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The 2009 occultation of the bright star 45 Cap by Jupiter

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1. Introduction

Photometric monitoring of stellar occultations is an established method of determining the structure and variability of planetary and satellite atmospheres [1]. It requires a sufficiently bright star to act as source and such opportunities are relatively rare. For the case of Jupiter, useful ground-based results have been obtained from campaigns involving the stars σ Arietis [2], β Scorpii A & C [3, 4, 5], SAO 78505 [6] and HIP 9369 [7].

A new campaign was organised in 2009 to observe the occultation of the bright star 45 Capricornii (V=5.5) by Jupiter during the night of 3/4 August 2009. Its occurrence during the summer months encouraged the participation of a large number of both amateur and professional observers as a "stress test" for an pro-am collaboration. Moreover, the latitude of the star's ingress and egress in Jupiter's atmosphere was similar to that of β Scorpii A during its 1972 occultation by the planet. Therefore, a direct comparison between the two sets of results could be made. Here we present and discuss some of the scientific results of this campaign.

2. Observations and data reduction

The occultation was recorded by both fixed and mobile stations in Europe, Africa and South America (Table 1). Observations took advantage of deep absorption bands in Jupiter's spectrum due to methane [8] in order to minimise the contribution of its atmosphere to the observed flux. The cadence used was in the range $0.4 - 10$ sec.

Even with the aid of methane absorption filters, separating the flux of the star from that of Jupiter proved to be an exacting process. For the K-band observations, we used the technique of [6]. For the 0.89 μm observations, and following subtraction of a template of Jupiter's disk (Fig. 1), we determine the photocentre of the star relative to a nearby moon - JII (Europa) for Ingress and JI (Io) for Egress. Then the intensity of 45 Cap, the Jovian limb, the sky background and the jovian background with apertures with radii from 2 to 7 pixels with an increment of 1 pixel were determined. Subtracting the intensities of the background from the aperture intensities of 45 Cap yielded the final intensity. The procedure was tested by checking the uniformness of the Jovian background several tens of minutes after the star was occulted. The fractional variation of Jupiter's background flux was found to be 0.5% of the flux from the star.

Table 1: List of observers.

Obs ID	Location	Exp rate (s)	Wave length (μm)	Aperture (m)
EPPICH	Namibia	0.70	0.89	0.4
BATH	"	0.45	0.89	0.5
TSATIG	Greece	2.40	0.89	0.4
ALIAKOS	"	2.40	0.89	0.4
ASRIB	Brazil	0.78	0.89	1.6
RCASAS	Spain	2.33	0.89	0.5
EBACAS	"	0.37	2.2	2.2
MCDIAZ	Canary Is	10.0	U	0.8
SCHMAS	"	1.0	2.2	1.5

3. Results

The lightcurves were fitted to Baum-Code isothermal models in order to extract the time of half-light and the effective scale height of the atmosphere. The latter was found to be in the region 20-30 km, in agreement with previous works. We have reproduced the Star-Jupiter-Observer geometry in each case using kernels and subroutines from SPICE [9] and found that the at-

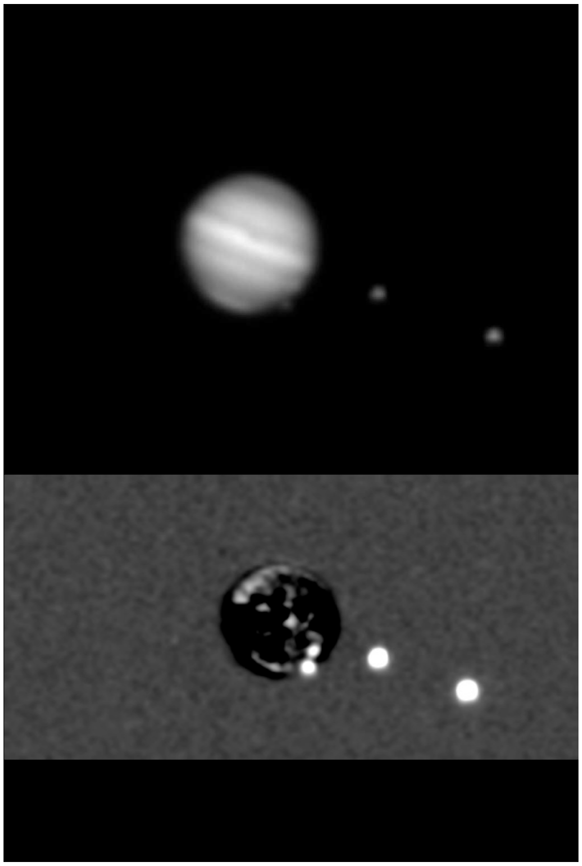

Figure 1: Sample frame from the Sabadell observations in the 0.89 μm methane band before (top) and after (bottom) template subtraction. 45 Cap can be seen impinging on Jupiter's disk just below the Great Red Spot. The sources to the right of Jupiter are, from left to right, the moons Io (JI) and Europa (JII).

mospheric heights relative to the 1-bar level are systematically higher at ingress than those at egress, by $\sim$ 100 km. This is probably due to the uncertainty in the star's position with respect to Jupiter combined with Jupiter's position with respect to the Earth. We are currently in the process of inverting the lightcurves to produce temperature and pressure profiles of the jovian atmosphere. The results will be reported at the meeting.

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