LUNAR OCCULTATIONS OF YOUNG STELLAR OBJECTS IN THE TAURUS AND OPHIUCHUS STAR FORMING REGIONS

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Abstract. We have carried out lunar occultation observations at $\lambda = 2.2\mu$m at the WHT and Calar Alto telescopes of young stellar objects both in the Taurus and the Ophiuchus star forming regions. We report the discovery of 4 new binary systems: IW Tau and HK Tau/G2 in Taurus as well as GSS 35 and VSSG 14 in Ophiuchus; the projected separations are about 70 milli-arcseconds (mas) for each of the Taurus objects, while for the Ophiuchus sources they are about 20 and 100 mas, respectively (20 mas correspond to 3 AU).

1. Introduction

In the course of a program aimed at a survey of young stellar objects for the detection of binary systems (Leinert *et al.* 1992), we have observed lunar occultations of sources in the Taurus and Ophiuchus star forming regions. The observations were carried out at the Calar Alto 3.5 m and at the La Palma 4.2 m telescopes. In the first case, the instrument was a specklegraph used in fixed–aperture mode, in the second case an InSb integrating photometer.

So far, we have been able to observe binaries with separations as small as $0''.02$ and with components as faint as $K > 9$. While lunar occultations provide 1–D scans and therefore only projected separations can be deduced, we have been able to combine our results with independent occultation measurements by other authors (Chen *et al.*), and/or with subsequent speckle interferometry, so that often the true separations and positions angles could be recovered. In some cases, the young stellar objects appear to be surrounded by compact dust shells, that show up as extended components (i.e. without fringes) in the occultation lightcurves. We have detected such a compact shell around DG Tauri (Leinert *et al.* 1991), with a FWHM of only $0''.045$ ($\sim$7 AU), which contributes about 30% of the total flux at 2μm. Another such example is that of Haro 6–10, for which we report here a preliminary result: the (unresolved) star appears to be surrounded by extended emission with a FWHM of about $0''.15$, emitting about 25% of the total flux at 2μm. The interesting feature is that the star appears to lie on one edge of the extended emission, rather than at its centre. Accurate reduction of the data and interpretation is still under way.

2. The New Binaries

The results of our occultation observations are summarized in Table 1. In particular, we present here four binaries newly detected in our survey. The data and

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TABLE I
Summary of Lunar Occultations of YSOs

Source	Date	*	K	Sep.	PA	ΔK	Notes
GU Tau	17-10-89	C	9.1	Unresolved			
FV Tau	17-10-89	C	7.4	0."073	229°	0.00	also speckle
DG Tau	17-10-89	C	6.9	Unresolved			Extended component
FW Tau	18-10-89	C	9.4	0."517	226°	0.18	also speckle
DL Tau	04-11-90	C	8.1	Unresolved			
Haro 6–10	28-09-91	P	7.4	Unresolved			Extended component
HK Tau/A	29-09-91	P	8.4	Unresolved			
HK Tau/G2	29-09-91	P	8.1	0."065	239°	0.17	also speckle
FY Tau	29-09-91	P	8.1	Unresolved			
AA Tau	29-09-91	P	8.3	Unresolved			
IW Tau	29-09-91	P	8.3	0."069	250°	0.06	also speckle
GSS 32	13-06-92	P	7.0	Unresolved			
GSS 35	12-06-92	P	6.3	0."021	110°	1.74	
El 30	13-06-92	P	6.8	Unresolved			
SR 9	13-06-92	P	7.0	Unresolved			
VSSG 14	12-06-92	P	7.3	0."098	102°	0.81	Extended component
SR 10	13-06-92	P	8.0	Unresolved			
IRS 58	13-06-92	P	6.5	Unresolved			
EL 38	13-06-92	P	7.1	Unresolved			
VSS 35	13-06-92	P	8.5	Unresolved			
SR 20	13-06-92	P	7.2	Unresolved			
VSS 42	13-06-92	P	5.9	Unresolved			
ROX 42B	14-06-92	P	8.2	Unresolved			
Ha 1–16	14-06-92	P	7.4	Unresolved			
El 44	14-06-92	P	7.0	Unresolved			

*: C=Calar Alto, P=La Palma. The projected separations along the given position angle (PA) are reported. Some sources could also be resolved by speckle interferometry, allowing the true separation and PA to be recovered.

corresponding best fits, as well as the fit residuals, are shown in the four panels of Fig. 1. IW Tau and HK Tau/G2, observed at the WHT in September 1991, could be resolved also by subsequent speckle interferometry observations. Their actual parameters are d = 0."27, PA=177°, and 0."18 and 300° respectively (see Leinert *et al.* 1992). GSS 35 and VSSG 14 were observed at the same telescope in June 1992, and no additional information has been collected yet. VSSG 14–B appears as an extended source, with size ~ 0."04 or ~6 AU: further analysis of these data is currently under way.

3. Discussion

Our preliminary conclusions are that the frequency of binary systems in the Taurus region is 41 ± 6%, at least within our survey limits which are 0."13 $\leq d \leq$ 10" and $K \leq 9.5$ (Leinert *et al.* 1992). Concerning the Ophiuchus region, we have

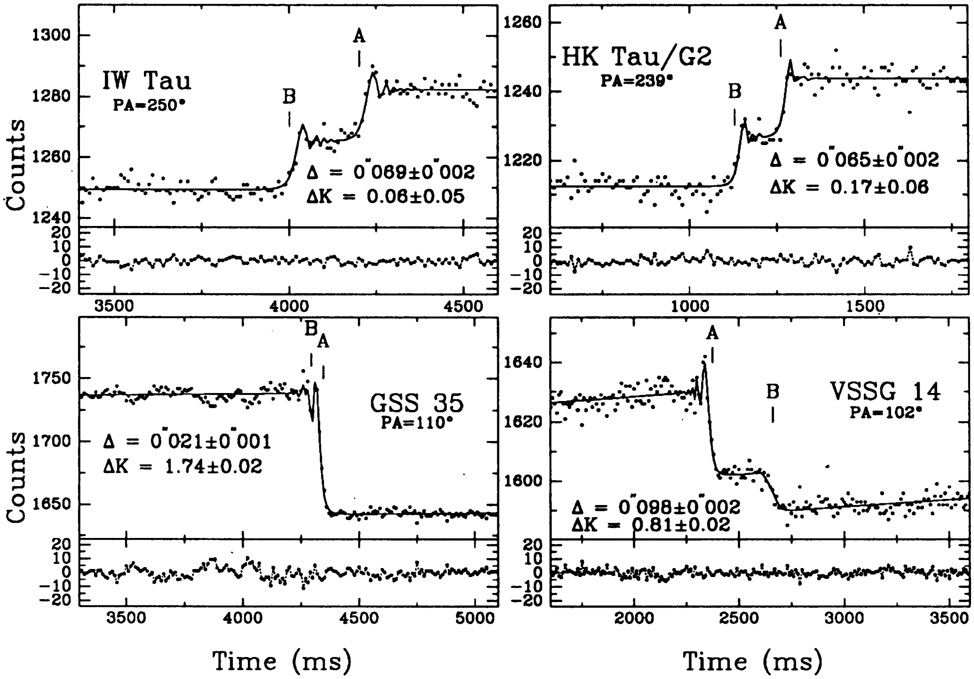

Fig. 1. Occultation data (dots) and best fits (solid lines) for IW Tau, HK Tau/G2, GSS 35, VSSG 14. The lower panels show the fit residuals. The individual components are marked as A (brighter at 2μm) and B.

only occultation results, that have shown two binaries in a total of 14 events. This would indicate a lower frequency of binary stars in Ophiuchus as compared to the Taurus region, a possibility which is however not supported by the results of Ghez *et al.* (1992). Clearly more observations are required to confirm these numbers.

From our observations, we can deduce that lunar occultations on a large telescope allow us to study sources with $K{\sim}10$, and offer a resolution as good as 0\".005. We expect that the introduction of array detectors for occultation work (see Richichi, these proceedings) will allow us to study sources 2–3 magnitudes fainter than at present, and to extend the dynamic range for the detection of companions.

References

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