The Reticon has been used for 1 night in the spectral range 8500–10000 Å to study the CI atoms in the metastable level $2p^2\ ^1D_2$. The atoms in this level can give emission, by resonant scattering of solar radiation, at 1931 Å, and by spontaneous decay to the $2p^2\ ^3P_{1,2}$ ground state, at 9823 and 9850 Å. Measurements of the 1931 Å line with IUE, for other comets, have shown a very fast decreasing of $^1D_2$ population with heliocentric distance, indicating the possible presence of collisional sources (Feldman, 1983). It would then have been important to measure the two near infrared lines in various parts of the coma to map the CI atoms in this metastable level. Unfortunately, also in the spectrum taken with the longest exposure on the photometric nucleus, there was no presence of these lines. These spectra are still under study in order to evaluate upper limits to be compared with ultraviolet measurements.

References

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Halley Through the Polaroids

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According to ancient tales a comet brings severe misfortune to people. This was again confirmed by the appearance of Comet Halley (see photo on page 18). We had in mind to perform linear and circular narrow band polarimetric measurements of this comet using the new ESO polarimeter. However, mostly due to a damage of the polarization optics which happened last year on transport from Europe to La Silla, this instrument was not available for the scheduled observations in March 1986.

To get the best out of it, we decided to convert the one-channel photometer at the ESO 50-cm telescope into an auxiliary polarimeter. Since during our observing time the comet could be measured only for about 30 minutes to 100 minutes in the very last part of the night, this had to be done without affecting preceding photometric investigations of other objects. Inserting sets of specially prepared Polaroid sheets into the filter wheel of the photometer provided an uncomplicated and economic solution. There were different reasons to restrict ourselves to circular polarimetric measurements: Whereas a large amount of linear polarimetric observations has been performed during the past years, only very few circular measurements exist up to now. To determine linear polarization, at least three sets of Polaroids are necessary whereas two sets are sufficient to derive the circular polarization. Since the different sets can be used only sequentially, the time to complete one measurement is much longer and therefore the required tracking accuracy must be much higher for linear polarimetric observations. Furthermore, measuring linear polarization requires a very precise alignment of the Polaroid sets relatively to each other, whereas the circular polarization can be determined without specially fixed positions of the two sets. Moreover, long-lasting calibration measurements of polarized standard stars are necessary in order to determine the coordinate system of the instrument for the linear polarimetry. Finally, the linear polarization is much more affected by the sky background polarization, especially shortly before and during dawn.

We prepared two sets of Polaroid sheets fabricated by E. Käsemann Ltd., each containing one Polarex polarizer and two quarter wave foils (retarders). The first quarter wave foils were placed in front of the polarizers and aligned with the fast axes at +45° respectively −45° versus the polarization axes of the polarizers. So, within the limits imposed by the effective wavelength (approx. V band, given by the spectral response of the Polaroids and the photomultiplier as well as the spectral distribution of the comet), these sets exhibit maximum transparency for + circular respectively − circular polarization. The remaining retarders were each placed behind the polarizers in such a way that the linear polarized light leaving the polarizers was again transformed into circular polarized light, thus avoiding the instrumental problems arising from the recording of linear polarized light. A consecutive measurement through these two sets (A and B) allows then the determination of the circular polarization.

What is the accuracy of such an arrangement? The one-channel version does not allow for a seeing compensation and causes together with the absorption of the Polaroids a light-loss of about 70 %. To shorter and longer wavelengths the retarders deviate gradually from the quarter wave characteristics, thus producing a depolarization. The same holds for the cometary emission lines, especially the C_2 λ 5165 complex. Based on tests in the laboratory and on previous experiences with such Polaroids, we estimate the error of a single polarization determination to be of the order of 0.5 %. This means that the circular polarization of Halley to be detected by this device must be of the order of a few per cent.

Indeed, theory predicts circular polarization in comets up to 4 % (Dolginov, A.Z., and Mitrofanov, I.G., 1975, *Russ. Astron. J.* **52,** 1268). However, no hint for circular effects was found in either Comet Kohoutek or Bradfield or West (Michalsky, J.J., 1981, *Icarus* **47,** 388) or Tago-Sato-Kosaka (Wolf, G.W., 1972, *Astron. J.* **77,** 576). The reason for this could be that the measurements were made using too large apertures (up to 42″) centred on the core of the comet, thus averaging over too large areas. Indeed, the dusty Comet Bennet showed up to 5 % and even once 18 % circular polarization when measured through a 14″ aperture placed on different areas within the coma (Metz, K., 1970, Thesis University Munich).

After some test runs in situ, five successful observing runs between March 16 and 20, 1986, could be obtained. Halley showed a pronounced condensation of a few seconds of arc around the nucleus as seen through the view finder. This allowed an accurate positioning of selected areas to be measured using its cross wire and concentric rings. These areas are shown in Figure 1. The tracking speed of the telescope has been adjusted to the actual motion of the comet. However, due to differential refraction (high air mass at start time), there remained a very small uncompensated motion which could influence the subsequent measurements. To overcome this, the sequence ABBA was taken for one polarization measurement. Normally the smallest aperture (10″) was used since obviously the measured degree of polarization decreases with increasing diameter of the diaphragm. This is well known for linear polarization and suspected to hold also for the circular one. An integration time of 20 seconds per Polaroid set proved to be appropriate. Several unpolarized standard stars of solar type were measured every night at the beginning and the end of the Halley run in order to derive the instrumental effects. There was no moon and perfect meteorological conditions prevailed all the time except one night when some cirri were present. Altogether about 170 polarimetric observations for different parts in Halley's coma could be obtained.

The reduction revealed that nearly all measured areas around the core (except position 2) exhibited a circular polarization between 0.5% and 0.9%. Though these values are very near to the detection limit of our device, it is important to note that the sign of the polarization did not change, it was always left-handed. Area 7 did not reveal any polarization. However, area 2 was variable in its polarization from night to night with polarization degrees up to about 2% decreasing for the distance of 15" and 60" as well. These variations were evidently correlated with the strengthening and faintening of red dust jets emanating from the sun-heated side of the core. The jets showed a length of about 20" during our observing runs as seen through the Bochum 61-cm telescope (Celnik, W., 1986, private communication). The changing activity did, however, never affect the sign of the polarization at all. This indicates that the measured polarization is not an artifact photometrically produced by these events. Furthermore, subsequent measurements using 21" and 10" apertures revealed that the observed polarization was diminished by a factor of 8 for the larger aperture whereas the result for the smaller one remained the same. This also seems to prove that the circular polarization is (at least in area 2) a small-scale effect. The core was measured also using different apertures. A maximum circular polarization of about 0.9% was determined for an aperture of 15" decreasing appreciably with increasing or decreasing apertures.

How can our measurements be interpreted in terms of the present theories concerning the mechanisms for producing circular polarization in comets? Basically an admixture of non-metallic particles within the coma is needed for scattering processes of the sun light. If these particles are non-spherical, they must be aligned either by magnetic fields or by radiative pressure at least for single scattering. This type of scattering, however, should be excluded by the fact that the sign of the polarization in different areas remained always the same. It is highly improbable that the alignment of the particles is everywhere the same in view of such an active nucleus. Multiple scattering in the dust rich area near the nucleus seems to give a more promising explanation. This process would not necessarily need non-spherical aligned particles for a phase angle (Sun-Comet-Earth) not too far away from 90°. Both, degree and sign of the circular polarization, depend then on the actual phase angle which was around 66° during our observing runs. The results of multicolour observations obtained at roughly the same phase angle are needed to support this interpretation.

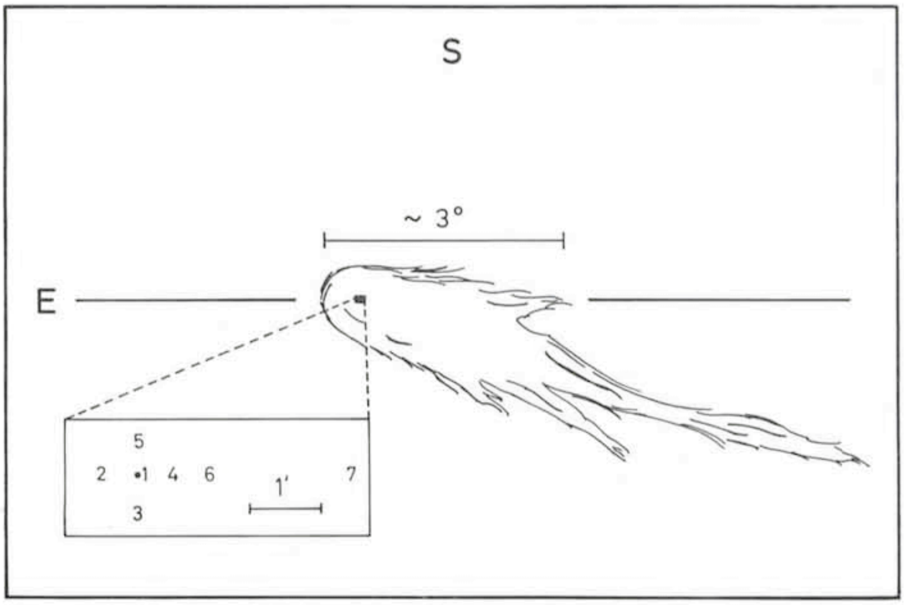

Figure 1: *Sketch of Comet Halley as it appeared during the observing runs. The enlarged portion shows the different positions of the measurements. The core is indicated by 1. Positions 2, 3, 4 and 5 refer to a distance of 30" from the core and are those areas where most of the measurements were obtained. Additional observations were also performed for distances of 15" and 60" in those directions. Position 6 corresponds to a distance of 60" and position 7 to a distance of 180". (10" correspond to a length of roughly 9,000 km on Halley.)*

Acknowledgement

We thank A. Urquieta for his technical support on La Silla and Dr. W. Schlosser for his help in obtaining the Halley photograph (page 18).

Images of Comet Halley – A Slide Set

ESO announces the publication of a limited edition of this slide set. It is composed of some of the best images of Comet Halley, obtained at La Silla during the period December 10, 1982, to April 30, 1986. The slide set only includes direct images, although other types of observations – for instance photometry and spectroscopy – were also carried out at ESO, cf. the articles in this *Messenger* issue. The 20 slides are in colour and B/W and emphasize the different observing techniques. They start with the first CCD images, which were obtained with the Danish 1.5-m telescope, when Halley was still more than 10 A.U. from the sun. The set also includes the recovery image on February 15, 1986, which was made only six days after perihelion. A spectacular disconnection event on March 10, 1986, is documented with three Schmidt pictures and the impressive changes in the tail can be followed on Wide-Field CCD images. Some slides are very beautiful, like a colour picture of Halley in the southern Milky Way.

The slide set is accompanied by a comprehensive text, giving details about the instruments used and the circumstances of each image. This set is therefore particularly useful for educational purposes. Copies may be obtained by sending DM 35,–, which is the equivalent of the cost price including postage, to:

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Do not forget to indicate your name and accurate address. Please note that the delivery time may be 3–4 weeks.

Comet Halley as seen on March 21, 1986, from La Silla (photograph: R. Haefner).