P/Halley: Characterization of the Coma Dust by Polarimetry

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The new photopolarimeter of Observatoire de Paris, at Meudon, was first used on Comet P/Halley with the 100-cm telescope of Meudon Observatory from September to December 1985. After full tests were secured and comet polarization measurements recorded, the instrument was packed and shipped to La Silla for an intensive polarization analysis of the comet with the 1.52-m ESO spectroscopic telescope. Nine nights were allocated from 7 to 16 April, 1986. Of these, eight nights showed a perfect sky with exquisit seeing! In addition, the telescope, perfectly well adapted for the purpose, was accurately operated by Messrs. Miranda and Borguez, under the supervision of Mr. Le Saux.

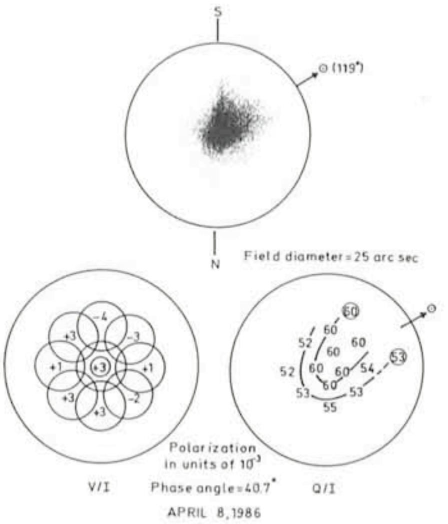

Figure 1: *Comet P/Halley. Polarization over the inner coma. Photopolarimeter PPHR of Observatoire de Paris, with the 1.52 m ESO telescope at La Silla. April 8, 1986, phase angle 40°.7, field diameter 25 arcsec. Top: Aspect of the inner coma and dust streamers. Bottom left: Positions of the hole and degree of circular polarization V/I in units of 10^{-3}. Bottom right: Degree of linear polarization Q/I in units of 10^{-3} and isophotes for 53×10^{-3} and 60×10^{-3}.*

Figure 1 shows the first of our polarization mappings over the inner corona on April 7–8, 1986. At the top, the coma is seen at the eyepiece with a magnification of 1,000, in a field of 25 arcseconds diameter. A dust streamer is ejected toward south, at 45° from the direction of the Sun. The sizes and the successive positions of photopolarimeter holes over this field are shown at bottom left in the figure, together with the values measured for the degree of circular polarization V/I, expressed in units of 10^{-3}. At bottom right, the measurements of the degree of linear polarization Q/I are given, also in units of 10^{-3}, together with the approximate isophotes for the two values 53×10^{-3} and 60×10^{-3}. The azimuth of the polarization was everywhere almost perpendicular to the direction of the Sun (meaning that the Stokes parameter U/I, which is at 45° from Q/I, is negligible). A wide band colour filter was used, centred at 500 nm (circle and dashed line in Fig. 9).

We have eight such maps. After April 10, we extended the coverage to a wider field of 120 arcseconds in diameter, and expressed the linear polarization by segments giving the azimuth and the degree P of polarization which is $P = \sqrt{Q^2+U^2} / I$. As the phase angle decreased with time, the polarization decreased also and the effect of deflection in the azimuth of polarization took more significance. Figures 2, 3 and 4 show at top the full development on the fountain-line dust ejection by the nucleus toward the direction of the Sun and at bottom right the linear polarization which decreases with phase angle and also progressively wanders in its azimuth. On April 16 it is almost randomly oriented; at the corresponding phase angle of 21°.6, the polarization produced by isotropic scattering is almost zero and the polarization effect produced by anisotropies in the dust configurations remains almost alone. The small and variable circular polarization V/I which is recorded probably results also from such dust shape anisotropies.

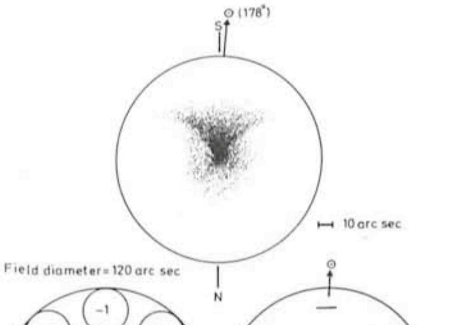

Figure 2: *Same as Figure 1 but over a larger field of 120 arcsec. diameter on April 14, 1986, at phase angle 24°.2. The linear polarization is expressed by segments giving the azimuths and the degree of polarization (see scale).*

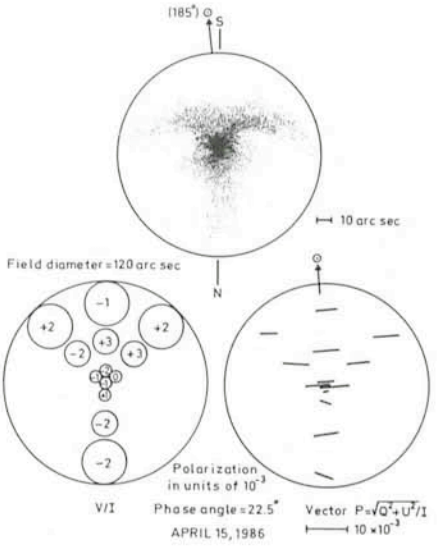

Figure 3: *Same as Figure 2 but for April 15, 1986, at phase angle 22°.5.*

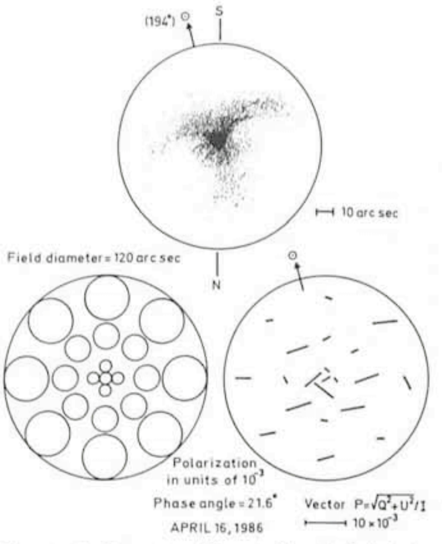

Figure 4: *Same as Figures 2 and 3 but for April 16, 1986, at phase angle 21°.6 for which the linear polarization produced by isotropic scattering is almost negligible. The linear polarization which remains is largely produced by orientations and anisotropies in the dust shapes.*

We detailed also the polarization in the inner part of the coma within 3,000 km from the nucleus, by using concentric holes centred at the nucleus. The measurement with a hole is then corrected by those with smaller size. The smallest hole had 2.1 arcseconds diameter, or a radius of 300 km around the nucleus. Figure 5 shows the luminence (in relative units) and the degree of polarization (in units of 10^{-3}) so deduced, as a function of the distance of the nucleus, given in arcseconds and in

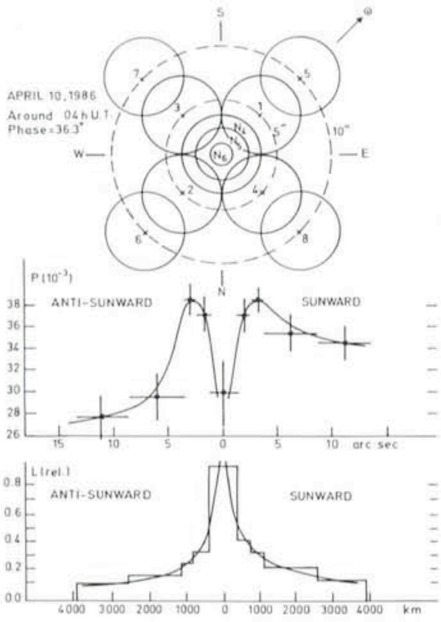

Figure 5: *Detailed analysis of the polarization over the inner part of the coma, close to the nucleus. April 10, 1986, at phase angle 36°.3. Top: Positions and sizes of the holes. Middle: Degree of linear polarization with distance to the nucleus, sunward and anti-sunward. Bottom: Same, for the luminence.*

kilometres, for the observation of April 10, 1986, at phase angle 36°.3. A very bright point source, almost star-like, was seen around the nucleus (within hole N6). It corresponds to a sort of permanent envelope surrounding the nucleus. At the apparent distance of 4,000 km from the nucleus in the direction opposite to the Sun, the polarization is 28×10^{-3}. Approaching the nucleus,

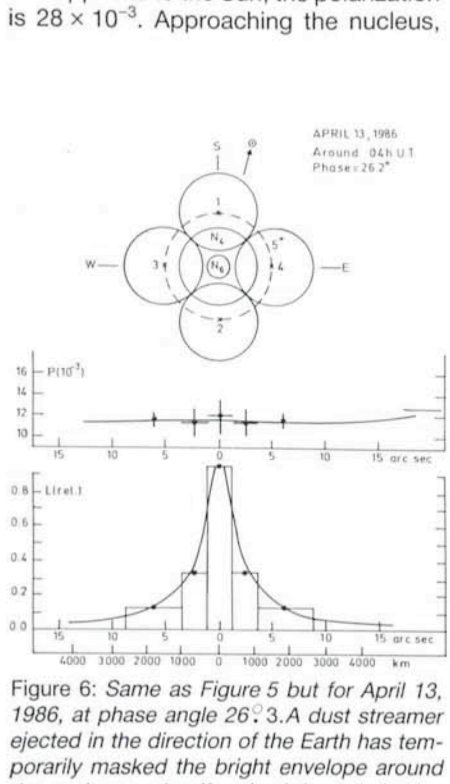

Figure 6: *Same as Figure 5 but for April 13, 1986, at phase angle 26°.3.A dust streamer ejected in the direction of the Earth has temporarily masked the bright envelope around the nucleus and uniformized the polarization over the field.*

the polarization increases up to 38×10^{-3}. Then the envelope discloses a completely different and smaller polarization. Towards the Sun, the fountain of fresh dust maintains a high polarization. On April 13, at phase angle 36°.2 (Fig. 6) a gust of fresh dust ejected towards the observer screened completely and temporarily the bright envelope around the nucleus which disappeared. The polarization then uniformized all over the field. Next day, on April 14 (Fig. 7), the dust streamer having spread out, the envelope was seen again with its anomalous polarization, now observed at phase angle 24°.2.

Our data include 9 documents such as those of Figures 5, 6, and 7, and 8 maps like those of Figures 1 to 4, plus measurements directly recorded around the nucleus. With these data, we derived the Figure 8 showing the curve of variations of the degree of polarization as a function of phase angle, for the dust at 3,000 km (dots), for the fresher dust at 1,000 km (crosses) and for bright envelopes around the nucleus (circles). These measurements have been subjected to a slight correction due to the smaller polarization produced by the emission lines partly included in the spectral band isolated by our filter. The effect is to increase the polarization for the largest phase angles. The uncorrected data are given in the Figure 5 of the paper by Dollfus et al. (1987) cited in reference. Our measurements with narrow colour or interference filters, such as those of Figure 9, indicate also that there is only a small variation of the continuum polarization with wavelength.

Curves of polarization are related to the nature of the dust particle responsible for the scattering; they help to characterize their physical properties. Without entering here into the details of the interpretation, which is still under

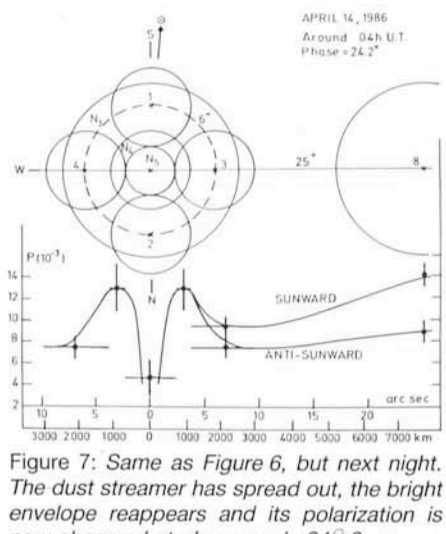

Figure 7: *Same as Figure 6, but next night. The dust streamer has spread out, the bright envelope reappears and its polarization is now observed at phase angle 24°.2.*

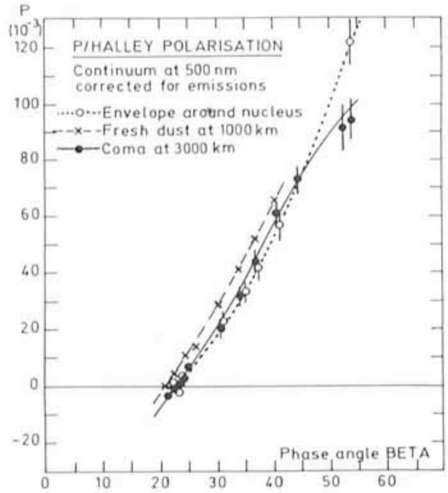

Figure 8: *Degree of linear polarization as a function of phase angle: curves of polarization for the coma dust at 3,000 km from the nucleus (dots), for the freshly ejected dust observed at 1,000 km (crosses) and for the bright envelope around the nucleus (circles). The measurements have been corrected for the polarization produced by the gas emissions included in the spectral band transmitted by the filter.*

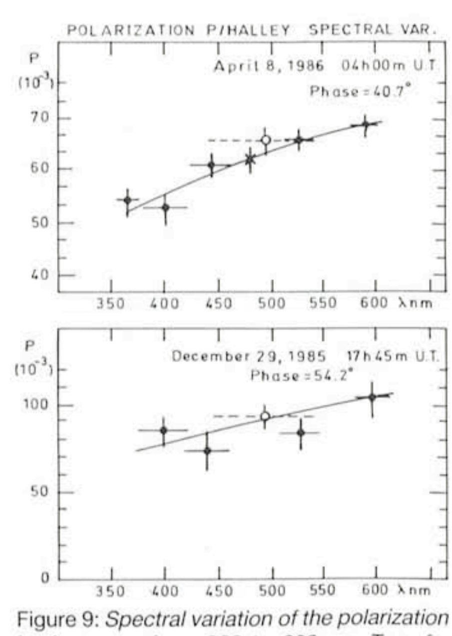

Figure 9: *Spectral variation of the polarization in the range from 360 to 600 nm. Top: for phase angle 40°.1. Bottom: for phase angle 54°.2. Measurements corrected for gas emission polarization when relevant.*

progress, we note that curves such as those for crosses and dots in Figure 8, are compatible with, and even suggestive for, a model of grains made of fluffy aggregates of small particles. The grains have to be very dark and neutral in colour. These structures, fragile and uncompacted, may be somewhat elongated or filamentary, as suggested by the deflected and the circular polarizations.

The polarization by the bright halo

which is enveloping the nucleus (circles in Figure 8) does not fit as easily with such a model. Other types of grains may be required, perhaps of higher albedo. Water ice may be considered.

Reference

Dollfus, A., Suchail, J.-L., Crussaire, D., Killinger, R. (1987): Comet Halley: Dust characterization by photopolarimetry. To be published in Proc. ESA Symposium Exploration of Halley's Comet, Heidelberg, FRG, 27–31 Oct. 1986.

MESSENGER INDEX

An index of all contributions published in the Messenger from No. 1 to No. 46 (1974–1986) has been compiled and will be distributed with this issue of the Messenger.

The index consists of three parts. The first part – the Subject Index – lists the contributions grouped by 20 subject titles. In the second part – the Author Index – the articles are listed by authors, in alphabetical order. The third part contains the Spanish summaries, grouped by subject titels and in chronological order.

Although the division of the contributions into 20 subjects and their assignment to these subjects may not be perfect, it is hoped that the index will help the reader to obtain a better overview of the articles which have appeared in the Messenger and permit him to find them more easily.

In the future, annual indexes will be compiled.

Multiple Object Redshift Determinations in Clusters of Galaxies Using OPTOPUS

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Introduction

From recent developments of observational astronomy, the overall view of the structure of the universe appears to be very different from the homogeneous and isotropic one claimed by traditional cosmology. The hypothesis of long, interconnected linear filaments or even large "bubbles" characterizing the concentration of galaxies now seems to be well established, these regions being separated by large voids empty of bright galaxies.

One of the fundamental factors in the understanding of such formations is the determination of their structure in the third dimension as opposed to their flat "projected" appearance.

If the redshift determinations represent virtually the only tool giving access to the third dimension, they are also essential to the understanding of structural dynamics because they provide us with a wealth of information concerning the velocity dispersion in particle systems. Radial velocity measurements are essential to the understanding of structures such as galaxy clusters, as dynamic analysis of their velocity distribution can lead to mass determinations and to an estimate of the missing mass in the universe.

Analyses of some Abell clusters have recently been published; as an example it has been shown that the A496 cluster has a complex structure formed essentially by a main cluster (or main subcluster), and another small sub-cluster,

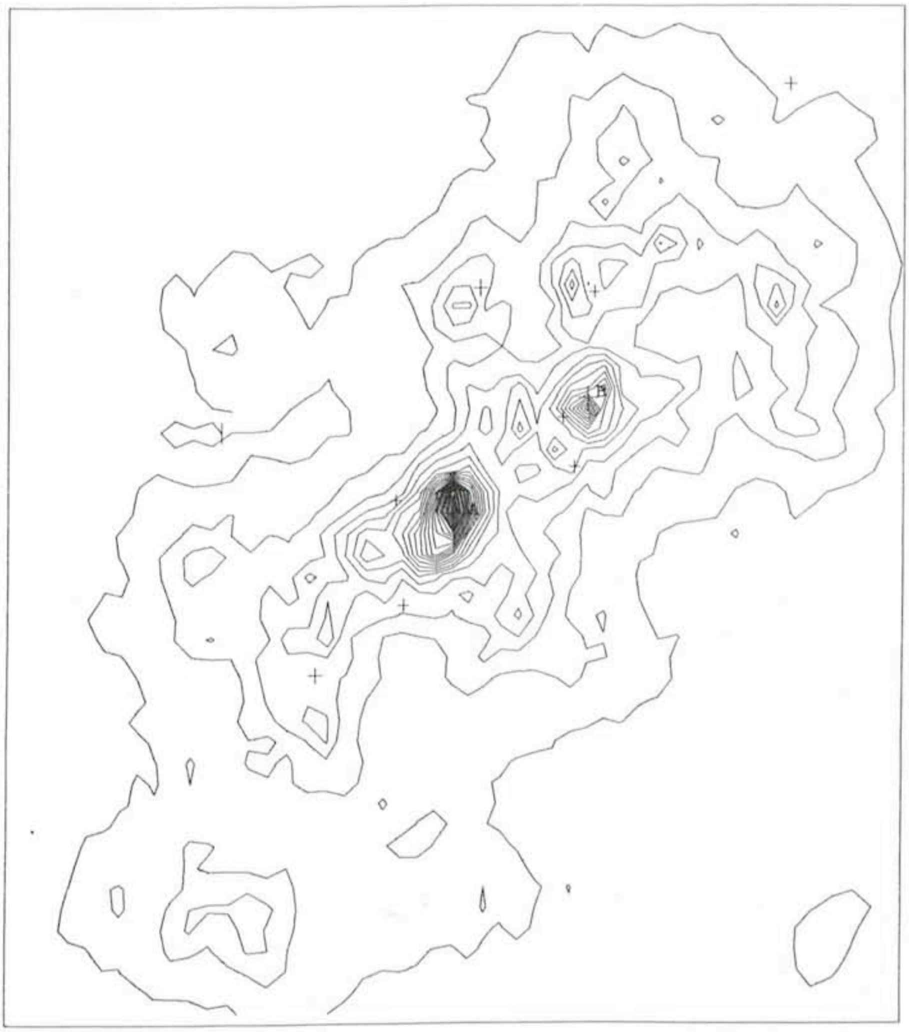

Figure 1: *Isocontours of SC2008-565. The ten brightest galaxies are plotted. The radial velocities of A and B are 16,490 and 16,890 km/s.*