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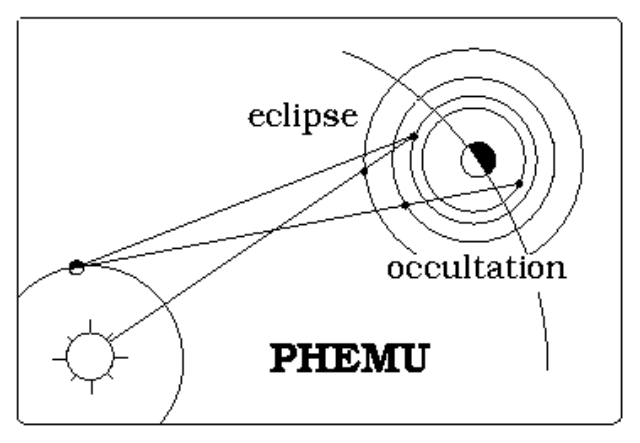

Technical Note n°4
PHEMU
v. of May 17, 2008

THE OBSERVATION OF MUTUAL EVENTS USING VIDEO CAMERA

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1. Introduction

The goal of the observations of mutual events of the Galilean satellites is to record fast variation of the light received from these satellites. The receptors which are well adapted to this type of observation are the fast photoelectric photometers including CCD driven by computer. However, the camescope or video cameras recording movies are interesting for the recording of these events if specific precautions are taken. Especially for amateurs, they allow to record easily the events. The present note does not describe the methods to be used for the reduction of the observations but provides indications and help in order to make observations with this type of camera.

2. The material

The making of the recording of a mutual event needs to be careful and to follow some regulations which will permit to obtain a useful record leading lately to useful data for the study of the dynamics of the Galilean satellites. The first thing is the camera which should produce either an analogue signal (video composite signal black and white -CCIR norm- or a colour signal PAL, NTSC or SECAM) or a numerical signal. The second thing is the recorder of either the analog signal or the numerical one. Recorders allow to have a sound track which may be used for recording an audio clock that will secure the timing of the images which is essential for the use of the data (cf. figure 1).

a) The camera

Any video camera may be used but it is preferable that it is not equipped with an automatic gain not removable. This would make difficult the photometric analysis of the signal. The CCD targets are now used world-wide. They are more reliable because either for the photometry or for the geometric characteristics of the targets. We should mention here that we are speaking of uncooled CCD cameras needing a fast recording. This is not a problem because of the fast lecture of the target thanks to the movie norm: numerical signal or CCIR norm (50 half-images interlaced per second analogically recorded by the VCR). The video camera must but settled on the telescope directly at the focal plane without its objective. It is preferable to avoid any optical system between the telescope and the camera. However, if the objective is not removable or if the field is too large due to a too short focal length of the instrument, it

may useful to add lenses in order to increase the focal length and to have on the image well separated satellites and to avoid the presence of the planet Jupiter in the field, or, more simply, to get an image... The satellites of Jupiter are very bright and a filter may be used (cf. paragraph 3.a) or the image may be put slightly out of focus (we are recording a flux signal, not an image).

b) The timing of the events

As it has been recommended in previous technical notes, it is necessary that an observation be correctly related to the Universal Time within 0.1 second of time. The best way for that is the use of an image clock incrustator which will be carefully settled to the Universal Time and to verify at the end of the observation that it is always correct. If your internal clock incrustator is not in UTC, you may note the difference to UTC before and after the observation.

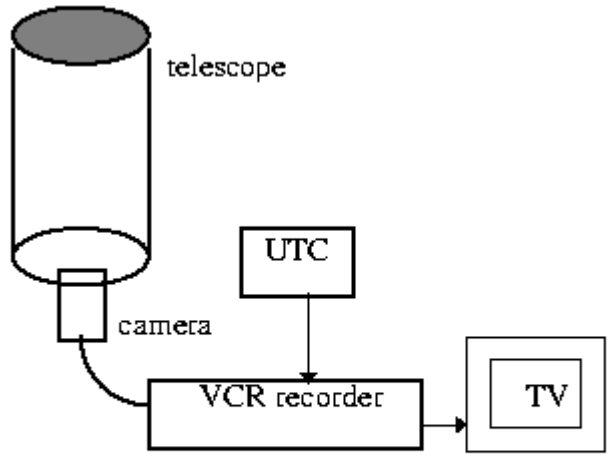

Fig. 1 - The connection telescope/camera/VCR.

If the use of an incrustator is not possible, one may use only the sound track of the VCR by recording an audio clock (clock by phone or time signals by radio broadcasting). If necessary, one may record only from time to time a signal on the image corresponding to a given date. One may also record the image of a digital clock at the beginning and at the end of the observation providing that the recording will never stop between the two timings. The speed of the VCR will be used to make the timing of each image between the time signal. However it is important to never stop the recording even when moving from the sky to the clock in order to keep the correspondance time/images.

c) The recorder

With an analog signal, a VHS standard VCR (with clean heads and brand new video tapes) allows to make a useful record. Some improved video standards (S-VHS or Hi-8) or professional (U-Matic) allows to get a record of better quality. Short tapes (1 or 2 hours long) are less fragile. The black-andwhite position should be used when it exists, otherwise use the PAL mode. Note that the colour mode has no interest. The S-VHS, Hi-8 or U-matic formats may enhance the resolution using the black-and-white position. With a numerical signal, the main problem is to be sure that the siganl is not compressed too much leading to a loss of information.

d) The monitor

A TV screen monitor will be connected to the output of the camescope or the VCR in order to watch the observation which will be recorded (most of the camescope have a control screen included). It is useful to mark on the screen the position of the implied satellites in order to keep them always at the same place on the target by driving the telescope each time it is necessary. Then, the reduction will be more easy thanks to the stability of the position of the observed objects.

3. The observation

The technical notes PHEMU describing the photometric techniques of observation (note n°3) should be read carefully. The principles have to be applied with any receptor, even camescopes or video cameras. It is necessary to follow the same regulations in any case.

a) Choice of the gain and/or the sensitivity

The recording must be made in a linear zone of the sensitivity which is normally the case with CCD targets. However, the observed objects must never saturate the target. If the seeing is bad, when the objects are closer, saturation may occur. In order to avoid this, you may decrease the gain or put slightly out of focus the image, in order to spread the light on the target. Don't forget that we record a light flux, not an image.
If the camera is equipped with a gain controller, it is important to choose a level for which the saturation will never be reached for the satellites during the event. Be careful when Jupiter is after its rise and when the absorption is continuously decreasing. Be careful also to the sky background when the Sun is just before its rise. In the case where it is not possible to choose the sensitivity (this one should however be kept constant during all the observation) one will use filters in order to avoid the saturation. One should try the different possibilities before the observation of the events. Simulations should be made several days before the events mainly for events occurring during twilight. Do not forget that the variation of the sky background is exponential. The use of a R or I filter is very interesting by decreasing the brightness of the sky.

b) The timing of the observation of a mutual event

- *Reference objects :*
During a mutual eclipse, only one satellite is implied : in the field, the eclipsing satellite will be visible most of time. It will be interesting to keep it in the field in order to have a reference object available in the field and allowing to correct for a variable absorption. In the case of an occultation (or if the eclipsing satellite is too close or too far from the eclipsed satellite) both occulting and occulted satellites will be observed together. Before and after the occultation, they will be observed separately but, during the occultation, it will be interesting to put in the field a third satellite which will be the reference object. If this configuration is not possible, two cases could occur : first, the event is a short one (less than 15 minutes). Then the reference object will be recorded only before and after the event. Second, the event is longer (more than 15 minutes) ; then it will be possible to move the telescope every 5 or 10 minutes towards the reference object if this one is not too far (it will be necessary to find the objects rapidly in order to loose as less event as possible).
- *Duration of the observation :*
It is important to record enough signal around the date of the event provided in the predictions. The analysis of the signal before and after the event allow to appreciate the quality of the signal and to proceed to a better reduction. If the duration of the event is « N » minutes and if the observing conditions are good (twilight, elevation above the horizon), then, the observation must be as follows :

short event :		
15	minutes:	the satellite before the event
N	minutes:	the event
15	minutes:	the satellite after the event
long event :		
5	minutes :	reference object
15	minutes:	the satellite before the event
10	minutes :	the event
1	minute :	reference object
10	minutes :	the event
1	minute :	reference object
and so on until the end of the event		

Don't forget to take into account the time necessary for the pointing of the telescope in order to go from one object to another.

- *The driving of the telescope :*
The reduction will be more easy if the occulted or eclipsed satellites stay in the same zone of the field during all the observation. A good driving of the telescope is necessary and one should drive the telescope properly through the TV screen monitor.

c) Important items

Keep in mind that the Universal Time must be recorded during all the observation in order to date each image. An audio signal may be recorded through the microphone on the sound track during all the observation. If the time signal is recorded from time to time (not continuously) be careful to do not stop the recording even during the moving of the telescope from one object to another, since the timing of the images will come from the regularity of the recording. If the recording must be stopped for any reason, note it and record again the Universal Time.

4. The reduction of the observations

Even the stability of the observations made using a video receptor and recorded on VCR is not of a high level, the reduction of the observations may lead to very good and useful results. The main problem will come from the gain of the receptor which may be not linear. This could be checked: a reciprocity function may be built either with solar-type stars or with artificial sources well calibrated in a laboratory. Such a function should be available for the reduction in order to rebuild the true light curve of the event with the real magnitude drop. Then, the reduction will be made according to paragraph 3 of Technical Note n°5.

5. Other observations

A two-dimensional receptor allows to make another type of interesting observation as follows thanks to its speed of a acquisition :
- occultations of stars by asteroids during close approaches (appulses) between asteroids and stars are observable anytime. Each year more than 30 occultations may be observed from a given site. The goal is to observe stellar occultations which, contrarily to mutual events, are observable only from restricted geographic areas since the prediction of such events is not accurate. These observations allow to get data providing information on the structure and the shape of the asteroids. These observations are performed simultaneously by several observers through a network such as EAON in Europe . Observations made using a video camera provide images and, if the magnitude of the observed objects is sufficient, they allow the interpretation of the observations made by the other observers of the network observing most of time with a fast photometrci receiver or even with the naked-eye.

6. Conclusion

The two-dimensional receptors such as the camescopes or video cameras will provide very useful observational data of the mutual events. However, the observers must be sure that the recommendations provided in the present note are strictly applied. Then, the photometric accuracy of the data will have a good level.
IMCCE developed a system (AVIA) of digitization for analog recording useful for the reduction of video observations. The observers may contact us for more details on the reduction procedure.
Examples of light-curves obtained through video cameras are available on the server of IMCCE/Bureau des longitudes in the catalogues of the observations made during the previous campaigns and in the Technical Note n°6.