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September: Joergensen/Hansen/Noergaard-Nielsen, Johansson/Bergvall, Gregorini/Messina/Vettolani, Fusi Pecci/Buonanno/Ortolani/Renzini/Ferraro.

50-cm Danish Telescope

May: Franco.

June: Grenon/Bopp, Ardeberg/Lindgren/Lundström, Group for Long Term Photometry of Variables.

September: Ardeberg/Lindgren/Lundström.

90-cm Dutch Telescope

June: Grenon/Lub.

July: v. Amerongen/v. Paradijs.

August: Schneider/Weiss.

SEST

May: Reipurth/Lada/Bally, Israel/de Graauw, Crane/Kutner, Lequeux/Boulanger/Cohen, Israel/Baas, Israel/Baas/de Graauw/Douglas, Heydari-Malayeri/Encrenaz P./Pagani, Garay/Rodriguez, Reipurth/Olberg/Booth, Haikala, Radford/Cernicharo/Greve, Crane/Mandolesi/Palazzi/Kutner, Wouterloot/Brand, Stutzki/Zinnecker/Drapatz/Genzel/Harris/Olberg/Rothermel.

July: Burton/Liszt, Reipurth/Olberg/Booth, Wielebinski/Mebold/Whiteoak/Harnett/Dahlem/Loiseau, Bosma/Deharveng/Lequeux, Prusti/Clark/Wesselius/Laureijs, Dettmar/Heithausen/Hummel, Henkel/Wiklind/Wilson, Loiseau/Harnett/Combes/Gérin, Henkel/Wilson, Pottasch/Pecker/Sahu/Srinivasan, Moneti/Natta/Evans, Bajaja/Hummel, Bajaja/Harnett/Loiseau, Pérault/Falgarone/Boulanger/Puget, Dennefeld/Pérault/Bottinelli/Gouguenheim/Martin.

September: Chini/Kreysa/Mezger, Gérin/Combes/Buta, Dupraz/Casoli/Combes/Gérin/Salez, Combes/Casoli/Dupraz/Gérin/Harnett/Loiseau, Combes/Casoli/Dupraz/Gérin, Gérin/Combes/Casoli/Nakai/Hummel/van der Hulst, Melnick, Lellouch/Combes/Encrenaz T./Gérin, Casoli/Combes/Dupraz/Gérin, Booth/Nyman/Winnberg/Olofsson/Sahai/Habing/Omont/Rieu.

Pre- and Post-Perihelion Spectrographic and Photometric Observations of Comet Wilson (1986 ℓ)

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Hardly had Halley's comet left our immediate vicinity when a relatively bright, "new" comet, Wilson (1986 ℓ), was discovered in the summer of 1986. The announcement of this discovery was the more exciting as early predictions gave some hope that the newcomer might become of similar brightness to Halley's in April–May 1987, just about one year after P/Halley had made its own show. As the comet would be located in the southern sky at that time, and encouraged by our successful Halley runs at ESO, we proposed a programme that would give the opportunity to make a comparison between two comets of quite different dynamical ages observed at similar distances from the sun and with similar instrumentation. Another comparison seemed interesting: to study the behaviour of the comet before and after its passage through perihelion, which occurred on 21 April, 1987. Indeed we were able to carry out observations in April and in May, both spectrographic (2.2-m ESO-MPI telescope, 1.4-m CAT + CES, and 1.5-m telescope) and photometric (0.5-m ESO telescope). Some of the most significant results of these observations will be described briefly here. They refer to spectra in the ultraviolet, blue and red regions, as well as to photometry through narrow-band filters.

Comet Wilson proved to be considerably fainter than had been anticipated on the basis of the optimistic predictions. In early April it was estimated to be roughly four times weaker than comet Halley had been one year earlier at the same heliocentric distance. However, as far as spectrography was concerned, this weakness was, in a sense, compensated by the use of CCD detectors, which had not been available during our observations of P/Halley.

This was indeed a great improvement, for CCD's are particularly suitable for the observations of extended objects: in addition to their high quantum efficiency, linearity and high dynamic range, they offer the crucial advantage of two-dimensional detectors, allowing the determination of the spatial distribution of the spectral emissions over an appreciable region of the object. Furthermore, when they are used at the Cassegrain focus, as with the 2.2-m and the 1.5-m telescopes, one avoids the loss of spatial resolution caused by the field rotation inherent to the coudé focus (where photographic plates were traditionally used in cometary spectroscopy). Knowledge of the radial profiles of the cometary emissions is absolutely necessary to analyse the physical processes responsible for the formation and for the excitation of the various emitting species, to evaluate their production rates, to construct or to test models of the coma and tail. It can also help in the identification of new spectral lines, since the extent of a given emission on each side of the comet centre is related to the nature of the particular atom or molecule involved (neutral or ionized species; short- or long-lived particle).

Ultraviolet – Blue Region

Particular emphasis was laid upon the near ultraviolet because this region has been as yet poorly explored. Besides, advantage was taken of the availability of a CCD with fluorescent coating for ultraviolet sensitivity. The importance of the UV-blue region stems also from the fact that it contains emissions of OH, CO_2^+, OH^+, CO^+, hence information related to the abundance ratios of the major constituents of the cometary material, water and the carbon oxydes.

As an example, a spectrum obtained at moderate resolution is shown in Figure 1. The heliocentric distance (r) of the comet was 1.21 A.U. pre-perihelion, and its geocentric distance (Δ) was 0.95 A.U. The upper tracing corresponds to a strip 10 arcsec or 7,000 km wide, approximately centred on the nucleus, extracted from the CCD. The flux unit is arbitrary on this and the two other plots. No correction has been applied to take out the atmospheric extinction and the instrument + detector response, in order to illustrate the tremendous attenuation produced by these effects. For instance, the difference in overall flux reduction between 387 nm and 308.5 nm amounts to about 4 magnitudes in this case: the OH (O-O) band is, in fact, appreciably stronger than the CN (O-O) band, outside the earth's atmosphere. The middle and bottom panels compare, at a magnified scale, extractions of the same width as above, but offset by about 40,000 km on each side of the

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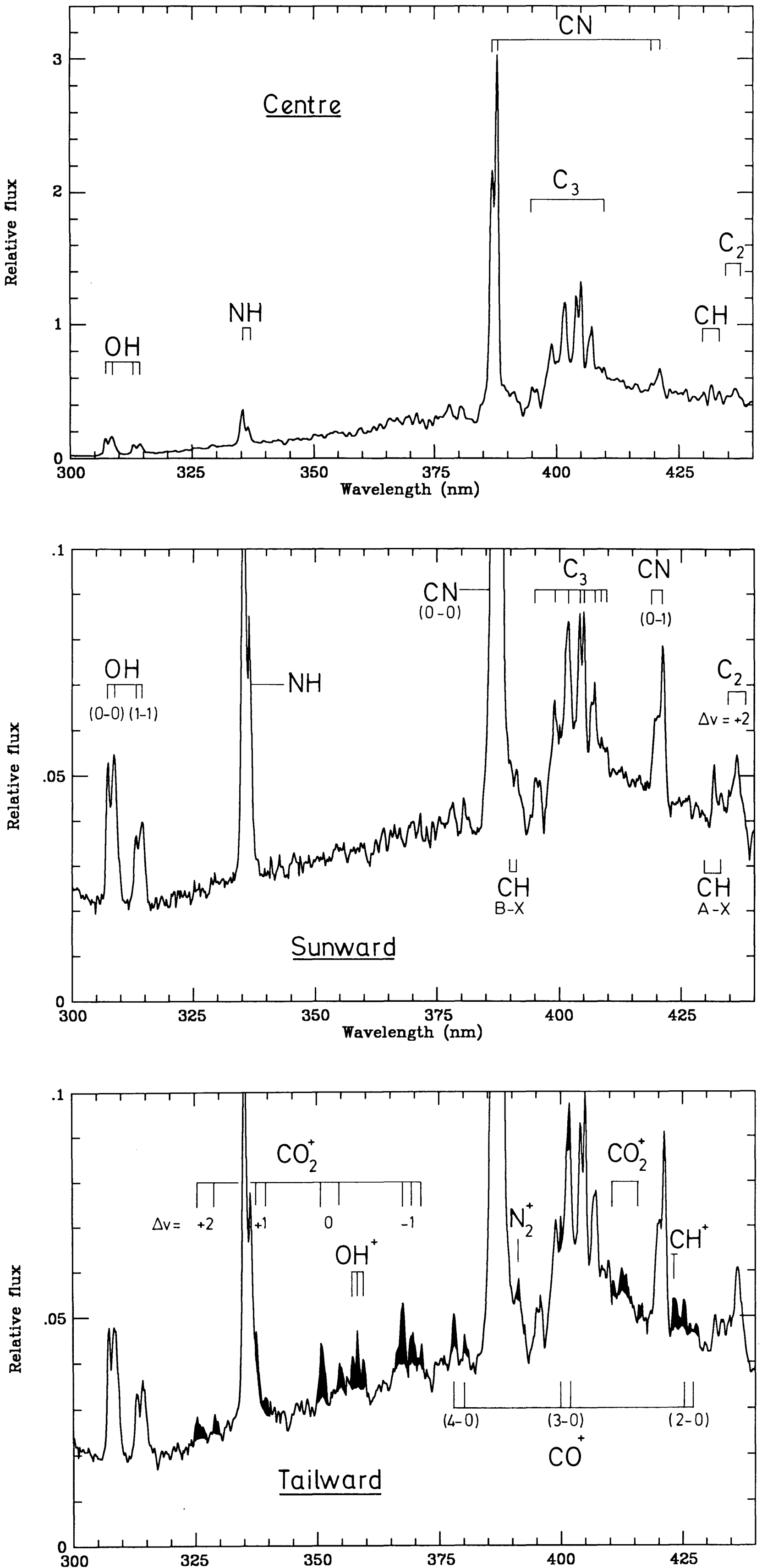

Figure 1: *Spectrum of comet Wilson (1986 ℓ) in the near UV-violet region (12 April 1987, r = 1.21 A. U., Δ = 0.95 A. U.; 2.2-m telescope + Boller and Chivens spectrograph with coated GEC CCD, resolution ~ 0.5 nm; exposure 45 min). Extractions corresponding to three different locations in the comet are shown on an arbitrary flux scale (see text).*

nucleus. While the emissions from the neutral radicals are nearly symmetrical, the ionic emissions on the contrary are present only on the side opposite to the sun, at this distance from the centre of the comet. To bring out the latter emissions, their contributions have been indicated qualitatively in black on the tailward spectrum.

A striking difference with P/Halley's spectrum in this wavelength range concerns the strength of the CO_2^+ emissions as compared to the OH^+ band, which was predominant in P/Halley near 1 A. U. from the sun after perihelion (C. Arpigny et al., 1986). This was not caused by a difference in the fluorescent excitation of the emissions and since the relative ionization efficiencies involved were probably similar as well, it appears that the proportion of released carbon dioxyde relative to water was higher in comet Wilson than in comet Halley at their respective heliocentric distances. As for the CO^+/CO_2^+ ratio, it is comparable in the two comets and we reach the conclusion that the relative abundance of carbon monoxyde too was larger in Wilson.

We note that the emission near 413 nm has been assigned to CO_2^+ on the basis of a higher resolution spectrum where we measured the same features at 410.9, 412.3, 414.6, and 416.2 nm that we had discovered in P/Halley (ibidem). The identification of these emissions was possible thanks to the kind help of S. Leach, who is currently analysing further the CO_2^+ spectrum in this region. Looking back at some older spectrograms, we found that this 413 nm feature was present in comets showing CO^+ and CO_2^+, like Bester, Humason, Bennett, West. At lower resolution it tends to be mistaken for the (4-1) CO^+ band, which has but a very small contribution in the case of Wilson.

In view of the importance of the carbon compounds, especially those containing the C-H band, as revealed by Halley's comet, the analysis of the CH emission seemed attractive. Thus, we took a spectrum of the R and Q branches of the A-X (O-O) band of this radical (Figure 2). The high resolution used (50,000, or about 0.01 nm) allows the separation of the satellite lines such as Q_{21} or R_{12} from their companion principal lines. This yields useful additional information since these lines are issued from different upper energy levels. Another unusual characteristic of this spectrum is the weakness of the R_1 (2) line. Comparing with the CH spectrum of P/Halley, for example, we see that the excitation rate of this line was indeed roughly twice as low in comet Wilson. It should be pointed out that although the

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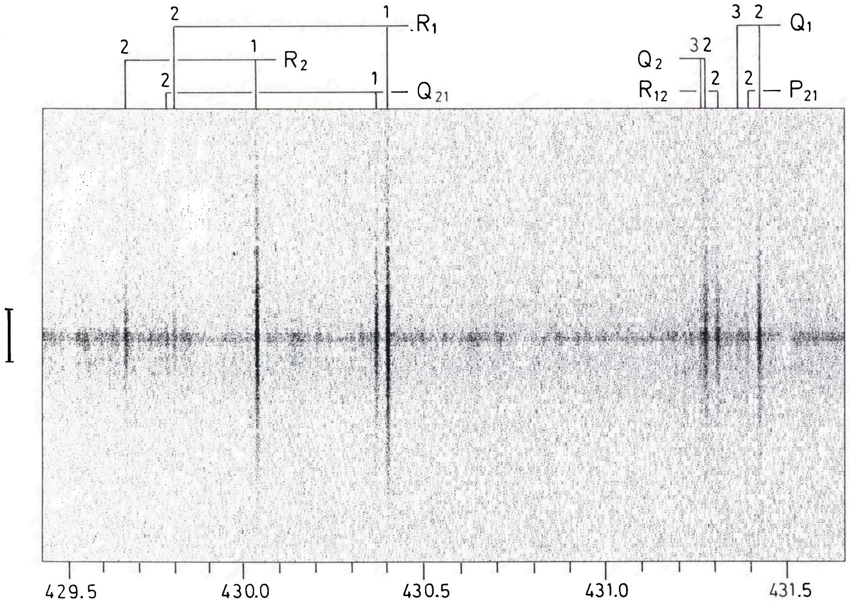

Figure 2: *High-resolution spectrum of the A $^2\Delta - X\,^2\Pi$ (O-O) band of CH showing the complete resolution of the R and Q branches. The slit was approximately aligned (± about 10°) with the radius vector from the sun during the 70 minutes exposure obtained with the 1.4-m CAT + CES and CCD. The tail is in the upward direction on this reproduction. The vertical bar represents 10^4 km on the comet (7 April 1987, r = 1.22 A. U., Δ = 1.10 A. U.).*

electronic transitions are produced by resonance-fluorescence, collisional processes which influence the populations of the lower rotational levels in the inner coma, have to be taken into account when interpreting the spectrum of CH (C. Arpigny et al., 1987 b). On the other hand, we also draw attention to the spatial extent of the emissions. The lifetime of the CH radicals in the solar radiation field is quite short, ~ 10^2 sec (Singh and Dalgarno, 1987) and their velocity cannot be much larger than 1 km/sec. Therefore, in order to explain their presence out to more than 40,000 km from the centre, we have to assume that they are released by particles which have a much longer lifetime. The detailed study of the radial profile of the CH lines should be instructive in this respect.

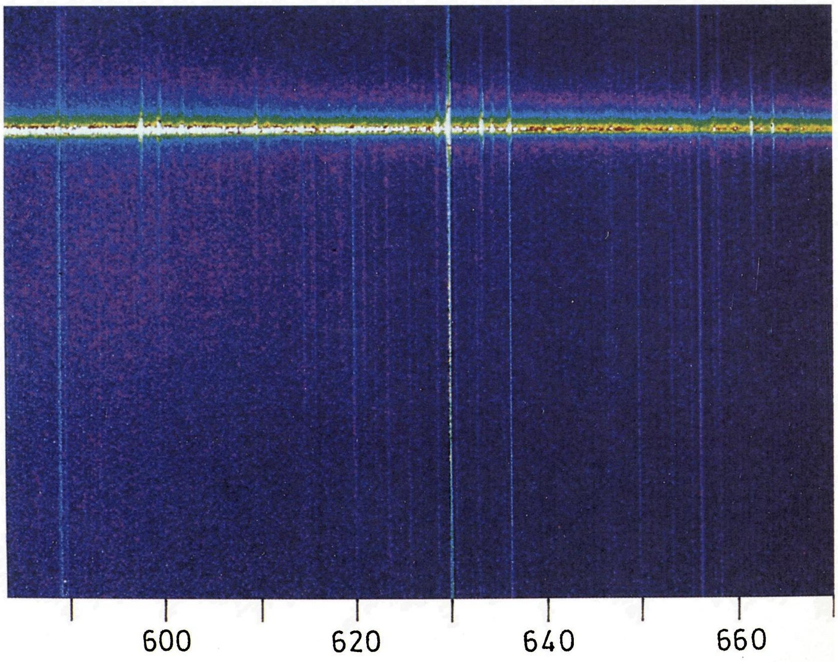

Figure 3: *Section of the spectrum of comet Wilson in the visual region (see Figure 4 for detailed identifications). (14 May 1987, r = 1.25 A. U., Δ = 0.78 A. U.; 1.5-m telescope with B & C spectrograph and CCD, resolution ~ 0.2 nm; 40 min exposure).*

Visual Region

Besides the C_2 Swan band sequences, whose interpretation still meets with difficulties, we selected another interesting wavelength interval, comprising the 9-0, 8-0, and 7-0 bands due to NH_2, the red forbidden lines of oxygen, as well as the 8-0 and 7-0 bands of the H_2O^+ ion. These emissions were monitored both before and following perihelion, the main difference between these periods being the fading of the comet after perihelion and the increase in night sky contamination in May as compared to April. The 590-670 nm region recorded after perihelion is illustrated in Figures 3 and 4, where we see that the contribution of the night sky (n.s.) is indeed quite substantial. Even the weak (9-3) and (6-1) bands of the Meinel system of the hydroxyl radical show up clearly, near 630 and 655 nm, respectively (see Kvifte, 1959, for line identifications); the red [O I] doublet is dominated by the telluric emission; at 656.3 nm the situation is rather complex, with three contributors coming in: nightglow Hα, cometary Hα, and a line of the H_2O^+ 7-0 band (which, incidentally, is quite weak compared with the 8-0 band in this spectrum).

The ionic emissions extend to distances of ~ 30,000 km on the sunward side on our different spectra, which is comparable to what we saw in P/Halley post-perihelion. This may at first appear contrary to expectation, in view of the lower gas production rate of comet Wilson. However, the solar wind conditions may have been different themselves, the relative "softness" of the cometary obstacle being, so to speak, balanced by a weaker incoming breeze in the latter case.

As far as the neutral species are concerned, the predominance of NH_2 in this spectral range is a common characteristic among comets near 1 A. U. from the sun or a little beyond. So is the weakness of the C_7 Swan $\Delta v = -2$ sequence. The $\Delta v = -3$ sequence of the same system, which should be about three times weaker still, does not appear on our spectra, although its presence on spectra for the same period has been reported by Jockers and Geyer (1987). This detection seems rather surprising, especially at a distance of 5 arcmin or 140,000 km away from the nucleus!

In April 1987 we were able to repeat on Wilson the same high-resolution observations of the [O I] + NH_2 blend we had made on P/Halley (Arpigny et al., 1987 a). The relative intensities of the various lines turned out to be similar in these two objects, although Wilson was appreciably fainter.

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Photometry

Comet Wilson was observed photometrically in March, April and May 1987. The special filters defined by the IAU were used in the standard one-channel photometer of the ESO 50-cm telescope. These filters have narrow bandpasses and isolate essential information concerning several molecular emission features (OH, CN, C_3, C_2, CO^+, H_2O^+) and the continuum (ultraviolet, blue, and red). Because of the faintness of the object, only the central part of the coma could be measured. On the contrary, in the case of P/Halley (C. Arpigny et al., 1986) it had been possible to map a wide area (over about 5 arcmin).

The main characteristic of comet 1986 ℓ was its stability. While comet Halley varied by as much as a factor of 3 or 4 within one day, comet Wilson proved remarkably steady. Between March 30 and April 10, for instance, the apparent brightness increased by little more than 0.2 magnitude, although the comet was nearing both the earth and the sun. Actually, a more significant quantity can be derived by removing the effect upon the apparent brightness of the varying geocentric distance. Besides the purely geometrical dilution effect, proportional to $1/\Delta^2$, we have to take account of the fact that the fraction of the coma seen by the photometer also varies as Δ changes. The latter part of the correction can be estimated approximately by adopting a model representing the brightness distribution within the cometary disk (e.g. Haser's model, corresponding to the outflow of "parent molecules" decaying into the observed radicals, which are themselves destroyed by photodissociation). When applying the Δ-correction in this way, we find that the intrinsic brightness in the various filters remained very nearly constant as the comet approached its perihelion. There was even a tendency for the scattered continuum to weaken slightly.

When we observed the comet again, in May 1987 (4 nights), it was at about the same geocentric distance as in the beginning of April, so that the corresponding data are directly comparable. Unfortunately, the weather was very bad in May and did not allow many measurements. It seems that comet Wilson was somewhat more variable after perihelion. Comparing the fluxes in various filters, it also appears that it was intrinsically fainter by a factor of 1.5 to 2.0 postperihelion, except perhaps in the light of OH, which seemed to stay at about the same level. It should be noted that this last result is rather uncertain because the atmospheric extinction is not easily evaluated at 309 nm.

This is to be compared with P/Halley. Photometric measurements were made at approximately the same comet-sun distance (~ 1.25 A.U.), both before and after perihelion (Haute-Provence Observatory Chiran, New Zealand Mount John, ESO). The geocentric distances differed appreciably in these cases; fortunately, however, a whole series of diaphragms were used at the Chiran and in New Zealand. By interpolating between the results from the different diaphragms it was possible to derive the flux received from a given volume equi-

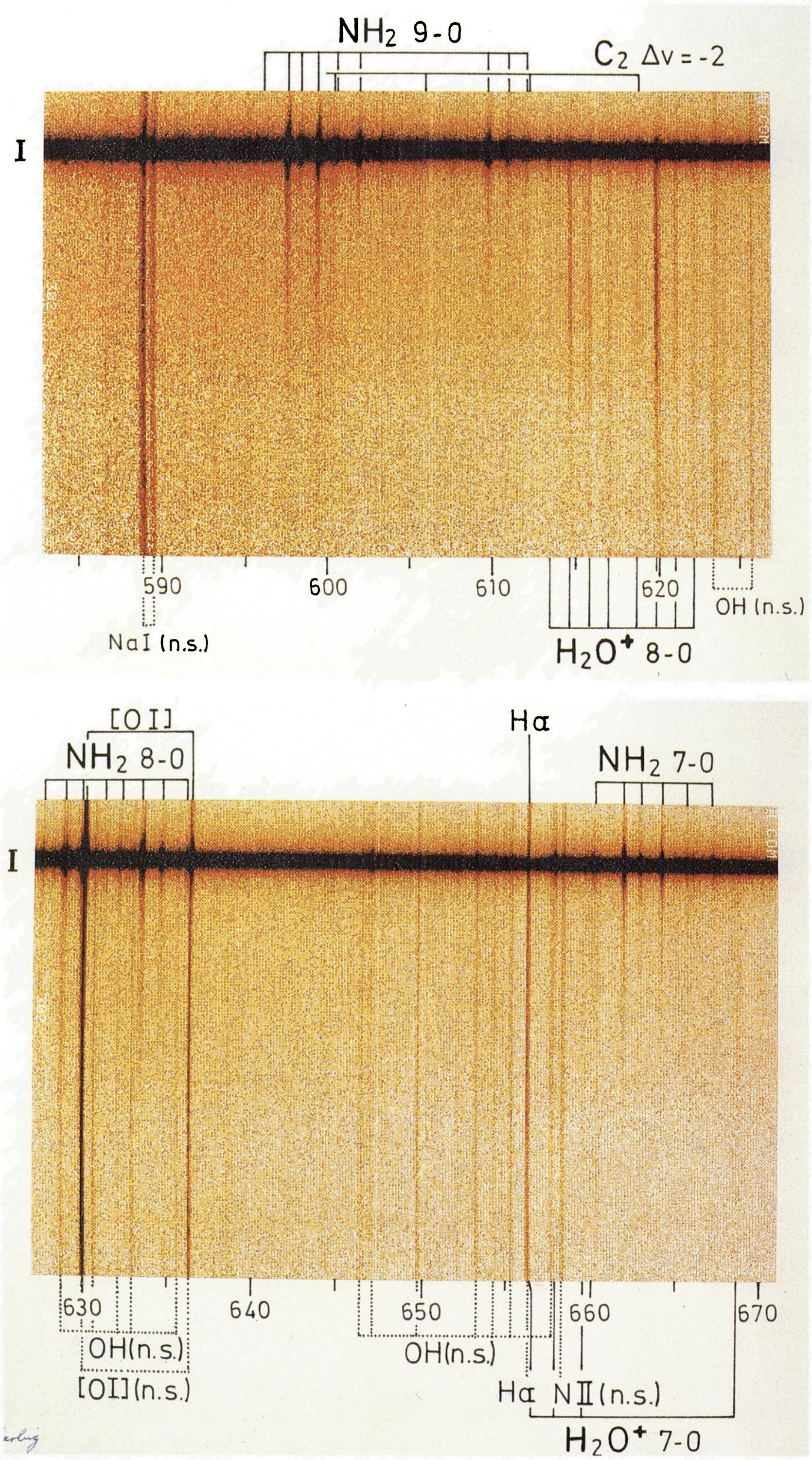

Figure 4: *Same spectrum as in Figure 3, shown here at a larger scale. Numerous emissions due to the nightglow are seen in addition to the cometary lines. The slit was set parallel to the projected sun-comet line with the comet's nucleus near one edge in order to record the tail emissions. The total height of the spectrum corresponds to ~ 2.5 × 10^5 km at the comet's distance.*

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valent to that delimited by 30 arcsec at 1.24 A.U. from the earth (as for Wilson). Then, obtaining the fluxes corresponding to a fixed distance of 1 A.U. from the earth ("heliocentric" fluxes), we conclude that Halley's comet did brighten intrinsically following perihelion. It was also more variable.

To illustrate these results, Table 1 presents a comparison between the behaviours of comets Wilson and P/Halley before (b) and after (a) perihelion in two filters (Blue continuum, BC, centred at 484.5 nm, and the C_2 Swan $\Delta v = 0$ bands near 514 nm).

TABLE 1. *"Heliocentric" fluxes corresponding to a diaphragm of 27,000 km projected on the comet.*

Comet	Δ (A.U.)	r (A.U.)	BC	C_2
Wilson	1.24 1.23	1.24 b 1.35 a	7.1 (−13)* 4.3 (−13)	1.7 (−10)* 8.5 (−11)
P/Halley	0.82 0.46	1.27 b 1.24 a	3.4 (−13) 1.2 (−12)	1.9 (−10) 3.9 (−10)**

* The fluxes are given in ergs cm^{-2}s^{-1} and the numbers between parentheses indicate the power of ten by which the entry is to be multiplied.

** This point was obtained during a minimum of activity. P/Halley was as much as 3 times brighter at other phases of its lightcurve.

Were the intrinsic brightness dependence upon r expressed as an inverse power law, the derived exponents would be in the range 5-8, when our measurements pre- and post-perihelion are compared. Such steep variations with r have been reported for a number of comets in the past. However, this kind of interpretation may not be very significant. Not only is our number of points post-perihelion too small, but we also have to consider that the activity of a comet, its matter and light output, may be strongly influenced by the combined effect of the inhomogeneous morphology of its nucleus and the change in orientation of its spin axis with respect to the sun, as regions of its surface with different structures and compositions are successively exposed to the solar radiation. The recent passage of Halley's comet has demonstrated this very extensively and, at times, in a spectacular manner. A possible explanation of the brightening of this comet following perihelion has been given in terms of such a "seasonal" effect (Weissman, 1986). Did, then, the fading of comet Wilson (1986 ℓ) we recorded reflect some general trend in the comet's evolution (progressive shortage of volatile material, building-up of a "crust") or was it rather the result of a geometrical effect associated with the rotation of the comet's nucleus and the presence of discrete active areas on its surface? Hopefully, more will be learned about this when we have a complete view of the various observations that were made of comet Wilson.

We are grateful to ESO and to all who helped us during our observations. In particular, the kind collaboration of D. Hofstadt and his team was greatly appreciated. Our thanks are also due to C. Sterken for communicating us the photometric data on comet Halley he obtained at Mount John Observatory, New Zealand.

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Resolving Young Stellar Twins

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Introduction

We report infrared speckle observations of SR-12 and Rox 31, two subarcsec pre-main-sequence binaries in the Rho Ophiuchi dark cloud (distance 160 pc). The binarity of these sources was discovered in a recent 2.2 μm lunar occultation observing programme of young stars carried out by Simon et al. (1987).

Many pre-main-sequence objects in star-forming regions are now known to be binary systems (see the review by Reipurth 1987). It is important to resolve these systems, otherwise properties such as the luminosity and the colours of young low-mass stars may be misjudged. Even for binaries in the most nearby dark clouds (with distances of the order of 150 pc), sub-arcsec observations are required to resolve most of them into their components (judging from the statistics of binary separations of solar-type main-sequence stars for which the most frequent separation is of the order of 30 AU, corresponding to 0.2 arcsec at a distance of 150 pc). Therefore, sub-arcsec observations such as lunar occultation and speckle observations of the nearest T Tauri stars are of great interest, in the optical as well as in the near infrared. As for speckle observations, Nisenson et al. (1985) discovered an optical companion to T Tau at 0.3 arcsec separation, and Dyck et al. (1982) had previously discovered an infrared companion to T Tau at 0.6 arcsec separation. We also mention the optical speckle studies of S CrA and V 649 Ori (Baier et al. 1985) and the infrared slit scans of Elias 22 (Zinnecker et al. 1987, Chelli et al. 1988). These are young binary stars with separations in the 1−2 arcsec range. We note that infrared observations are the appropriate tool to study young stellar objects because these are fairly cool objects that have not contracted to the main sequence yet. Furthermore, there are objects still embedded in the parental molecular cloud or in their dusty circumstellar envelopes so that they can escape optical detection.

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