OBSERVATIONS OF THE 2001 LEONID METEOR STORM FROM NORTHERN AUSTRALIA WITH THE TEIDE IMAGING METEOR SYSTEM

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ABSTRACT

We describe the Teide Imaging MEteor System (TIMES), a fully automatic experiment consisting of two fixed image-intensified video cameras which are operated from Teide Observatory (Tenerife, Spain). A second station equipped with an identical system is located in Maspalomas (Gran Canaria, Spain). TIMES has been designed to work with the MetRec detection software for efficient video observations of meteors with a minimum of human interaction. The system will be used to monitor the shower and sporadic meteor activity for at least three years. In addition, double-station observations will be made on every clear night for orbital calculations and light curve analyses.

We also present preliminary results on the 2001 Leonid storm observed by TIMES during the scientific mission organized by the Instituto de Astrofísica de Canarias (Spain). Double-station observations were carried out in Central Australia from 16 to 18 November 2001. In this contribution we concentrate on the night of maximum activity and construct the activity curve and magnitude distribution of the Leonid meteors detected by our video system in the interval from 18 to 19 UT, 18 November 2001.

Key words: meteors, meteoroids.

1. INTRODUCTION

TIMES (Teide Imaging MEteor System) is operated in Teide Observatory (longitude 16°30′37″ W, latitude 28°18′06″ N, altitude 2200 m) on the island of Tenerife (Spain). It consists of two identical image-intensified video cameras based on 18 mm, second-generation micro-channel plates from Delft Electronic Products (Netherlands). Equipped with standard 50mm, f/1.4 photographic lenses, the cameras give a field of view of 20 degrees in diameter and The output window of the intensifier is imaged by a Panasonic NV-RX27EG video camera. The video signal (PAL, 25 frames per second, two interlaced video fields per frame) is transferred to a PC and digitized at half resolution with the help of a Matrox Meteor II frame grabber. The frame grabber allows 8-bit resolution, which translates into a dynamical range of about 6 magnitudes. The data acquisition and reduction is based on the MetRec software package [1]. MetRec inspects the video stream for moving objects in real time. The appearance time, the equatorial coordinates of the beginning and end points, the angular velocity, and the apparent magnitude are computed for each meteor detected. The individual frames and the total image showing the meteor are stored on disk for further analysis.

The aiming points of TIMES 1 and TIMES 2 are kept fixed to simplify the observational procedure. Both instruments are housed in a building to avoid extreme weather conditions. An automatic window is opened after sunset and closed before sunrise in order to allow observations. Robust mounts are employed to prevent the cameras from moving. Keeping the elevation and azimuth of the cameras fixed makes regular double-station observations feasible. The second station, equipped with an identical system dubbed TIMES 4, is operated by members of the Spanish Meteor Society in Gran Canaria, a nearby island situated some 100 km east of Tenerife.

TIMES has been designed to be portable, and can be operated using autonomous power supply. TIMES was used in this way for observations of the 1999 Leonid storm from Vilaflor (Tenerife, [2]) and of the 2001 Leonid storm from the Northern Territory in Australia.

The main scientific goal of TIMES is to produce a complete map of the distribution of meteoroids along the Earth's orbit. To this end, a survey will be conducted during three years in order to derive the spatial number densities [3] and orbital parameters of the various meteoroid streams encountered by the

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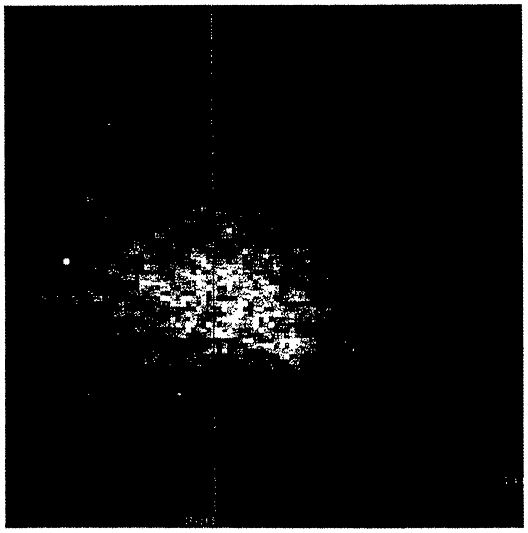

Figure 1. Radiant of the southern δ Aquarids (SDA) as determined from 5281 meteors recorded by TIMES 1, 2 and 4 in the period 25 July–4 August, 2000 and 2001. The software RADIANT [6] has been used to compute the backward tracings of all meteors (including sporadics and other shower members). This image shows the number of meteors whose backward prolongations hit each pixel. The gray scale ranges from 0 to 54. The pixel size is 0.1°. *A radiant motion of* 0.75° *per day in ecliptical longitude has been adopted to refer all meteors to the same solar longitude* $\lambda_\odot = 125.7°$. *The circle marks the nominal radiant of the SDA as derived from visual observations, and has a diameter of 5 degrees. The video observations reveal a much more compact radiant of approximately 1 degree in diameter.*

meteor light curves. This photometric information will allow us to determine important physical parameters such as meteoroid bulk densities [4]. The main advantage of TIMES compared with similar video systems operating from urban locations is that the detection rates are about 5-10 times higher thanks to the excellent conditions at Teide Observatory. As a result, the time needed to gather a statistically significant number of meteors is reduced. Another advantage is the southern location of the observing site, which permits the observation of low declination radiants under good geometrical conditions. As an example, Fig. 1 shows the radiant position of the southern δ Aquarids as determined from the backward prolongations of all meteors recorded by TIMES 1, 2 and 4 in the period 25 July–04 August, 2000 and 2001 [5].

2. OBSERVATIONS OF THE 2001 LEONID STORM

Observations of the 2001 Leonid meteor storm were made from Australia's Northern Territory during the nights of November 16, 17, and 18. Two locations

Table 1. Geographic coordinates of the observing sites and other observational details

	Devil's Marbles	Tennant Creek
Longitude	134°15′45″ E	134°12′00″ E
Latitude	20°33′54″ S	19°51′42″ S
Camera	TIMES 2	TIMES 1
LM	7.5	7.6
Interval (UT)	17:56-19:11	17:47-19:11
Leonids	98	103
Sporadics	6	9

servations: TIMES 1 was situated in a location close to Tennant Creek and TIMES 2 in Devil's Marbles (see geographic coordinates in Table 1). Both cameras were aligned in order to monitor the same atmospheric volume at a heigh of 100 km above the Earth's surface.

The analysis presented here is based on the results of a visual inspection of the VHS video tapes covering the Asian Leonid storm (18-19 UT, 18 November 2001). The time intervals and number of Leonid and sporadic meteors detected by TIMES 1 and TIMES 2 are given in Table 1. The final data analysis is in progress and will include radiant determinations and light curve studies.

2.1. Activity

Figure 2 shows the activity profile of the Asian Leonid storm obtained by averaging the number of meteors detected by each camera in five minute intervals. These numbers refer to a field of view 20 deg in diameter, and have been corrected for radiant elevation $h_{\rm R}$ and effective observing time $T_{\rm eff}$ according to

$$N = N_{\rm obs}\, T_{\rm eff}^{-1}\, \sin^{-\gamma} h_{\rm R}, \qquad (1)$$

where N represents the observed number of meteors. We have adopted $\gamma = 1$ following [7]. The limiting magnitude was close to +7.5 for the two cameras, and remained constant during the whole observing period. Because of this reason, the rates presented in Figure 2 do not include any limiting magnitude correction factor. Note that the activity profile presented here cannot be compared with those derived from standard visual observations due to the different fields of view and correction factors applied. The error bars shown in Fig. 2 are 1-σ confidence intervals corresponding to the average of quantities having individual uncertainties $\sigma_N = N/\sqrt{N}$.

According to our results, the highest activity occurred at 18h 17m ± 3m UT ($\lambda_\odot = 236.458° \pm 0.002°$, J2000.0), in excellent agreement with the main ac-

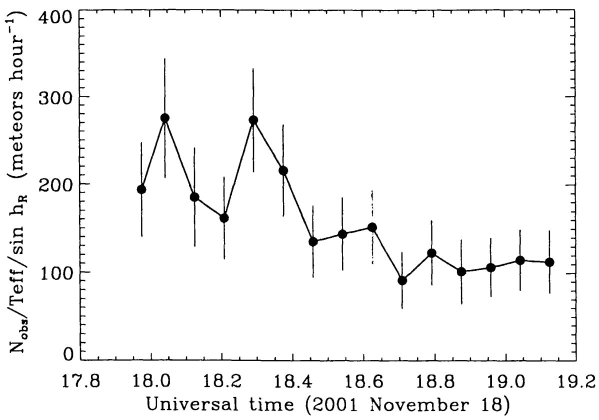

Figure 2. Activity curve of the 2001 Leonid storm as observed by two intensified video cameras in Central Australia. The raw numbers have been corrected for effective observing time and radiant elevation (but not for limiting magnitude) before being averaged. Error bars represent 1-σ confidence intervals.

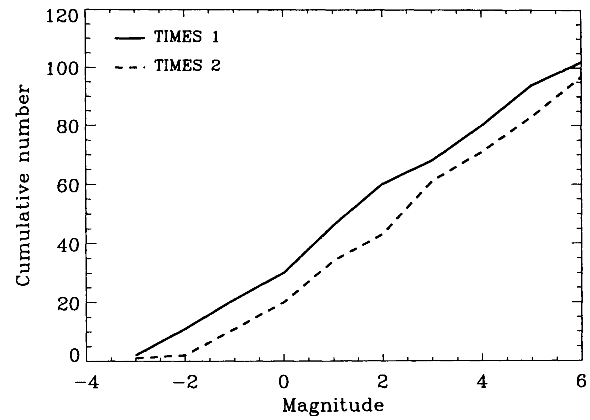

Figure 3. Cumulative number of Leonid meteors brighter than magnitude m as recorded by TIMES 1 (solid line) and TIMES 2 (dashed line) in the interval 18-19 UT, 18 November 2001. These numbers have not been corrected for detection probability.

This peak was produced by the 4-revolution old dust trail created by Tempel-Tuttle in its 1866 perihelion passage [9].

Our observations reveal a second peak at 18h 02m ± 3m UT ($\lambda_\odot = 236.447° \pm 0.002°$), in good agreement with the visual observations [8]. This activity enhancement was predicted in [9] and corresponds to the 9-revolution old dust trail (perihelion passage in 1699). However, we cannot confirm the additional peak at 18h 30m UT reported by visual observers [8]. Although there is some hint of enhanced rates at this position in Fig. 2, the large error bars do not allow us to draw any statistically significant conclusion. In any case, we note that the peak at 18h 30m UT inferred from visual observations has not been predicted by any available model.

2.2. Magnitude distribution

Figure 3 displays the cumulative number of meteors brighter than a given magnitude for the two cameras. The magnitude of each meteor was estimated by comparing the point of maximum light with field stars, and should be accurate to within ±0.5 mag. Remarkably, we find an almost perfect linear behavior, not only for the fainter meteors, but also for the brighter ones. The observed numbers have not been corrected for detection probability, implying that the actual number of faint meteors was larger than that shown in Figure 3. However, for the brighter meteors we expect the observed and real numbers to coincide because the detection probability is unity at such high light levels. Thus, restricting ourselves to the magnitude range from −3 to +2 (well above the meteor limiting magnitude of the video systems), we find that the brightness distribution of the video reported for the 1999 Leonids [2], although no satisfactory explanation has been given so far.

In the interval from −1 to +2, the magnitude distributions presented in Fig. 3 can be described by a classical power law to a reasonable degree of accuracy. Taking the logarithm of the cumulative number of meteors as a function of magnitude, the slope of the best-fit straight line gives the population index $r = N(m+1)/N(m)$, where $N(m)$ is the observed number of meteors of magnitude m. In the magnitude range $[-1, +2]$ we find $r = 1.49 \pm 0.33$ (90 meteors). This is equivalent to a mass index $s = 1.23$. Our value is remarkably small, and compares well with the value $r = 1.5 \pm 0.3$ determined in [10] for meteors in the magnitude range from −3 to +1. We do not confirm the rather large value of $r = 2.02$ derived from CCD observations [11]. We mention, however, that this population index applies to very bright meteors. As a consequence, it is not comparable to our value (especially if the brightness distribution does not follow a power law as indicated by Fig. 3.)

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