EPSC Abstracts
Vol. 10, EPSC2015-619, 2015
European Planetary Science Congress 2015

Jupiter's Galilean satellites mutual events as a teaching tool

J. F. Rojas (1,2), A. Sánchez-Lavega (1,2).
(1) Departamento de Física Aplicada I, E.T.S. Ingeniería, Universidad del País Vasco, Alameda Urquijo s/n, 48013 Bilbao, Spain. (josef.rojas@ehu.es / Fax: +34-946014178)
(2) Aula EspaZio Gela – UPV/EHU, Spain.

Abstract

We present a set of observations of the mutual phenomena (occultations and eclipses) between Jupiter's Galilean satellites in 2014 and 2015 obtained with a Celestron 11 telescope from the Aula EspaZio Gela at E.T.S.I. - UPV/EHU. These observations are used as a practical teaching tool for photometry and astrodynamics in different matters of the Master in Space Science and Technology UPV/EHU.

1. Galilean Satellites Mutual Events

On February 5, 2015 the Sun transited the equatorial plane of Jupiter (the equinox) and the Earth passed this plane on November 8, 2014 and April 10 and May 5, 2015, and therefore the orbital planes of Jupiter's main satellites [1]. As a consequence mutual occultations (O) and eclipses (E) occurred between the main satellites. Because the Galilean satellites are bright objects and have appreciable sizes around ~ 1 arcsec, these mutual events are observable with small-medium telescopes and their accurate photometry and timing have been used for precise astrometry of their orbits [2]. In this communication we use the observations of the mutual phenomena as a teaching practice to accurately study the satellites properties and orbits, complementing our previous work on the same subject [3]. The present observations are also useful for astrometric use.

2. Observations

In Table 1 we list the captured mutual phenomena. The observations were performed with a Celestron 11 telescope (28 cm aperture, f/10) from the Aula EspaZio Gela of the UPV/EHU [4]. The telescope was placed in Getxo (Latitude 43° 21' 44.46" North and Longitude 3° 01' 06.65" West). We used a DMK21 AU618 camera with a Barlow X2 Celestron magnification lens in order to have enough spatial resolution to capture, under good seeing conditions, the disks of the satellites. For each event we took several image frame series with short exposures. The exposures ranged between 1/15 s and 1/100 s depending on the seeing quality. Photometry on the satellite target was performed by integrating the total number of counts in a disk aperture typically about three times the size of the satellite. A satellite not suffering the mutual phenomena is used as a photometric reference. When there is a mutual occultation, the summation of the integrated count numbers of both satellites is used to obtain the photometric curve.

Table 1: Observed Mutual Events

Date	Event type
28-Oct. 2014	2O3
22-Dec. 2014	4E1
24-Dec. 2014	2E3
05-Ener. 2015	3E1
07-Ener. 2015	4E3
09-Feb. 2015	3O1
09-Feb. 2015	3E1
09-Mar. 2015	3O2
11-Apr. 2015	1E3

Even type first number is the satellite producing the event and second number the satellite suffering the event: 1 (Io), 2 (Europa), 3 (Ganymede), 4 (Calisto). E = Eclipse, O = Occultation.

For generating imaging sequences of the mutual events, the 'lucky imaging' method has been used with the same tools described in previous works [3, 5]. This method provides high spatial resolution, once the frames are selected by their quality, then re-centered and co-added, allowing resolving the disks

of the satellites. Figure 1 shows an example of a time occultation series.

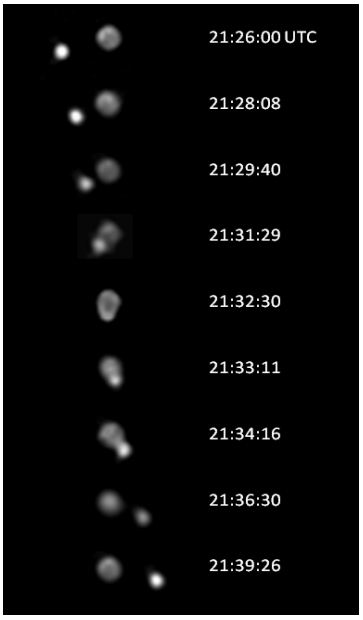

Figure 1: Mutual event of Ganymede occulting Europa on March 9, 2015.

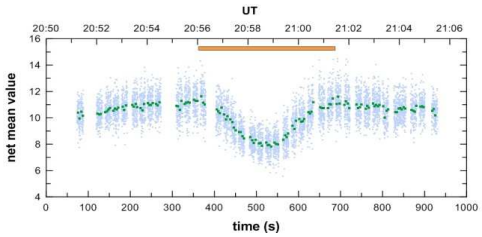

Figure 2: Photometric curve of the occultation of Io by Ganymede on February 9, 2015. The bar marks the event duration.

3. Results

The photometric curves (Figure 2) are fitted to a simple model for the satellites as disks of uniform surface brightness producing and suffering the occultations and eclipses [6]. The time lapse sequences allow the determination of the times of the start and end of the events and also de reduction in light received. From these data the basic orbital parameters and radii of the satellites can be measured and compared with a model prediction [7].

Acknowledgements

This work has been supported by a research grant from Departamento Promoción Económica Diputación Foral de Bizkaia, AYA2012-36666 (with fondos FEDER), Grupos Gobierno Vasco IT765-13 and UPV/EHU UFI11/55.

References

[1] PHEMU 2015
http://www.imcce.fr/phemu/index.php?popup=3

[2] Arlot, J.E. et al., The PHEMU09 catalogue and astrometric results of the observations of the mutual occultations and eclipses of the Galilean satellites of Jupiter made in 2009, *Astronomy and Astrophysics* 572, A120 (2014).

[3] I. Ordoñez, T. del Rio-Gaztelurrutia, A. Sanchez-Lavega. Retrieval of orbital parameters of the Galilean satellites using small telescopes. *Eur. J. Physics*, 35, 045020, 14 pp (2014).

[4] A. Sánchez-Lavega, S. Pérez-Hoyos, R. Hueso, T. del Río-Gaztelurrutia and A. Oleaga. The Aula EspaZio Gela and the Master of Space Science & Technology in the Universidad del País Vasco (University of the Basque Country. *European Journal of Engineering Education*, 39, 518-526 (2014).

[5] I. Mendikoa, S. Pérez-Hoyos, A. Sánchez-Lavega, "Probing clouds in planets with a simple radiative transfer model: the Jupiter case", *European Journal of Physics*, 33, 1611-1624 (2012).

[6] X-l. Zhang, Z. Liu, Z-h. Tang. Astrometric results of the mutual events between the Saturn's satellites observed at Yunnan Observatory. *Planet. Space Sci., 76***,** 83-86 (2013)

[7] Grischa H. & M. Jacquesson,WinJUPOS - Database for object positions on planets and the Sun (2011).

http://www.grischa-hahn.homepage.t-online.de/astro/index.htm