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# THE CALAR ALTO LUNAR OCCULTATION PROGRAM: A STATUS REPORT

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**The status of the Calar Alto Lunar Occultation Program is presented. This has been conducted at IR and optical wavelengths through OAN 1.5m and CAHA 2.2m telescopes, operating either with fast IR array or CCD. The scientific throughput is double: first, angular diameter determinations (>1-2 mas) of late-type stars and circumstellar matter detection of astrophysically interesting targets (YSOs, T Taus, carbon stars, masers). Second, new binaries detection with projected separations > 5*mas*, and brightness ratios up to 1 : 50. We detail the runs carried out so far and summarize the scientific results obtained.**

## 1. INTRODUCTION

Lunar occultations (LO) turns to be one of the simplest and more powerful techniques to achieve high angular resolution. It consists in recording at millisecond rate, the light curve produced when a star is occulted by the limb of the Moon. Angular resolution information at the scale of 1 *mas* can be retrieved from the analysis of the diffraction fringes (Richichi 1989). Although, they are fixed-time events and are restricted to zodiacal zone, there is still a huge number of potential objects. As a result, LO technique is still one of the main sources for current high angular resolution catalog (Richichi et al. 2005). In addition, compared to other high angular resolution techniques such as adaptative optics (AO) and long-baseline interferometry (LBI), its cost and required observing time are dramatically inferior.

## 2. EQUIPMENT AND PROGRAM DESCRIPTION

As a result of considerations in § 1, we started a LO program at the Calar Alto Observatory. Both OAN 1.5 m and CAHA 2.2 m telescopes dispose of a

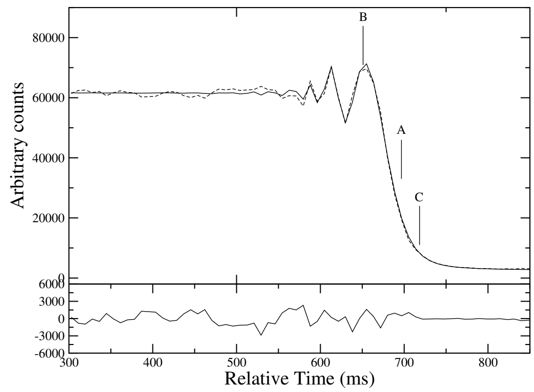


Fig. 1. Suspected triple IRC -30319.

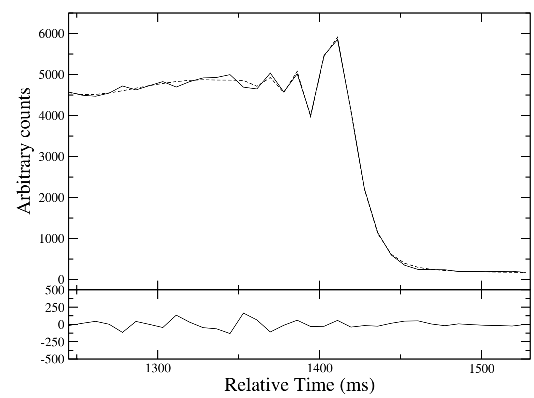


Fig. 2. Diameter for V 349Gem.

prototype of an IR NICMOS3 array based camera, called MAGIC (Herbst et al. 1993) which can be operated in subarray mode. We also observed LO with a CCD in drift-scanning mode (Fors et al. 2001). The achieved light curve sampling was 2 and 8 milliseconds, for CCD and IR array respectively. Limiting magnitude was found to be $K_{lim} \sim 8.0$ and $\sim 9.0$, for the 1.5 m and the 2.2 m, respectively. A limiting resolution study in the same fashion of Richichi et al. 1996 yielded a value of $\phi_{lim}$, ranging 1-3 mas.

In Table 1, we detail the observational effort conducted so far. Despite the bad weather incidence, a total number of 492 useful events have been recorded. As seen in the table, the scientific scope of the program is two-fold. On one hand, we determined an-

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TABLE 1

SUMMARY OF OBSERVING RUNS

| Run | Date | # nights | Telescope | Detector | Events description | # occultations | Publications |
|---|---|---|---|---|---|---|---|
| A | Mar-01 | 8 | OAN 1.5m | CCD | Binaries search | 0 | |
| B | Oct-01 | 6 | OAN 1.5m | CCD | Binaries search | 13 | Fors et al. (2004) |
| C | 02-Feb-02 | 4 | CAHA 2.2m | MAGIC | T Tauri region | 0[a] | |
| D | Feb-02 | 4 | OAN 1.5m | MAGIC | Binaries search | 27 | Fors et al. (2004) |
| E | Feb-03 | 5 | OAN 1.5m | MAGIC | Binaries search | 0[a] | |
| F | Nov-03 | 5 | OAN 1.5m | MAGIC | Binaries search | 14 | |
| G | Dec-03 | 5 | OAN 1.5m | MAGIC | Binaries search | 0[a] | |
| H | Feb-04 | 6 | OAN 1.5m | MAGIC | Binaries search | 54 | |
| I | Mar-04 | 7 | OAN 1.5m | MAGIC | Binaries search | 4 | |
| J | 28-Jul-04 | 0.5 | CAHA 2.2m | MAGIC | Gal. Center passage | 54 | in preparation |
| K | 30-Oct-04 | 1 | CAHA 3.5m | OMEGA-CASS | T Tauri region | 0[a] | |
| L | Nov-04 | 6 | OAN 1.5m | MAGIC | Binaries search | 51 | in preparation |
| M | Dec-04 | 5 | OAN 1.5m | MAGIC | Binaries search | 7 | in preparation |
| N | Jan-05 | 5 | OAN 1.5m | MAGIC | Binaries search | 134 | in preparation |
| O | Feb-05 | 5 | OAN 1.5m | MAGIC | Binaries search | 138 | in preparation |

[a]Bad weather conditions.

gular diameters of foreground resolved stars (usually late-type objects) with diameters >1-2 mas and circumstellar matter detection in astrophysically interesting targets located at a given area. This latter group ranges from YSOs, such as binary and multiple T Tau stars, to evolved stars which could be enshrouded in circumstellar matter (carbon stars, maser stars, AGB stars). In this sense, particular interest has been raised for the observation of a passage of the Moon close to the galactic center in run J, resulting in 54 occultations recorded in just two hours. Runs C and K also fell in previous category, but were unproductive due to bad weather conditions. On the other hand, we detected new binaries with projected separations >5 mas, and with brightness ratios up to 1 : 50. The followed strategy was to search over random background stars fields scanned during Moon crescent period. This is the case of runs A,B,D-I and L-O. Optical speckle follow-up observations are under way to extract deprojected separations, as well as planned AO and LBI observations.

## 3. ANALYSIS AND RESULTS

The resulting light curves clearly shows diffraction fringes due to Moon interference. Stellar diameter ($\phi$), extended emission and binaries (or multiples) separation ($\theta$) and brightness ratio $R$ detection were derived using the algorithm described in Richichi (1989). Due to the large volume of accumulated data, an automatization of the data reduction process has been carried out (Fors et al. 2005), allowing to save time and face more populated runs in the future.

TABLE 2

RESULTS STATISTICS

| Run | # unresolved | # binaries | # triples | # diameters |
|---|---|---|---|---|
| B+D | 25 | 5 | 0 | 2 |
| F,H,I,L-N | 73 | 10 | 1 | 2 |
| J | 46 | 4 | 1 | 3 |

In Table 2, we anticipate global statistics of results obtained so far. Runs F to N are still in preliminar reduction stage, and O has not been unpacked yet. Note that in some runs, the binaries detection efficiency reaches a success rate of ∼10%. Figures 1 and 2 show one example for each category of results that were introduced above. First, the M type star IRC-30319 was found to be suspected triple, with temptative separation values of $\theta_{A-B} = 14.50 \pm 0.04$; $\theta_{A-C} = 6.86 \pm 0.03$ and brightness ratios of $R_{A-B} = 8.02 \pm 0.03$; $R_{A-C} = 5.51 \pm 0.02$. Second, V349 Gem, a variable star of Mira Cet type, was found to have a diameter of $\phi = 5.10 \pm 0.08$.

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