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OUTBURST AND NUCLEAR BREAKUP OF COMET HALLEY - 1910

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ABSTRACT

Computer processing of five plates of Comet Halley taken during the 1910 apparition shows that on May 24 strong asymmetric (with respect to the tail axis) fountain-like parabolic plumes had developed on the sunward side of the nucleus. Visual observations showed that after an initial fading while passing in front of the sun, the brightness increased to about magnitude 1. On the plates taken May 31 the nucleus is clearly divided into at least three parts of nearly equal brightness. However, the last plate on June 3 shows a symmetrical coma with a small stellar-like nucleus.

INTRODUCTION

During the compilation of a plate catalogue of minor planet observations at the Institute for Astronomy of the University of Vienna, Austria, we came upon five excellent plates of the Comet Halley taken during the 1910 apparition. The plates were taken by R. Krumpholz with the 30 cm "Normalastrograph" (scale 60" per mm) and are described by Rheden (1912). The publication includes photographic reproductions of several of the plates. Presently available are the plates 142a, and 143a (May 23, 1910), 144a (May 24, 1910), 145a (May 31, 1910), and 146 (June 3, 1910). A number of plates were lost during the decades and the two world wars. In addition, simultaneous visual observations were carried out at a remote station on the Sonnwendstein and are described by Rheden (1911). Two of the four drawings by J. Hartmann and J. Rheden confirm the photographic results given in this paper.

IMAGE PROCESSING

(a) Two of the five plates available will be described here. Plate 144a was taken on May 24, 1910, at 09:22 MZW (=20:17 UT) with 19 min. exposure time including two interruptions. As in the 15 and 20 min. exposures on the previous night May 23, the coma shows a distinct spiral structure but now considerably more developed. Figure 1 shows a negative print from plate 144a.

The plates were digitized using a PDS-1000 microdensitometer. Pixel size is 20 by 20 microns, a 20 micron square diaphragm was used. All processing was done with the Tololo- Vienna Interactive Image Processing System (Albrecht, 1979). Additional software for this project was developed in Vienna by R. Albrecht.

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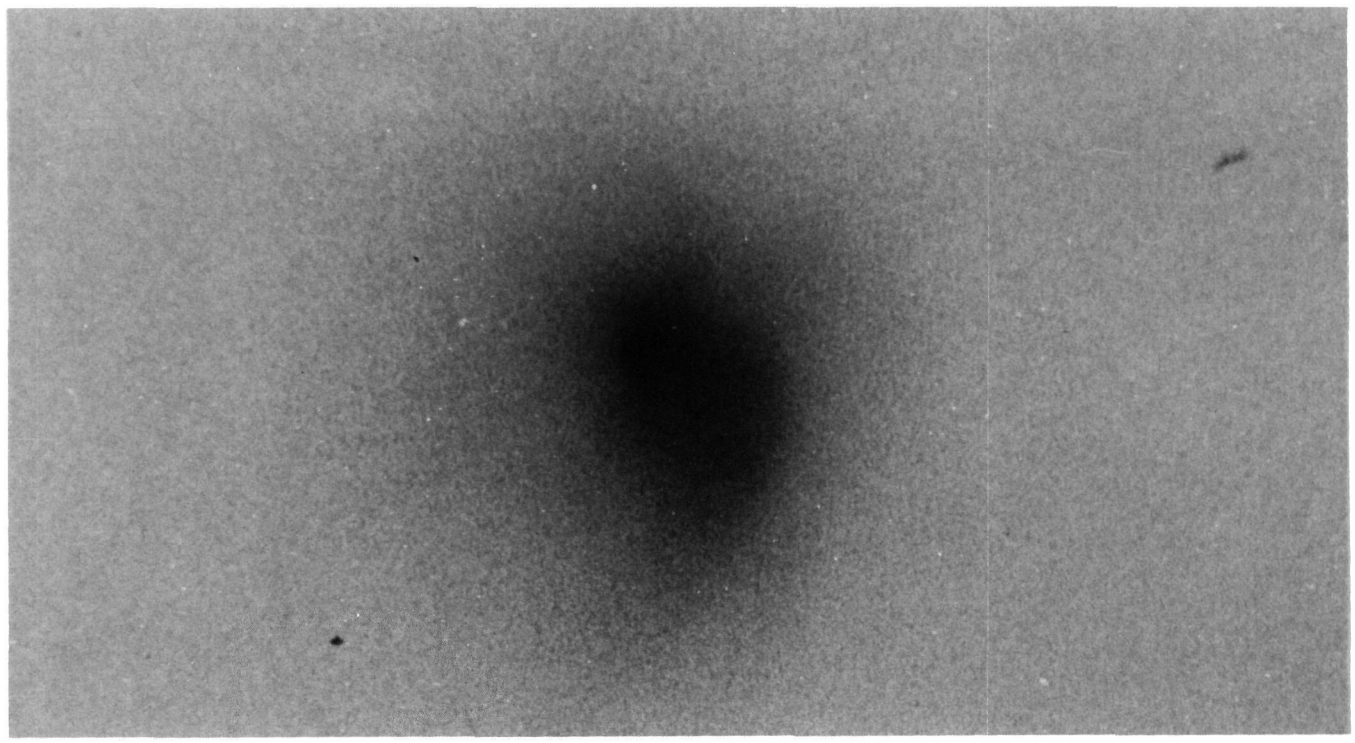

Figure 1. Print from plate 144a of Comet Halley on May 24, 1910. The sun is at approximately the 2 o'clock position with respect to the nucleus. The distance between the short star trail segment at right edge and the nucleus is approximately 6 arc min. Same scale as Figure 2.

Figure 2 shows the derivative in both the X and Y coordinates of the digitized plate 144a taken in the approximate direction of the solar illumination. Figure 2 has been printed to the same scale as Figure 1. A similar derivative image appears in the July 1980 Report of the Science Working Group of The International Halley Watch (NASA TM 82181, Figure 15b, p. 22). However, this image is the sum of four exposures and is considerably more heavily exposed than plate 144a.

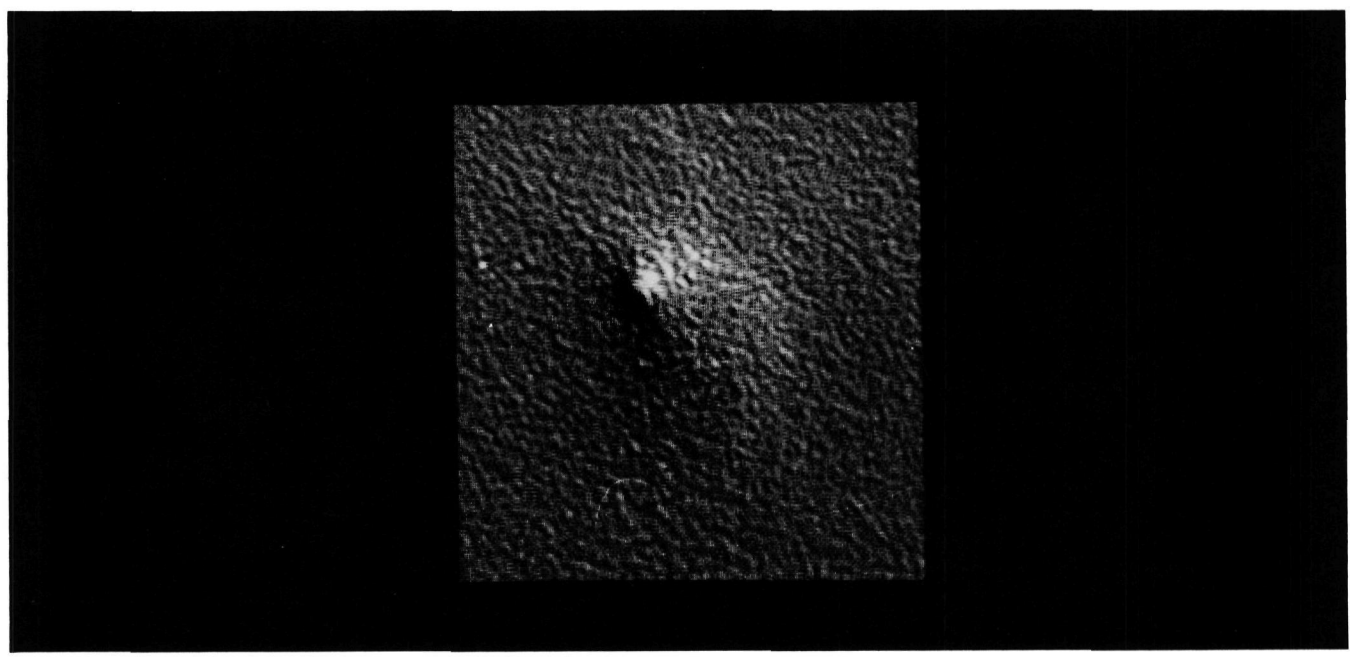

Figure 2. Derivative of digitized image from plate 144a of Comet Halley on May 24, 1910. The sun is at approxmately the 2 o'clock direction with respect to the nucleus. Same scale as Figure 1. The weak upper and strong lower parabolic dust plumes leave the nucleus in the sunward direction.

Figure 2 shows clearly the parabolic form of the plume structure, continuing all the way into the nucleus, until the resolution limit of the emulsion is reached. The lower (southward) plume is distinctly stronger than the upper plume. Detailed examination of the original plate shows that the plumes emanate in the sunward direction from the nucleus and only bend backwards away from the sun far from the nucleus.

The jet-like appearance of the plumes suggest the presence of accelerating forces. Yeomans (1977) has shown that non-gravitational accelerations due to the rocket effect of the rapid outgassing of water-ice modify the orbit of the comet. Transverse accelerations are negligible. Yeomans found that the lag angle between the subsolar meridian and the direction of maximum mass ejection averaged less than four degrees. Our study of plate 144a does not differ from this interpretation.

The small crater-like features which dominate the background of the derivative display reflect the structure of the emulsion.

(b) Plate 145a was taken on May 31, 1910, at 09:15 MZW (=20:10 UT) with 61 min. exposure time including several interruptions. Guiding was excellent as can be seen when one inspects the straight and uniform star trails on the plate (not shown in the figures).

Figure 3 shows the digitized image form plate 145a. Here the computer processing technique allows us to show structure at optical density three. A wrap-around at lower density levels (here at density approx. 0.5) allows us to simultameously show the outer coma and direction of the tail. Contour plots (not shown) indicate that the strong parabolic-form asymmetry of Figure 2 is completely missing on May 31: outside the triple nucleus, the isodensity contours of the coma are nearly circular down to levels where the tail begins to distort them.

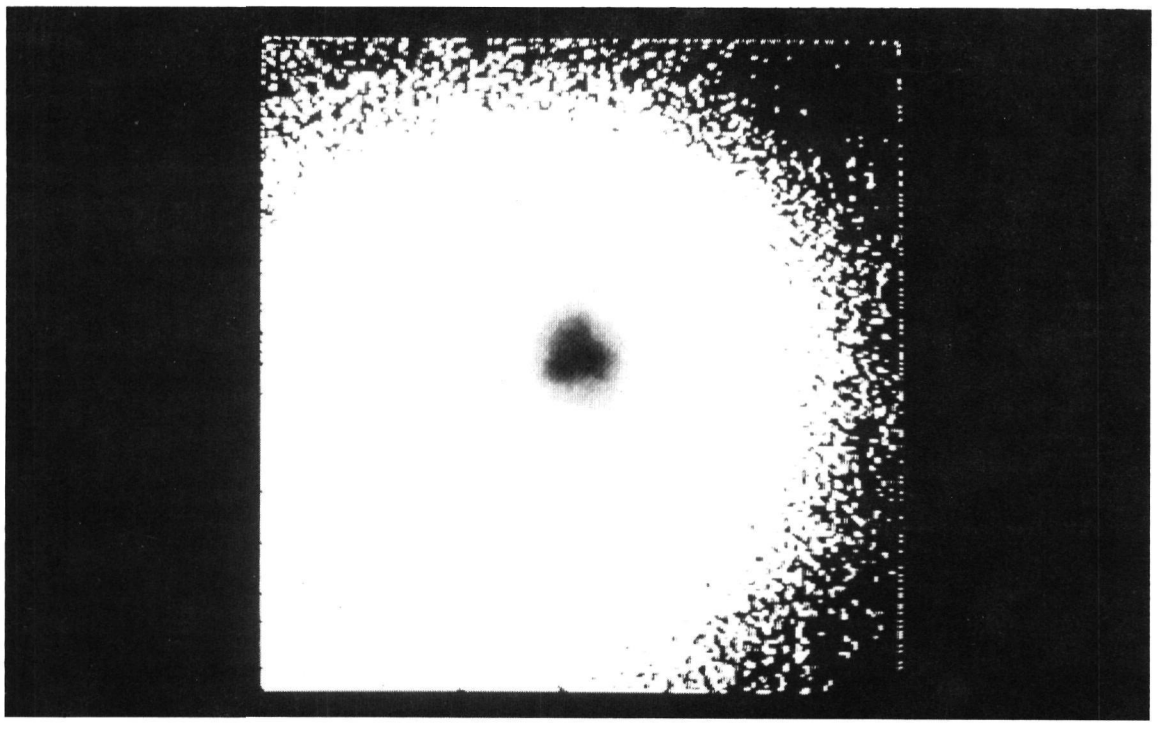

Figure 3 - Computer processed image from plate 145a of Comet Halley on May 31, 1910. The sun is at approximately the 2 o'clock position with respect to the nucleus. The distance between the two lowermost parts of the nucleus is approximately 40 arc seconds. Isophotes (not shown) between the tripartate nucleus and the outermost isophote shown are nearly circular.

Three dimensional graphic displays ("hidden line plots") of the innermost region reveal that the upper left fraction of the nucleus again consists of two components.

Concurrent visual observations carried out by J. Rheden at the Sonnwendstein field station confirm that the nucleus indeed consisted of at least four parts.

Rheden also did visual estimates of the brightness of the comet, using a 135 mm f/10 refractor. Nucleus plus coma were of about second magnitude on May 23 with a flaring up ("Lichtausbruch") to first magnitude on May 24. The next observation on May 26 gave about 2.5 mag. Until June 3 the brightness faded to about 4 mag. There were indications of brightness changes on a time scale of tens of minutes on May 28.

CONCLUSION

Computer processing of the 1910 plates of Comet Halley has aided us in showing:

(a) that the strong plume emission on May 24, 1910, does not imply rapid rotation of the nucleus or strong tangential accelerations. Evidence is given by the fine structure of the pattern and the fact that sublimation occurs only at the subsolar meridian.

(b) that the formation of a multiple nucleus took place on May 31 after the plume emission.

Plate 146 taken on June 3, 1910, shows circular isodensity contours in the processed image with a sharp stellar-like nucleus. The comet is considerably fainter than on 24 and 31 May. Thus either the triple nucleus recompacted under self-gravitation by June 3, or the visible components were relatively small and active blocks of ice which have completely sublimated in the interval between May 31 and June 3. Certainly we see no evidence of the characteristic separation of the components as is the case of Comet West.

ACKNOWLEDGEMENTS

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