Asteroids, Comets, Meteors 1991, pp. 349-352
Lunar and Planetary Institute, Houston, 1992

S83-90

140938

N93-19196

POLARIMETRIC OBSERVATIONS OF COMET LEVY 1990c AND OF OTHER COMETS : SOME CLUES TO THE EVOLUTION OF COMETARY DUST

A.Ch. Levasseur-Regourd, J.B. Renard and E. Hadamcik
Université Paris 6 / Service d'Aéronomie, BP 3, 91371 Verrières, France

ABSTRACT. The evolution with the phase angle α of the polarization degree P of light scattered by comet Halley's dust is well documented. No significant discrepancy is found between Halley and Levy polarization curves near the inversion point. From all available cometary observations, we have derived polarimetric synthetic curves. Typically, a set of about 200 data points in the red wavelengths range exhibits a minimum for ($\alpha \approx 10.3°$, $P \approx -1.8\%$) and an inversion point for ($\alpha \approx 22.4°$, $P = 0\%$), with a slope of about 0.27% per degree.

A significant spreading of some data (comets Austin 1982VI, Austin 1989c$_1$, West 1976VI) is found at large phase angles. The analysis of our polarimetric maps of Levy reveals that the inner coma is heterogeneous. The increase of the inversion angle value with increasing distance from the photometric center is suspected to be due to the evolution with time of the grains ejected from the nucleus. A fan like structure could be produced by a jet of grains freshly ejected.

POLARIMETRIC OBSERVATIONS OF HALLEY 1986III

Numerous measurements of the linear polarization degree of solar light scattered by comet Halley's dust have been performed in 1985-1986. Polarization compilations have been published (e.g. Dollfus et al., 1988) or are available from IHW (International Halley Watch) archives. There is a fair agreement among all the observers, at least as far as the solar distance is smaller than 2 AU and the polarization is estimated over the whole coma.

The evolution of polarization degree P with phase angle α shows a negative branch (direction of polarization in the scattering plane) for α smaller than α_0, with a minimum (α_{min}, P_{min}) and an almost linear increase at a rate h near the inversion point (α_0, 0). Synthetic curves (Levasseur-Regourd, 1990) derived from all available data in the blue and red wavelengths ranges lead respectively to $\alpha_{min} = (9.6 \pm 2.0)°$, $P_{min} = (-1.3 \pm 0.8)\%$, $\alpha_0 = (21.2 \pm 1.0)°$, $h = (0.21 \pm 0.03)\%$ per degree and to $\alpha_{min} = (10.4 \pm 2.0)°$, $P_{min} = (-1.5 \pm 0.8)\%$, $\alpha_0 = (22.3 \pm 1.0)°$, $h = (0.25 \pm 0.03)\%$ per degree. New polarimetric observations performed since the return of comet Halley allow comparisons to be made.

POLARIMETRIC OBSERVATIONS OF LEVY 1990c

We have obtained CCD polarimetric images of the inner coma of comet Levy 1990c from the Pic du Midi 2 meters telescope on five consecutive nights, August 15 to 19, 1990. The phase angle was decreasing from 21.6° to 17.6°, and the effective width of the images was equal to 6800 km. Four polaroid filters mounted at 45° from one another were used ; measurements with the 0° (component I_1) and 90° (component I_2) oriented filters were made consecutively, while measurements made with the 45° and 135° filters allowed the orientation to be checked. Two red continuum filters, centered at 650 nm and 684 nm, were used to provide gas emission free signals. Details on the observational techniques and on the data reduction can be found in Renard et al. (1991).

Two results appear immediately from the analysis of the intensity ($I_1 + I_2$) and polarization ($I_1 - I_2 / I_1 + I_2$) maps derived from the images. First, the intensity maps are quite smooth, with an anisotropy with respect to the solar/antisolar direction (ratio of about 1.4) ; secondly, the polarization maps are found to be heterogeneous. Fig. 1 shows typical scans ; the resolution is of about 200 km.

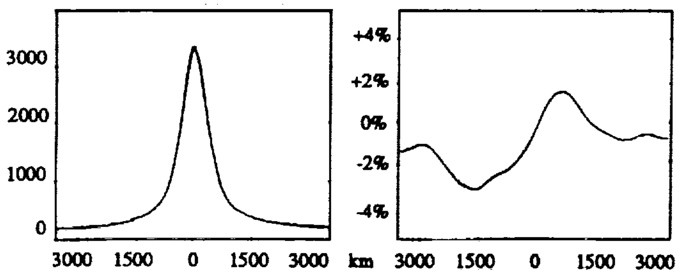

Figure 1 - Scans of intensity map (left, arbitrary units) and polarization map (right, %) obtained on the 19 August 1990 around 01h16m. Each (east-west) scan is 6800 km long and is made through the photometric center (linear scale).

Besides, from data obtained relatively far away from the nucleus (typically in a 1800 km wide frame located at 2500 km from the photometric center), the evolution of polarization with phase angle is found to fit perfectly with that obtained for Halley ; α_0 is computed to be equal to $(22.0 \pm 0.8)°$ and h to be equal to $(0.29 \pm 0.03)\%$ per degree.

PHASE ANGLE EFFECT

From the good agreement between the results from comets Levy (outer coma observations) and Halley (large aperture observations mainly corresponding to the outer coma, due to a dilution of the polarization variations), it makes sense to compare all the available polarimetric observations. The data are restricted to : i) the same wavelengths range, ii) solar distances smaller than 2 AU.

Figure 2 (left) presents, in the blue range, the data from Bastien et al. (1986), Dollfus and Suchail (1987), Kikuchi et al. (1987, 1989), Kiselev and Chernova (1978), Le Borgne et al. (1987), Michalsky (1981), Myers (1985), Sen et al. (1991) and Visvanathan et al. (1991). The derived synthetic curve leads to $\alpha_{min} = (9.8 \pm 2.0)°$, $P_{min} = (-1.4 \pm 1.0)\%$, $\alpha_0 = (21.7 \pm 1.0)°$ and $h = (0.22 \pm 0.03)\%$ per degree.

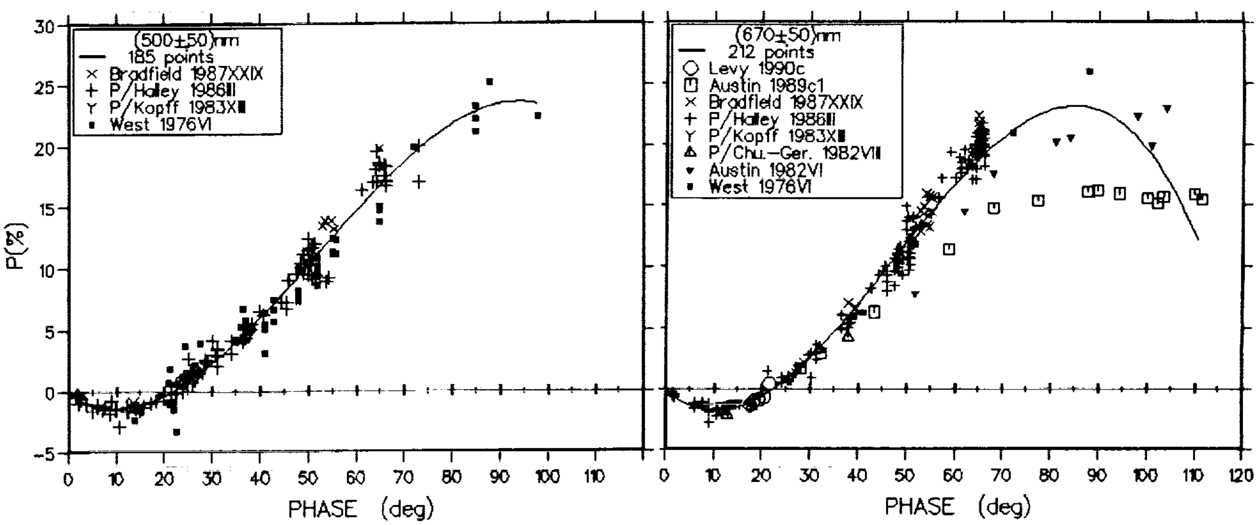

Figure 2 - Evolution of the linear polarization degree with phase angle for $\lambda \approx 500$ nm (left) and $\lambda \approx 650$ nm (right). Synthetic curves are superimposed on the data points from 8 different comets.

Figure 2 (right) presents, in the red range, data from Bastien et al. (1986), Kikuchi et al. (1987, 1989), Myers (1985), Myers and Nordsieck (1984), Renard et al. (1991) and Sen et al. (1991). The derived synthetic curve leads to $\alpha_{min} = (10.3 \pm 2.0)°$, $P_{min} = (-1.8 \pm 1.0)\%$, $\alpha_0 = (22.4 \pm 1.0)°$ and $h = (0.27 \pm 0.03)\%$ per degree.

There are no significant discrepancies between Halley's and other comets data at phase angles smaller than about 45°. However, as already mentioned by Mukai et al. (1991), significant discrepancies seem to occur at large phase angles, and specially in the 80° to 110° maximum region. More cometary observations are certainly needed at large phase angles.

DISTANCE TO THE NUCLEUS EFFECT

It had been noticed (Bastien et al., 1986 ; Dollfus and Suchail, 1987) that the polarization of Halley was changing with the size of the diaphragm. We have derived from our observations of Levy (Renard et al., 1991, fig. 4) that, on the average, α_0 slightly increases while h drastically decreases when the distance from the (near nucleus) photometric center increases. Such an effect is likely to be due to the heterogeneity of the polarization distribution in the inner coma.

Fig. 3 presents three polarization maps obtained from observations performed on 18/19 August 1990. The black regions correspond to a negative polarization of the order of $(-3.3 \pm 0.3)\%$. The white regions correspond to a positive polarization progressively increasing from 0.1% to 1.6%. The relative contribution of the white fan like structure increases with decreasing distance to the nucleus ; it could induce an effect similar to the effect previously mentioned for comet Halley.

It is likely that such a structure is due to a jet of grains freshly ejected from the nucleus. The velocity is estimated to be of the order of (120 ± 20) m s^{-1}, as measured on the observational plane. Since the Sun's direction is at about 70° from this plane, the outflow velocity in the jet can be roughly estimated to be in a 120 to 400 m s^{-1} range.

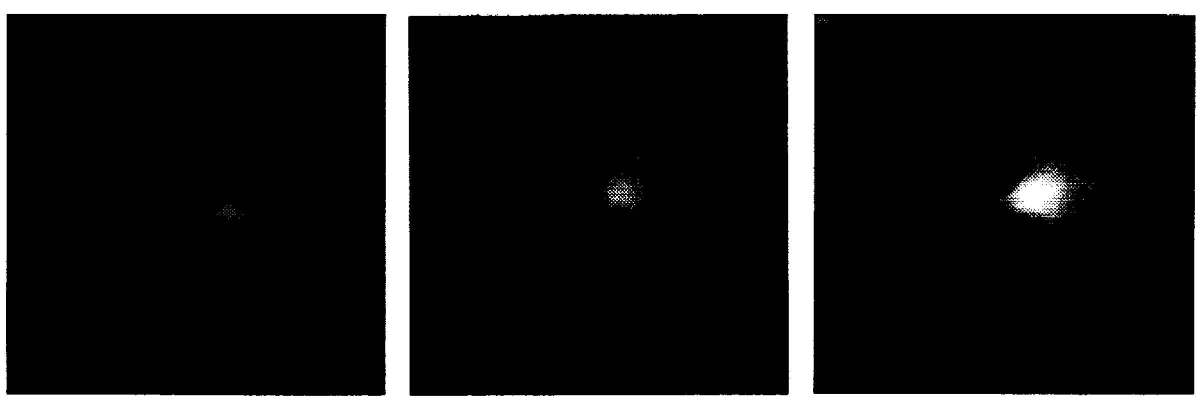

Figure 3 - Polarization maps (field of view 6800 km) of the inner coma of comet Levy, for the 18/19 August 1990, near 23h20m (left), 00h11m (center) and 01h16m (right). Black regions corresponds to $P \approx -3\%$ and white regions to $P \approx +1\%$.

CONCLUSION

The evolution with phase angle of the polarization degree is remarkably similar for all comets below 45° phase angle, at least as long as they are observed over the whole coma. Some discrepancies in the results obtained for various comets in the 80° - 110° maximum region could be indicative of physical differences in the aging dust grains. Some heterogeneities are observed on the polarization maps (obtained near the inversion angle) of the inner coma of comet Levy ; they are likely to be due to the evolution with time after ejection of the partly sublimating grains ejected with different velocities.

ACKNOWLEDGEMENTS. We thank specially A. Dollfus and R. Olombel. This work was partly supported by Programme National de Planétologie, France.

REFERENCES

Bastien P., Ménard F. and Nadeau R. (1986) Linear polarization observations of P/Halley, Mon. Not. R. Astron. Soc., 223, 827-834.

Dollfus A. and Suchail J.L. (1987) Polarimetry of grains in the coma of P/Halley : I. Observations, Astron. Astrophys., 187, 669-688.

Dollfus A., Bastien P., Le Borgne J.F., Levasseur-Regourd A.C. and Mukai T. (1988) Optical polarimetry of P/Halley : synthesis of the measurements on the continuum, Astron. Astrophys. 206, 348-356.

Kikuchi S., Mikami Y., Mukai T., Mukai S. and Hough J.H. (1987) Polarimetry of comet P/Halley, Astron. Astrophys., 187, 689-692.

Kikuchi S., Mikami Y., Mukai T. and Mukai S. (1989) Polarimetry of comet Bradfield, Astron. Astrophys., 214, 386-388.

Kiselev N.N. and Chernova G.P. (1978) Polarization of the radiation of comet West 1975n, Astron. Zh., 55, 1064-1071.

Le Borgne J.F., Leroy J.L. and Arnaud J. (1987) Polarimetry of comet P/Halley : continuum versus molecular bands, Astron. Astrophys., 187, 526-530.

Levasseur-Regourd A.C. (1987) Comets and their evolution in the solar system. In Formation of stars and planets, and the evolution of the solar system, (B. Battrick, ed.), pp. 105-111, ESA SP-315, Noordwijk.

Michalsky J.J. (1981) Optical polarimetry of comet West 1976VI, Icarus, 47, 388-396.

Mukai S., Mukai T. and Kikuchi S. (1991) Scattering properties of cometary dust based on polarimetric data. In Origin and evolution of interplanetary dust, (A.C. Levasseur-Regourd and H. Hasegawa, eds.), pp. 249-252, Kluwer, Tokyo.

Myers R.V. (1985) Polarization of comets at small phase angles, Icarus, 63, 206-216.

Myers R.V. and Nordsieck K.H. (1984) Spectropolarimetry of comets Austin and Churyumov-Gerasimenko, Icarus, 58, 431-439.

Renard J.B., Levasseur-Regourd A.C. and Dollfus A. (1991) Polarimetric CCD imaging of comet Levy 1990c, Annales Geophysicae, accepted.

Sen A.K., Deshpande M.R. and Joshi U.C. (1991) Polarimetric properties of Halley's dust. In Origin and evolution of interplanetary dust, (A.C. Levasseur-Regourd and H. Hasegawa, eds.), pp. 285-288, Kluwer, Tokyo.

Visvanathan N., Meglick Z. and Wickramasinghe D.T. (1991) Spectropolarimetry of comet Halley. In Origin and evolution of interplanetary dust, (A.C. Levasseur-Regourd and H. Hasegawa, eds.), pp. 245-248, Kluwer, Tokyo.