The Handbook of the PHEMU observer

The events:

During the equinox on Jupiter (when the Sun is in the Jovian equatorial plane, every 6 years), the Galilean satellites will occult and eclipse each other. These phenomena are generally short (a few minutes of time) and easy to observe: the magnitude drop may reach one magnitude or more. Their observation allows obtaining accurate relative positions between the two involved satellites. This accuracy is much larger than the one of astrometric ground-based observations, reaching the level of some space probe observations. More, the Galilean satellites are very bright and it is difficult to making imaging through telescopes so that the mutual event observations appear to be the best way to get astrometric data for dynamical purpose.

The 2014-2015 period

The mutual events will occur around the next Jovian equinox which will take place on February 5, 2015 (4 months before and 4 months after). Fortunately the opposition of Jupiter will occur on February 6, 2015 making easy the observations. So that the events will occur and will be observable from October 2014 to June 2015. The declination of Jupiter being positive, the observers of the Northern hemisphere will be favored.

Choosing a mutual event to be observed

Three criteria must be applied when choosing an event to observe:

- Jupiter must be observable, sufficiently high above the horizon and the Sun must be sufficiently under the horizon. Observations are possible during twilight but need some precautions.
- The event must be easy to catch: it must occur sufficiently far from the bright disk of the planet (infrared images with long focus telescopes allow to catch events closer to Jupiter) and it must have a sufficient magnitude drop. The predicted flux drop must be larger than 10% to be easily measured. However, when several events occur during a night, one may try to observe even difficult events.
- Another satellite , different from the occulted of eclipsed one must be present in the field in order to be a photometric reference during the event allowing to eliminate light clouds passing in the sky during the event. We make relative photometry.

Tables and interactive softwares will allow the observer to find the best events observable from his own site of observation.

Events for a given site at: http://www.imcce.fr/hosted_sites/saimirror/nsszph515he.htm

Configuration of the jovian system at any time:
http://www.imcce.fr/hosted_sites/saimirror/nssima5he.htm

The telescope to be used

The Galilean satellites are very bright and observations may be made with very small telescopes. However, some criteria would decide if a telescope is able to make useful observations: the instrument must be very stable to guarantee stable images during all the observation and the guiding of the telescope must be confident in order to avoid a shift of the images during the observation. Refractors or reflectors may be used for observing the mutual events.

The detector, the filter

The observation is a photometric observation (measure of the magnitude drop during the occultation or the eclipse) made through images. The observation will be the measure of a light flux so that all the devices modifying the light flux must be avoided: any antiblooming system or any automatic gain will make the observation useless, so, be sure that these devices are not operating on your detector. The wavelength of the observation must be well known for the reduction. You may combine the sensitive profile of the detector with a filter for decreasing the light coming from the too bright Galilean

satellites but we need to know that exactly. The CH4 890nm filter may be helpful: it will darken the disk of Jupiter allowing to observe even with Jupiter close to the satellites.

The timing of the event

All the observations made worldwide will be put together for analysis of the dynamics of the satellites. In order to link the observations, we need that each image be dated in UTC (Universal Time) to the nearest 0.1 second of time. Several ways may allow this necessity. In any case, each image may be dated in a time scale (internal or local). This time scale may be linked to UTC through the GPS but if not possible, just determinate the difference to UTC before the event and after the event in order to get the difference and an eventual drift of the scale. Interpolation will then allow to go back to UTC for each image. Note that this point is very important. Without UTC timing an observation is useless.

Making the observation

First, the observer must identify the field well in advance. We provide configurations on our web site in order to identify the satellites and the size of the field. We need the presence of three satellites in the field, the third one, not too close to the others being the photometric reference. If the eclipsing satellite is sufficiently far from the eclipsed satellite, it may be used as the photometric reference. When starting the observation, be careful to record the right field by identifying correctly the North and the East.
Second, choose carefully the integrating time and the frequency of the images. A larger integrating time (time exposure for each image) will increase the signal/noise ratio but beware the brightness of the satellites. More than 10 images per second will make the reduction difficult.
The prediction of the events are not very accurate and the event may start several minutes before the predicted time. So, start to observe at least five minutes before the predicted beginning. For photometric purpose, we need to record the involved satellites separately before or after the event. For that, you may have to make images (during one or two minutes) of the satellites 15 or 30 minutes before or after the events. Most of time it is possible only before or after the event because of the motion of the satellites being too close to Jupiter of the arrival of twilight.
So that the observing sequence has to be carefully followed:
- be sure of the time scale
- observation of the satellites separately
- observation of the event starting at least five minutes before the predicted beginning and ending at least five minutes after the predicted end
- observation of the satellites separately if not done before the event

The reduction of the data

The final result of observation is a light curve, i.e. a file of successive values of the light flux, each one dated in UTC or in a time-scale referred to UTC. You may make this reduction yourself as follows:

- Measuring the flux of each satellite present in the field by substracting the sky background from each measure (first the satellites separately as observed, second the satellites during the event).
- Use the reference satellite to eliminate absorption: divide the flux of the observed satellites by the reference satellite

A Phemu technical note is available at http://www.imcce.fr/phemu/notes_tech/note05-en.php

Your light curve is now ready to be sent for a global analysis.

Sending your observation

A page for uploading your observation is available on our web site at
http://www.imcce.fr/hosted_sites/saimirror/phemuobs.htm
It is important to fill up all the request: this is necessary for further analysis of your data.
If you are not able to make the reduction, you may send all your recorded images (preferably in fits format) together with a report using the observational sheet at
http://www.imcce.fr/phemu/fichephemu15_en.txt