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Optical Observations of a Lunar Meteor Event during Leonid Meteor Showers in 2001

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Abstract. We report a probable transient lunar meteor event observed during careful video recording of the unlit portion of the moon during the Leonid shower activity on 18th November 2001. A video CCD was attached to the 1.2m Gurushikhar telescope with a tele-compressor for observing an unlit portion of the moon with a field of view of $3'.95 \times 2'.75$. Absolute time accuracy of 1 sec was maintained. Subsequent study of the video tape yielded five candidate events one of which has been independently observed. Details of the experiment, results and prospects of co-ordinated observations are discussed.

Keywords : Leonids, Moon, Optical flashes, CCD Video, Absolute time....

1. Introduction

It has been known only recently (Ortiz et al., 2000) that impacts of meteorids on the unlit portion of the moon can produce optical flashes detectable from earth. The moon can be regarded as a long exposure facility with huge collecting area and therefore measurements of direct impacts are potentially valuable in characterising the current population of meteorids in the vicinity of the earth-moon system. Further time predictions of peak activity on earth of various meteor showers have greatly improved in recent years and predictions are also available for enhanced meteor activity on the moon. In this paper optical video CCD observations of a lunar meteor event which occurred during the Leonid shower of 18 Nov. 2001 are presented and discussed.

2. Instrumentation and Observations

The specifications of the low cost commercially available CCD used are given in Table 1. The video output of CCD camera was given to a VCR to record video signals at a rate of 25 frames

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Table 1. 1/2 inch High Resolution B/W CCD Camera

Picture element	795 (H) × 596 (V)
Unit cell size	8.6 μm (H) × 8.3 μ (V)
Gain control	AGC/MGC
Power source	12 VDC ± 10%
Dimensions	42(W) × 48(H) × 95(D) mm

per second. A GPS unit recorded absolute time information. A microphone and audio amplifier were used for imposing time marks on the audio track every 5 minutes and for some necessary comments. The video tape was digitized afterwards for further analysis.

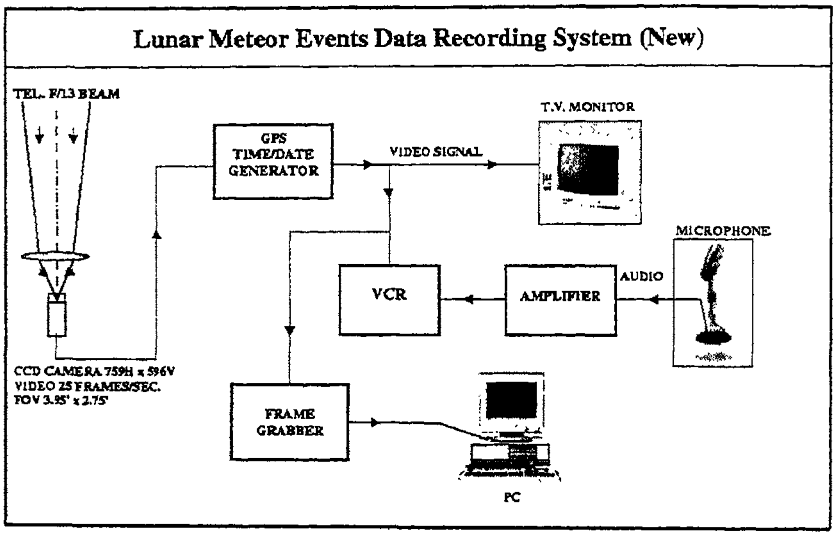

Figure 1. A Schematic of the present Lunar Meteor Events Recording system. During Leonids 2001 a simpler version without Frame Grabber or Time/Date Generator was used.

The video CCD system was coupled to the 1.2m telescope through a telecompressor lens to increase the field of view on the CCD to 3.95 arcmin × 2.75 arcmin. Video recording on a unlit portion of the moon near the terminator was started at 12:40:00 UT on 18 Nov. 2001 and continued uninterrupted till 14:14:00 UT at the rate of 25 frames per second. This period was also predicted to be a peak period of meteor activity on the Moon. The system was synchronised to 1 sec of absolute time using a GPS clock. Telescope console co-ordinates (RA and DEC) corresponding to the centre of the frame were noted at regular intervals. Immediately after the

Table 2. Absolute time (UT) and Lunar locations of optical flashes

Event No.	Time (UT) H M S	RA (Epoch J2001.5) H M S	DEC ° ′ ″
1	13 04 26	18 26 32.1	−24 44 45
2	13 22 16	18 26 51.1	−24 44 24
3	13 43 01	18 27 45.3	−24 39 55
4	13 53 14	18 28 11.8	−24 40 53
5	14 23 30	18 28 11.4	−24 40 40

video recording, two stars (41 π Sgr, $m_v = 2.89$ and θ' Sgr, $m_v = 4.27$) in the same region of the sky were successively acquired, centred on the CCD frame and console positions noted. The stars were used to derive the lunar positions on the CCD in the J 2001.5 epoch and to calibrate the optical flashes. A careful examination of the video tape, subsequent to observations revealed five transient events (optical flashes). The flashes were also seen on the monitor during observations. Their positions and exact time of occurrence are listed in Table 2.

Figure 2. The video frame exhibiting the optical flash at 18:53:14 UT on 18 Nov. 2001. The magnitude of the flash is estimated using standard stars to be $m_v = 5.6$.

3. Analysis

The duration of the each of the five events is less than the frame rate (i.e.) <·40 millisec. Event 2 was the brightest at $m_v \sim 2$. Of the five events only one (Event 4) has been simultaneously observed and recorded on video independently by another observer ~500 km away (Mr Kiran Shah, Pune). Simultaneous observations by spatially separated observers are necessary to exclude spurious local cosmic ray events. Considering only event 4 to to be the only true lunar meteor event in the sample, using calibrating stars we estimate visual magnitude of the optical flash of event 4 to be $m_v = 5.6$ (Fig. 2). Leonids strike the moon's airless surface at 72 km/s and release upon impact $\sim 2.5 \times 10^9$ joules of energy per kg. Recent estimates and numerical simulations (Melosh et al, 1993, Nemtchinov et al, 1998) show that the radiative efficiency of impact on the moon can lead to optical flashes detectable from earth. Earlier six such optical flashes have been recorded on the moon (Dunham et al 2000). Melosh et.al estimate that about 0.1% of the impact energy will be converted into visible light. The optical flash is of a very short duration lasting only milliseconds. If we assume a duration of about 5 milliseconds, it follows that with 0.1% conversion efficiency a 1 kg Leonid striking the moon will give rise to an optical flash of m_v ~ 3.2. In our case a flash of magnitude $m_v = 5.6$ corresponds to a Leonid impact on the moon by a body weighing about 100 g. Due to large uncertainties in optical conversion efficiency it is more likely that a meteor in the mass range 100 g - 1 kg has given rise to this event.

Since the real optical flashes lasting only milliseconds can be minicked by terrestrial effects, mainly cosmic ray events on the CCD, it is important to have co-ordinated simultaneous observations of the same portion of the moon by independent observers separated by 100 km or more. Since optical flashes upto $m_v \sim 10$ can be expected to be seen on the unlit portions of the moon with a small telescope, the position and accurate time recording of such transient events by co-ordinated amateur and professional groups would be invaluable in characterising the current level of meteor activity on the moon.

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