected region of the sky was photographed for about an hour, with suitable corrections applied to take into account its predicted apparent motion. As the comet brightened, the telescope could be guided on it. A photograph of the comet, obtained in 1985 October is shown as figure 1.

The standard stars on photographic plates were identified using the POSS charts, the SAO catalogues, and the 'standard stars catalogue for astrometry of comet

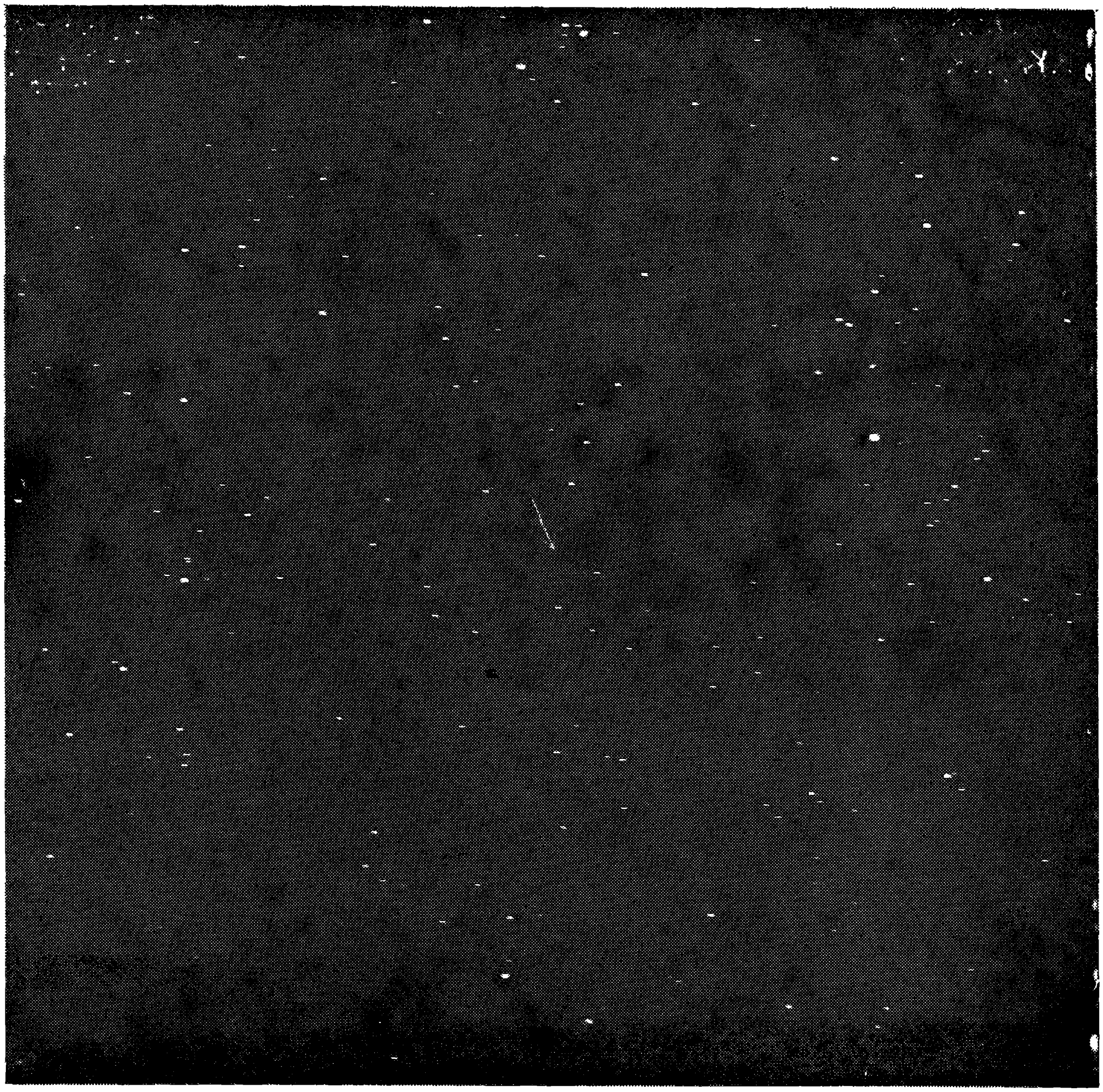

Figure 1. Photograph of comet Halley (indicated by an arrow) taken on 1985 October 8, between 2304 and 2324 UT at the Cassegrain focus f/13 of the Kavalur 1m telescope, using a GG filter and Kodak 103 aO plate.

Halley' specially prepared for the purpose by D. K. Yeomans. It was thus possible to identify 10 to 15 standard stars in a majority of the plates, in the magnitudes range of 8–14. As an illustration, the list of standard stars used for measurements on the plate of 1985 September 2 are given in table 1.

Measurement of relative positions of the identified stars and the comet were made on Carl Zeiss X–Y coordinate measuring engine which gives a positional accuracy of one micron on the photographic plate. As the stars trail in the photographs guided on the comet, it is customary to take the mean position with respect to the edges of the trails to be the position of the star at the mid-time of the exposure; the position of the comet is thus evaluated for this mean epoch (Roemer 1975). The edges of star trails in our plates were generally well defined for stars

Table 1. Standard stars on the plate of 1985 September 2

Yeomans' catalogue No.	B D No.	Right ascension (1950.0)			Declination (1950.0)			m_v
		h	m	s	°	′	″	
2985	+ 19 1247	06	08	09.160	+ 19	14	07.19	9.3
3014	+ 19 1254	06	09	05.492	+ 19	31	47.72	8.7
3018	+ 19 1255	06	09	14.500	+ 19	26	38.51	9.8
3041	+ 19 1258	06	10	14.113	+ 19	27	04.71	8.9
8434	—	06	08	11.644	+ 19	28	36.73	13.1
8439	—	06	08	24.923	+ 19	12	46.16	13.5
8444	—	06	08	38.689	+ 19	19	32.03	13.2
8448	—	06	08	40.925	+ 19	36	25.13	13.4
8459	—	06	08	57.499	+ 19	30	29.44	14.0
8460	—	06	09	00.113	+ 19	13	37.30	13.4
8470	—	06	09	21.035	+ 19	22	09.20	13.7
8479	—	06	09	39.124	+ 19	27	26.42	13.6
8484	—	06	09	54.708	+ 19	20	36.28	13.1
8503	—	06	10	21.787	+ 19	29	39.28	13.7

up to magnitude of 13–14. Care was taken not to include standard stars lying close to the outer edges of the plate as they considerably increase the error in the estimated RA and Dec of the comet.

3. Computation and results

In order to evaluate the apparent RA and Dec of the comet with respect to the standard stars, the practical and convenient method of triangulation suggested by Comrie (1929), also known as the method of dependence (Green 1985), was adopted. A computer program for single triangulation, written by R. Vasundhara was kindly provided by her for our use. We extended the program further to carry out multiple triangulations, in the way suitable for cometary astrometry. A listing of this program may be obtained from the authors. In the program, each case refers to a particular triangulation. The 'reference star' is a standard star close to the comet on the plates. For each case the estimated RA and Dec are given for the reference star and the comet. Each of the triangulations is thus tested for the accuracy in reproducing the RA and Dec of the reference star. The accuracy was found to be better than 0.5 arcsec in a majority of the cases. Values from such tested triangulations were used to get the mean RA and Dec of the comet for the mean epoch of the exposure.

An accuracy of ± 1 arcsec could be claimed in the measured position, when the comet was fainter than 10 mag. This is generally considered adequate for cometary astrometry (Marsden 1984). In table 2, the measured apparent RA and Dec are compared with the values predicted for the comet. It is evident that the measured values differ considerably from those predicted by Yeomans (1981). However, these predicted values were later revised using early astrometric data from various observatories (Yeomans *et al.* 1985). The revised predictions agree well with our measured values of RA and Dec for the first three epochs. The difference for the October 13 observation appears to be real as the measurement carried out is satisfactory with 10 standard stars and a reference star.

Table 2. Measured and predicted apparent positions of comet Halley

Date	Mean epoch UT	Right ascension (1950.0) Measured	Right ascension (1950.0) Predicted*	Declination (1950.0) Measured	Declination (1950.0) Predicted*
		h m s	*h m s*	° ′ ″	° ′ ″
1985 Sep 2	23 05 30	06 09 18.514	06 09 20.955	+ 19 22 56.24	+ 19 22 32.71
			06 09 18.494		19 22 56.05
Sep 9	21 41 30	06 11 49.398	06 11 52.194	+ 19 58 24.55	+ 19 57 48.80
			60 11 49.677		+ 19 58 24.75
Oct 10	23 14 00	06 07 10.668	06 07 13.646	+ 20 19 15.95	+ 20 18 31.45
			06 07 10.589		+ 20 19 15.82
Oct 13	23 30 00	06 02 27.795	06 02 31.655	+ 20 34 05.48	+ 20 33 13.99
			06 02 28.001		+ 20 34 03.77
Nov 14	18 47 30	03 59 32.928	04 00 18.873	+ 21 57 29.85	+ 21 56 25.21
			03 59 31.551		+ 21 57 37.71

*The first row gives values of RA and Dec interpolated following Yeomans (1981) ; the second row, following Yeomans *et al.* (1985).

In the case of the 1985 November plate, the difference between predicted and observed values of RA and Dec is considerable. This could be due to the following reasons : In order to evaluate the predicted RA and Dec for the epoch when the comet was observed, we have used a linear interpolation of the data for zero hours on the neighbouring two days. This procedure does not seem to work satisfactorily for the November 14 plate as the comet was very close to its ascending node. Our interpolated value for predicted RA and Dec for this day would hence be in error. Secondly, the November 14 plate has only four standard stars, one of them being near an edge of the plate and there is no reference star for a check on the triangulations. The measured values for the RA and Dec of the comet would hence be in an error of about $\pm$ 10 arcsec. Further, as we see for the October 13 case, there would also be a contribution due to the real difference in the apparent position of the comet and the predicted value.

As the coma size became bigger with the approach of the comet towards perihelion, the accuracy of the apparent position estimates reduced considerably. Astrometric measurements were hence not made for the plates obtained from 1985 December onwards during the pre-perihelion period. In the post-perihelion period, unfortunately, observatians could not be obtained due to unfavourable weather conditions on the nights set apart for astrometry.

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References

Comrie, L. J. (1929) *J. Br. Astr. Assoc.* **39**, 203.
Green, R. M. (1985) *Spherical Astronomy*, Cambridge Univ. Press, p. 325.
Marsden, B. G. (1984) *Cometary Astrometry* (eds : D. K. Yeomans *et al*) NASA, p. 31.
Roemer, E. (1976) IAU Coll. No. 25 : *The Study of Comets*, Pt. 1 (eds : B. Donn *et al.*) NASA, p. 396.
van de Kamp, P. (1967) *Principles of Astrometry*, Freeman, p. 85.
Yeomans, D. K. (1981) in '*The Comet Halley Handbook*', NASA, p. 34.
Yeomans, D. K., Harrington, R. S., West, R. M. & Marsden, B. G. (1985) in '*The Astrometry Network of the IHW Newsletter*', Oct. issue.