VIDICON PHOTOMETRY AND ASTROMETRY APPLIED TO OBJECTS OF THE SOLAR SYSTEM

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ABSTRACT

A SIT-Vidicon camera has been used for astrometric and photometric observations: phenomena of the Galilean Satellites, occultations of stars by asteroids and comets, closest approaches of fast moving objects. This paper tries to give a preliminary evaluation of the efficiency of these observations.

1. INTRODUCTION

The television-type detectors are now widely used for many astronomical applications. Their great sensitivity makes them well adapted to the observation of faint objects, and this is their main use in astronomy. Our aim is to use a standard television camera, a SIT-Vidicon type, for photometric or astrometric applications to objects of the Solar System.

2. THE EQUIPMENT AND THE METHOD

The SIT-Vidicon camera is mounted on the 1-meter telescope of Meudon Observatory which has a focal length of 21 meters. This type of camera presents the main advantage to realize simultaneously astrometric and photometric observation (bidimensional photometry) and we can observe phenomena and motions with great time resolution namely at a rate of 50 frames per second. Figure 1 shows the obtained light-curve of an artificial occultation of a star by a shutter in an unfavorable case: strong signal and large photoelectric amplification. We see that it remains less than 10% of the signal after 0.1 second of time (note that the noise of the curve is due to the agitation of the atmosphere). For each frame, we are able at the present time to produce a digitized signal of 285 rows of 150 pixels coded in 8 bits.

However, some problems limit the efficiency of the method. The ability to produce a digitized signal is very interesting but the great quantity

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of informations imposes on us the use of an analog recording.Each frame can be digitized into about 43000 pixels. This corresponds to a flux of 17 MegaHertz and forbids a real time treatment. To do it, it would be necessary to integrate several images and to keep only the interesting parts of the field. At the present time, we digitize only a small part of the recorded images after the observation has been carried out: the numerical analysis of the digitized images is very easy since it does not work in real time.

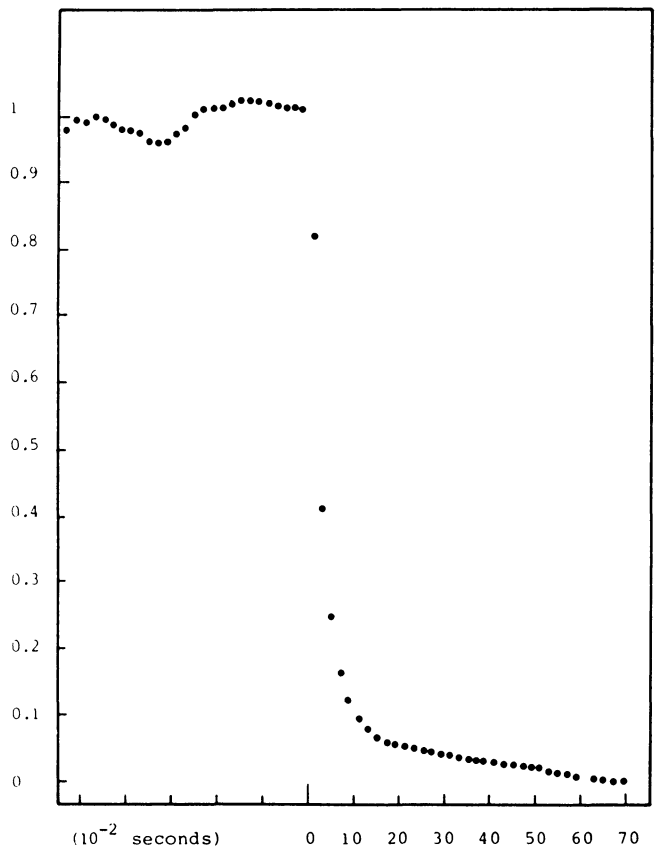

Figure 1: An artificial occultation : the time resolution of the system.

Other problems occur for the photometric and the astrometric calibration. For our relative observations, the photometric stability of the system is sufficient but may be improved. For the astrometric calibration we introduced an empirical term for geometric corrections : these corrections are very small because we use only a small field of about one minute of arc.

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However the method presents obvious advantages. Contrary to the photographic methods, the fast succession of images is very well adapted to fast moving objects. The speed and the relative trajectories of the objects can become new observational data. Furthermore, the two-dimensional photometry and the great time resolution permit us to observe short events and to time them with good precision. The light flux may be integrated over a small array around the object(s) : the signal is then like a signal obtained with a classical photoelectric photometer but the major advantages are to avoid the use of a diaphragm, the possibility to choose the optimum array and to record reference arrays: background, stars, ...

3. THE APPLICATIONS AND THE RESULTS

3.1 Galilean Satellites: phenomena

A current application is the classical photometry in difficult conditions. Recording of eclipses and of mutual phenomena of the Galilean Satellites have been made. Such observations have yet been carried out in the past at the Mount Wilson Observatory (Mosher et al. 1975) and at the Meudon Observatory (Arlot et al. 1982). In both cases, the observation was not possible with classical materials because of bad conditions (scattered light from Jupiter, atmospheric agitation).

3.2 Galilean Satellites: trajectories

Another interesting application is the observation of close approaches between two fast moving objects: for example the observation of the close approach (or conjunction) between two Galilean Satellites. Observations of this type were made visualy during the 18^{th} and the 19^{th} centuries. They were abandonned when eclipses were observed photometrically. But nowadays, to obtain the best precision for the ephemerides, we need to diversify the types of observations in order to evaluate and determine the systematic errors due to each type of observational technique used. Preliminary results were obtained for the observation of close approaches (Arlot,1982). The precision of the time of the close approaches was about 40 seconds of time but was improved and we will see afterward that we are now able to reach a precision of 20 seconds. Such precisions are comparable to that obtained for the timing of the observation of mutual phenomena. The separation at the time of the close approach, which was not measurable visually, is now determined with a precision of about 0".05.

The type of observation described above is applied to the Galilean Satellites. Note that it may be applied similarly to the Saturnian Satellites, but this has not yet been carried out.

3.3 Asteroids and comets: occultations and trajectories

Asteroidal occultations of stars are systematically observed at the Meudon Observatory. If the Vidicon technique does not improve the classical photoelectric technique (except for bad observational conditions with important atmospheric agitation where the absence of diaphragm is profitable), the possibility of determination of the minimum of distance

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between the star and the asteroid is very valuable: so, we are able to locate with a good precision the track of the umbra. It is thus possible to confirm an observation of the occultation of the star by the minor planet and to distinguish secondary events due to a would-be accompanying object.

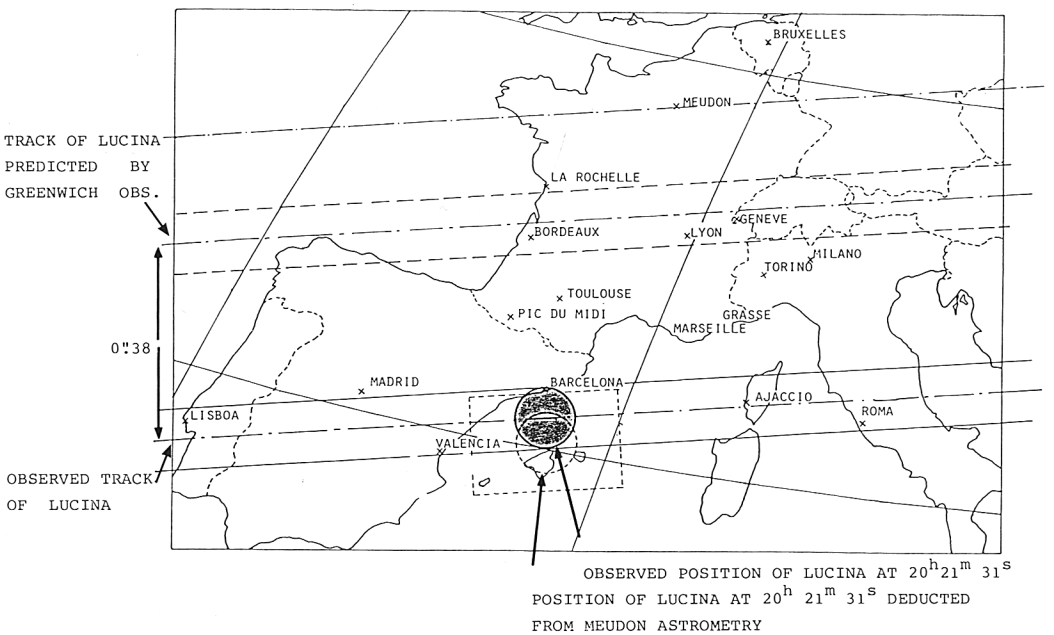

Figure 2 : Path of (146) Lucina on 1982 April 18

For example, on 1982 April 18, we observed the close approach of (146) Lucina (m_V=11.7) to the star AGK3+17°1309 (m_V=9.6). The prediction of the occultation was for a Lyon-Bordeaux line in France, 300 km south of Meudon. Our observation showed that the real path was located 729 km south of Meudon (see figure 2), on a Barcelona-Lisbon line. The precision of this determination is 38 km, corresponding to an angular position of the asteroid relative to the star of 0.03 arcsecond. This was confirmed by the observations of the occultation by Spanish observers. Furthermore a short secondary event recorded at Meudon with the Vidicon camera (duration 0.6 second of time observable only because of the good time resolution of the technique), was explained as an occultation of the star by an object accompanying Lucina (Arlot et al. 1985). If the occultation is easily recordable (it is sufficient to record the star and our equipment allows the observation at Meudon-an observatory near the city of Paris- of objects whose magnitude is about 13), the astrometric determination of the closest approach needs that the magnitude of both star and minor planet are not too different. At the present time,our

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observations have shown that the difference of magnitude may not be larger than 3 to get precise results.

On 1983 May 8, an observation of the comet Iras-Aracki-Alcock was realized during a close approach with a great angular velocity. The advantages of the two-dimensional photometry was very well adapted for that type of observation (Lecacheux et al. 1984).

4. CONCLUSION

The preliminary results we obtained are encouraging: the astrometric accuracy due to the long focal length and the small field used, is interesting and it would be possible to improve this type of observations with the use of a digitization and pretreatment in real time. We hope that these observations will be developed, particularly to diversify the observational data used in the elaboration of the ephemerides of the natural satellites of the planets.

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