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 $\Delta v = 0$

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.

We regret that due to a last minute mistake at the printer, the colour photo showing the Supernova 1987 A and the 30 Doradus nebula has been reproduced upside down. The error was discovered when this issue of the MESSENGER was delivered to ESO.

We trust that the readers will understand that under the circumstances it was not reasonable to repeat the entire printing run.

The editors

tions 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 mis-

vations 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.

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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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).

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Comet	Δ (A.U.)	r (A.U.)	BC	C_2
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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 sub-arcsec 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.

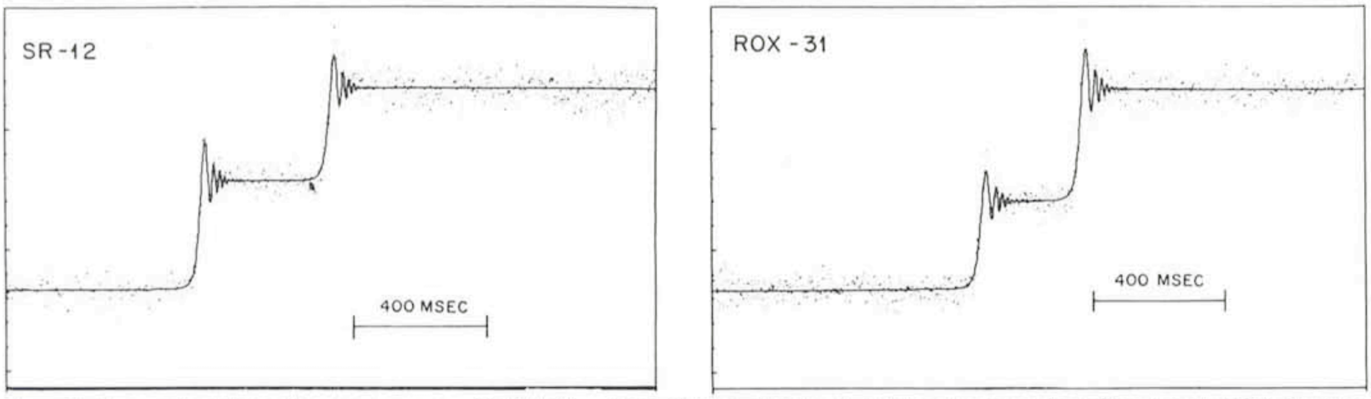

Figure 1: *Flux vs. time during the reappearance of (a) SR-12 and (b) ROX 31 behind the dark limb of the moon (from Simon et al. 1987). The dots represent the data at K (2 millisec integrations) and the solid line shows the binary model fit.*

The Objects Under Study

SR-12 is a Struve-Rudkjøbing emission line star. Its spectrum is classified as an M1 T Tauri star and its luminosity is estimated to be about 1 $L_{\odot}$. The object is also an X-ray source (ROX 21, Montmerle et al. 1983) suggesting that it is not too heavily obscured. It is coincident with a far infrared source in the IRAS maps presented by Young et al. (1986). ROX 31 is also a visible star and an X-ray source (Montmerle et al. 1983). There is no IRAS source clearly related with the star, but the object is known to be a weak 5 GHz radio source which on one occasion underwent a strong radio flare (Stine et al. 1988). The luminosity of ROX 31 has been estimated to be around 2 $L_{\odot}$, and its spectral type is K7-MO (Bouvier, priv. commun.). Bouvier also finds weak Hα emission confirming that it is a young object.

Lunar Occultation Data

In Figure 1 we reproduce the results of the lunar occultation experiment from Simon et al. (1987). The experiment was done at the IRTF on January 7, 1986. (A description of a lunar occultation experiment in the infrared done at ESO is found in the *Messenger* No. 50 (Richichi 1987)). Table 1 lists the derived parameters from Simon et al.'s work including the "separation" along the direction of the occultation.

The angular separation in the direction of the occultation follows from the time difference of the reappearances of the two components multiplied by the occultation rate of the moon at the contact point (0.43 arcsec/sec and 0.47 arcsec/sec for SR-12 and ROX 31, respectively). The flux ratios between the first (eastern) and the second (western) component of the two binary stars (0.85 and 1.29, respectively) can be read off from the levels of the flat parts of the signal after the occurrence of the Fresnel diffraction pattern. (Note that at 2.2 μm useful observations can be made only at the dark limb of the moon).

Infrared Speckle Follow-up Observations

We decided to follow up these observations by infrared speckle observations in order to confirm and to extend the lunar occultation data (particularly to obtain an infrared colour of the individual components). Our infrared speckle observations which were carried out in two orthogonal scan directions and in two infrared bandpasses (H and K) have added 3 pieces of information to the lunar occultation data:

(1) the "true" separation projected on the sky
(2) the position angle of the binaries
(3) the H-K colour of the individual components (of SR-12 only)

Let us remind the reader that, in speckle interferometry, the object is scanned across a slit at the photometer in one or more directions on the sky. The observational result is the visibility function. It is given as a function of angular frequency (cycles per arcsec) and is the square root of the power spectrum of the object's scanned signal divided by the power spectrum of the scanned signal of a point source, normalized to unity at zero frequency. The visibility of a binary star decreases from value 1 at zero frequency to a minimum and then increases; the shape of the visibility function is determined by the separation and relative fluxes of the two components. The separation is obtained from the spatial frequency at which the minimum occurs and the flux ratio is related to the depth of the minimum (for two equally bright components the value of the visibility function reaches zero).

Simon et al., in their paper, have already presented infrared speckle data (on SR-12 only, secured at UKIRT in Hawaii by Howell) which were used in conjunction with their lunar occultation data to derive further vital information on the nature of the source. We were trying to improve on their speckle data and add speckle data for ROX 31. Our data were obtained with the infrared specklograph at the ESO 3.6-m on the nights June 16 and 17, 1987 during which the seeing was rather good (1".2). For a description of the performance of the specklograph we refer to Perrier's (1986) article in the *Messenger* No. 45. Suffice it to say that the seeing was adequate to reach the faint magnitudes of the objects (K = 8.5, K = 8.1) and – in the case of SR-12 – the S/N high enough to get convincingly over the minimum in the visibility function – a goal that the previous speckle observations of SR-12 did not achieve. As a consequence we did not have to rely on the depth of its visibility function inferred from the 2.2 μm flux ratio measured in the lunar occultation experiment to determine the projected binary separation (see Fig. 5 in Simon et al.), although we do prefer the lunar occultation flux ratio R (E/W) = 0.85 at K over the flux ratio that we obtained from our speckle data (R = 0.45 derived from the fit in Fig. 2a). It is noteworthy that Simon et al.'s computed projected separation of 0".30 (48 AU) between SR-12E and SR-12W agrees well with our value measured directly from the speckle visibility functions in the E-W and N-S directions.

TABLE 1: *Data inferred from lunar occultation observations (from Simon et al. 1987).*

	"sep."	K (E-comp.)	K (W-comp.)
SR-12	0.19"	9.34	9.17
ROX 31	0.13"	8.72	9.00

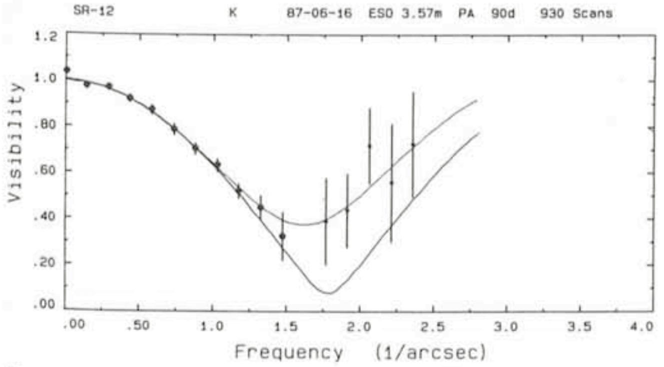

Figure 2a: *SR-12 E-W at K*
Bottom curve: fit to the data constrained by the measured lunar occultation flux ratio R (SR-12E/SR-12W) = 0.85. The resulting E-W separation is 0.28 arcsec.
Top curve: unconstrained fit to the data. In this case the resulting E-W separation is 0.30 arcsec.

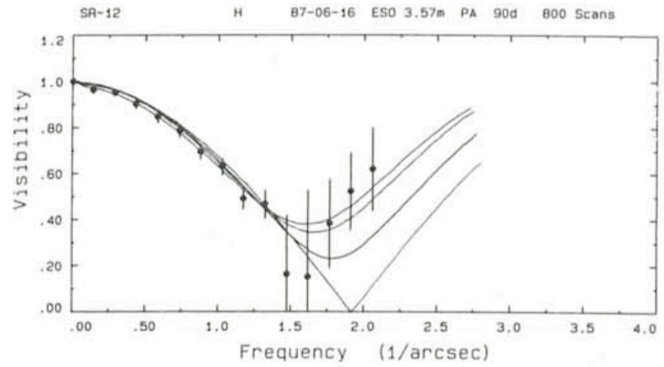

Figure 2b: *SR-12 E-W at H*
Top curve: fit where the separation was fixed at 0.30 arcsec.
Bottom curve: fit where the separation was fixed at 0.26 arcsec.
2nd curve from top: fit where both the flux ratio and the separation were free parameters.
2nd curve from bottom: fit where the separation was fixed at 0.28 arcsec (this is the value found at K under the constraint discussed in Fig. 2a/bottom curve).

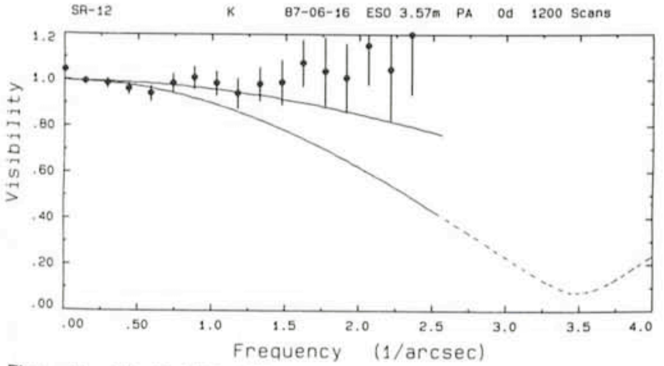

Figure 2c: *SR-12 N-S at K*
Bottom curve: fit to the data constrained in the same way as in Fig. 2a (bottom curve). The resulting N-S separation is 0.14 arcsec.
Top curve: fit to the data (unconstrained) yielding a N-S separation of 0.09 arcsec ($\chi^2 = 1$).

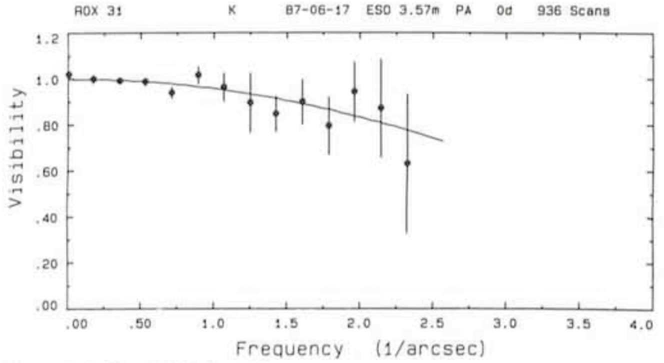

Figure 2d: *Rox 31 N-S at K*
The fit to the data gives a N-S separation of (0.09 +/– 0.05) arcsec.

Let us recall that the projected binary separation s is defined in the following way:

$$s = \left(\frac{1}{f^2_{1\,(E\text{-}W)}} + \frac{1}{f^2_{1\,(N\text{-}S)}} \right)^{1/2}$$

where f_1 denotes the spatial frequency of the minimum of the visibility function and the index E-W and N-S refers to the respective orthogonal scan directions. Figure 2 shows the 4 visibility functions that we obtained (for SR-12: K (E-W), H (E-W), K (N-S); for ROX 31: K (N-S) only). Table 2 summarizes the results.

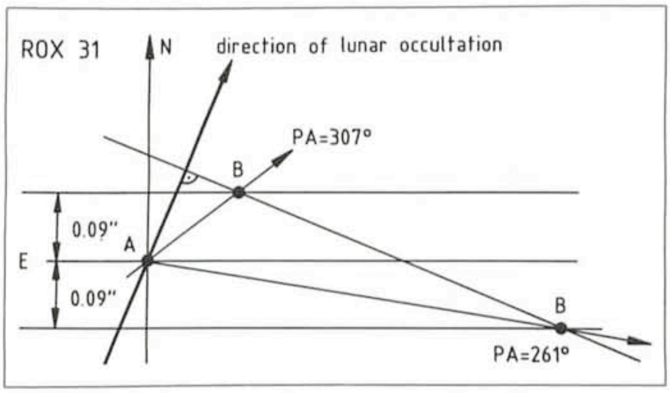

Figure 3: *The two solutions for Rox 31B The ambiguity is due to the 180° phase uncertainty for Rox 31B in the N-S speckle data, indicated by the two parallel horizontal lines 0."09 N and S of Rox 31A. Rox 31A at the origin is the brighter component at K of the Rox 31 binary system.*

TABLE 2: *Data inferred from all observations (speckle and lunar occ.)*

	proj. sep.	P.A.	K (E-comp.)	K (W-comp.)	H-K (east)	H-K (west)
SR-12	0."29	86	9.34	9.17	0.44	0.09
ROX 31	0."15*	307*	8.72	9.00	–	–

Notes to Table 2:
(i) The statistical error for the projected separations is 10%.
(ii) The position angles (east of north) should be accurate to about 10 degrees.
(iii) The K magnitudes are quite accurate (≤ 0.05 mag), while the colours are more uncertain (by 0.15–0.25 mag). The H-data for Rox 31 were too noisy to derive an H-K colour.
* There is a second (perhaps less likely) solution for Rox 31: proj. sep. = 0."55 and PA = 261 degrees (see Fig. 3).

Lunar Occultation Versus Speckle Observations

Finally we should summarize the relative merits of speckle observations versus lunar occultation observations:

(a) Lunar occultation observations can resolve binaries with separations as small as a few milli-arcsec (the limit comes from the orbital speed of the moon and the limitations of fast photo-