VIDEO TECHNIQUES FOR OBSERVATION OF THE LEONID STORMS

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1. Introduction

Video techniques, which provide high sensitivity, portability, moderate spatial resolution and excellent temporal resolution promise to be one of the most valuable methods for study of the forthcoming Leonid storm(s). While an unintensified video camera will detect very bright meteors (typically about 0 magnitude), some sort of image intensifier is needed to attain high meteor rates. Most current systems use a second or third generation microchannel plate (MCP) image intensifier lens or fibre-optically coupled to a charge coupled device (CCD) video detector.

With such systems one can detect stars down to about +8 to +9 apparent magnitude over fields of view of the order of 10 to 20 degrees. This results in sporadic meteor rates of the order of 10 to 25 meteors per hour. Photometry on the digitized video records allow determination of brightness to within about 0.4 magnitude. If one uses two image intensified systems separated by 25 to 150 km separations one can use triangulation to determine heights to within 0.2 km, velocities accurate to a few percent, and radiants to about 0.3 degrees. See Hawkes and Jones (1986), Hawkes (1993) and Molau *et al.* (1997) for reviews of video based meteor detection. In this paper we will present predictions of different types of video detection systems during Leonid storm conditions.

2. Leonid Video Observations

Although video techniques for the study of meteors began in 1961, there are no records of video observations of the 1966 Leonid storm. The normal Leonid shower and in some cases the recent beginning of elevated activity since 1994, have been observed by a number of authors including Babcock and Hawkes (1997, in preparation), Brown *et al.* (1997, in preparation), Fujiwara *et al.* (1997), Suzuki *et al.* (1997), Ueda and Fujiwara (1997), and Ueda and Fujiwara (1995).

3. Performance Evaluation

Most image intensified video meteor detection systems operate in the background limited regime, meaning that unresolved stellar sources and skyglow limit the detection of meteors. Under such conditions Hawkes (1993) has shown that one can express the limiting magnitude as

$$m_b = 3.8 - 5.0 \log\left(\frac{f_{ov}}{r_\ell}\right)$$

Here f_{ov} represents the field of view expressed in degrees and r_ℓ is the resolution of the detection system, expressed in number of video lines.

The sensitivity limit for meteors will be brighter than that for stellar sources, because of the spreading of the meteor luminosity over a number of pixel elements during a single video frame integration time. Hawkes and Jones (1986) have shown that this correction can be expressed through the following relationship.

$$corr.(mag) = 2.5 \log\left(\frac{180 r_\ell v \tau \sin(\xi)}{\pi f_{ov} R}\right)$$

J. Andersen (ed.), Highlights of Astronomy, Volume 11B, 1017–1019.

Here v is the meteor's geocentric velocity in km/s, τ is the frame integration time in s, ξ is the angle between the observing direction and the radiant and R is the range to the meteor in km.

Table 1 indicates the performance expected for several alternative meteor video detection systems assuming background limited performance, and loss of sensitivity for meteors according to the preceding relationship. Since there is some uncertainty regarding the probable strength of the upcoming Leonid storms, with most predictions putting the rate for 1998–1999 in the range 300 to 10,000 visual meteors per hourat peak, we present this table in terms of expectations for a corresponding visual rate of 100 meteors per hour. To obtain results for any particular storm prediction, e.g. 5000 meteors per hour, simply multiply the hourly rates given in the right two columns by the corresponding ratio (e.g. 5000 divided by 100 in this example).

TABLE 1. Expected Performance of Different Video Configurations

System	fov	app. mag.	MC–50	MC–15	Leo–r=2	Leo–r=2.5
camcorder (wide)	35	-0.5	2.5	0.9	0.5	0.1
LLL CCD (25)	14	+3	3.4	1.9	0.3	0.2
MCP-CCD (25)	44	+7.5	2.0	0.8	74	109
MCP-CCD (50)	22	+9.0	2.8	1.3	74	170
MCP-CCD (100)	11	+10.5	3.5	2.0	36	88

The systems considered are a typical color camcorder with a wide angle lens setting, a low light level monochrome CCD camera, and three image intensified systems each consisting of a microchannel plate image intensifier coupled to a CCD video detector (the number in brackets gives the objective focal length in mm). It has been assumed that all systems are optimized to the largest field of view, that the MCP has a 25 mm active area, and that the video has a 4:3 horizontal:vertical aspect ratio.

The next columns give the field of view (fov) in degrees, apparent limiting magnitude (app. mag.) for stellar sources, meteor magnitude correction (MC–50) for a situation in which the range is 110 km and the angle between the observing direction and the radiant is 50 degrees, similar magnitude correction (MC–15) for a range of 150 km and an angle of 15 degrees, the expected hourly detection rate (Leo–2) of the system under a Leonid shower with a population index of r=2.0 and assuming a visual meteor rate of 100, and the Leonid rate (Leo–2.5) assuming a population index of r=2.5. There is some evidence from 1966 that during the storm peak the Leonids are rich in small particles, and that the r=2.5 column is more appropriate.

4. Discussion

It can be seen that a standard camcorder would not produce impressive rates, even in a moderately strong storm. It is important to use intensified video systems with a range of objective focal lengths in order to provide a moderately large dynamic range to evaluate the mass distribution index for the shower. Longer focal length lenses, while permitting study of fainter meteors and better spatial resolution, result in a large number of partial trails (that end or begin outside the field of view) which complicate analyses. One of the greatest advantages of image intensified video detection methods is the provision of complete ablation profiles on individual events, and it is important to use sufficiently short focal lengths so that this is not compromised. It can be seen that the effective limiting sensitivity for Leonid meteors is 2–3 magnitudes or more brighter than the apparent (stellar) limit.

References

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