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The PHEMU97 catalogue of observations of the mutual phenomena of the Galilean satellites of Jupiter*

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ABSTRACT

In 1997 the Sun and the Earth passed through the equatorial plane of Jupiter and therefore through the orbital planes of its main satellites. During this period, mutual eclipses and occultations occurred and were observed. We investigate the precision of the catalogue to produce improved data for the development of dynamical models. Light curves of mutual eclipses and occultations were recorded by the observers of the international campaign PHEMU97 organized by the Institut de Mécanique Céleste, Paris, France. We made 275 observations of 148 mutual events from 42 sites. For each observation, information is given about the telescope, the receiver, the site and the observational conditions. This paper gathers together the data and gives a first estimate of the precision. The catalogue of these rare events represents a collection of improved accurate astrometric data useful for the development of dynamical models.

Key words. eclipses – occultations – astrometry – astronomical data bases: miscellaneous

1. Introduction

Observations of mutual events of natural satellites have been performed intensively since 1973 and they have proved to be a very accurate way to obtain astrometric measurements of natural satellites. Many such events involving the Galilean satellites of Jupiter have been observed. In 1994–1996, similar events occurred in the Saturnian system. In 1997, we organized and coordinated an international campaign to observe these rare events. This campaign, named PHEMU97, allowed us to collect 275 lightcurves of 148 mutual events by our international network of 42 sites.

We present our results here. Another paper (Vasundhara et al. 2003) provides the astrometric data extracted from the lightcurves using a sophisticated photometric model including the albedo map deduced from the space probe images. The aim of the present paper is to provide the photometric data and the observational parameters useful for future work on the improvement of dynamical models as well as of models of the surfaces of the satellites. These data will be available through the data base NSDC dedicated to the natural satellites (`http://www.imcce.fr/nsdc`).

2. The mutual events

The Earth and the Sun cross the equatorial plane of Jupiter every six years. The Jovian declinations of the Earth and the Sun become zero and since the orbital plane of the Galilean satellites is very close to the equatorial plane of Jupiter, the satellites occult and eclipse each other.

The 1997 period was favorable since it occurred during the opposition of Jupiter and the Sun.

Arlot (1996) made predictions of all the 1997 events using the G5 ephemerides based on Lieske's theory (Lieske 1977) of the motion of the Galilean satellites. 182 dates of mutual events were computed. Several campaigns of observations took place during the previous occurrences. Table 1 shows the results

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* Table 4 and figures are available in electronic form at `http://www.edpsciences.org`. They are also available on the following ftp server together with the digitized lightcurves available as ASCII files at `ftp://ftp.imcce.fr/pub/NSDC/jupiter/raw_data/phenomena/mutual/1997/`

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Table 1. Results of the past campaigns of observations.

	1985	1991	1997
Number of sites	28	56	42
Number of light curves	166	374	275
Number of observed events	64	111	148

obtained during each campaign. Our goal was to observe as many events as possible. Two observations of each event are needed to eliminate observational errors.

Since there is no thick atmosphere around the Galilean satellites, the photometric observations of such phenomena are very accurate for astrometric purposes. The results previously obtained after similar observations of the Galilean satellites (Arlot et al. 1997) show that an accuracy better than 30 mas can be expected.

This allows us to provide data necessary for the improvement of theoretical models of orbital motion and the determination of tide effects in the dynamics of Galilean satellites.

3. The PHEMU97 campaign

The observation of these phenomena required a coordinated international campaign in order to obtain a significant amount of data. These events occur over a short span of time so numerous observers located at several sites are necessary in order to avoid meteorological problems and observe from different longitudes to record different events. Thus observers previously involved in the PHEMU campaigns of observations of the mutual events of the Galilean satellites were invited to join the new campaign.

3.1. Receivers

For the observations of the mutual events only relative photometry is generally possible. Since the elevation of Jupiter above the horizon may be very small, the air mass is often too large and absolute photometry is not possible. The telescopes were equipped with the receivers listed in Table 2. Three kinds of receivers were used: photoelectric photometric single channel receivers, video cameras and two-dimensional CCD receivers. Visual observations are reported for comparison.

3.2. Sites of observation

This campaign, coordinated by the Institut de Mécanique Céleste, involved the different locations given in Table 3. This table gives the names, longitudes and latitudes of these sites.

4. Lightcurve reduction procedure

Lightcurves were derived from photometric measurements either with relative photometry performed with photoelectric photometers or with CCD cameras.

For observations made with CCD cameras in video mode the digitized signal was computed with digitizing boards. The lightcurves were obtained by aperture photometry, as were the observations for which a value of the diaphragm is provided. For CCD observations made in France, images were measured with the Gaussian photometry package of the ASTROL software (Colas 1996). Two dimensional measurements allow us to calibrate the signal of the satellite involved to the signal of a nearby satellite and to use data obtained under very difficult conditions (see for example Arlot et al. 1997).

The determination of the time of the minimum of light and of the value of the magnitude drop was based on a fit of the lightcurve with a sample polynomial. The errors in these determinations are also given. The error on the timing of the minimum is determined as follows: we calculate the noise in magnitude and transform it into a time error through the highest value of the decreasing speed in magnitude during the event. The largest errors occur for faint noisy events and the smallest for the fast ones. The errors are comparable only if the integration time is the same.

5. The catalogue

5.1. The data

Table 4 provides for each event (all dates are in UTC):

- prediction of the time of the event:

1. Date of the event and its nature;
2. Start time of the event;
3. Maximum of the event;
4. End of the event;
5. Calculated magnitude drop;
6. Phase angle in degrees;
7. Apparent distance satellite-planet in planetary radii.

-for each observation of the event:

1. The site of observation;
2. -
3. The observed time of the maximum of magnitude drop and observational error;
4. -
5. The observed magnitude drop and observational error;
6. -
7. -
8. (C–O) of the observation in seconds of time; these quantities take into account the phase effect (Aksnes et al. 1986);
9. Aperture of the telescope in centimeters (T = reflector; L = refractor);
10. Code of the receiver used in column "Recept." (cf. Table 2);
11. Elevation of Jupiter above the horizon in degrees;
12. Elevation of the Sun above the horizon in degrees;
13. The observational conditions in column "Obs. cond.": [0] means no information, [1] means very good conditions, [2] means acceptable and [3] very difficult conditions;
14. The filter used, if any, in column "Filter"; no filter used is denoted by "-";
15. The integration time of the measurements in seconds; a variable integration time is denoted "v";
16. Size of the diaphragm when used.

Table 2. Receivers used for the observations.

Code as given in the tables	Description	reference
VISU	Visual	BARCELONA, CATANIA2 (06-07-1997),CATANIA3 (03-08-1997) LUMEZZANE (18-09-1997),MILANO,SEVILLA,MADRID
	Single channel receivers	
PM	EMI9893	CATANIA1 (Blanco)
PM1	Photoelectric lp21	LUMEZZANE
PM2	Photometer (RCA 4840)	PARIS
PM3	Hamamatsu R647-04	FUNAHO,OKAYAMA
PM4	RCA931A	SAN-FERNANDO
PM5	UBV (Shugarov)	NAUCHNY (07-10)
PM6	Optec SSP3 Pin-Diode	ESSEN
PMW	Photometer WBVR	NAUCHNY
PMIR	Photometer IR	TENERIFE
PM7	Teloc II B channel photometric system	(CALERN)
PM7	Teloc II V channel photometric system	(CALERN)
PM7	Teloc II R channel photometric system	(CALERN)
	Video receivers	
V	Video OS25 (18-06)	PRAHA
V1	Video OS45D	PRAHA
V2	Ikegama B/W camera ICD-42E TypeF	WILP-ACHTERHOEK
V3	CCD MKII in video mode	MEUDON
	CCD receivers	
CCD	Starlight SX Xpress	CACERES,ZARAGOZA
CCD1	TH7863	BORDEAUX,OHP
CCD2	TC-211	BOWIE,ELLINBANK,NEW-YORK,SASSOEIROS,TORINO
CCD3	IRAC2	ESO
CCD4	SPT-M102CE Sony B/W	LISBOA
CCD5	NXA 1001/03	REUX
CCD6	VC100-camera B/W	COMTHUREY
CCD7	CCD B/W camera	OOSTDUINKERKE
CCD8	KAF-6300 KODAK	UKKEL
CCD10	Hi-SIS11	CHATEAUGIRON
CCD11	LYNX CCD camera 192x168 pixel-chip	STUTTGART
CCD12	0.01 lux CCD video camera	TOPEKA
CCDI	Hisis-22	BUCHAREST1 (Vass),PIC-DU-MIDI
CCDL	LYNX PC	ASHEVILLE
CCDM	TC245 (IOC)	MUNICH
CCDS	Chip CCD Sony	RAGUSA
CCDW	Wright 1024x1024	TENERIFE
CCDST	ST-6V SBIG	ALMA-ATA,BUCHAREST2 (Stefanescu)
CCDVX	HCS MXRII	BOSKOOP
CCDC	Thomson-CSF 7862 CDA chip (photometrics CCD system)	KAVALUR

For each observation, a corresponding lightcurve is provided in Figs. 1 to 33 showing the magnitude drop versus UTC time scale.

These data and light-curves are available at the Natural Satellite Data Center (NSDC) server (`http://www.imcce.fr/nsdc`).

5.2. Discussion

This catalogue provides observational information and reduced data issued from the PHEMU97 campaign. Another paper (Vasundhara et al. 2003) provides the astrometric data extracted from the lightcurves.

The quality of each lightcurve may be judged either by the value of the errors on the determined parameters (time of the minimum of light and lightflux drop) or the appearance of the lightcurve itself.

As for the previous catalogues of such events, we computed the errors on the determined parameter as follows. The error on the lightflux drop is deduced from the standard deviation of the fit to the model light curve. The error on the date of the minimum is determined from the error on the magnitude drop combined with the speed of the decrease of the lightflux

Table 3. Main sites of observation.

Main observatories	Telescope diameter in cm	Longitude				Latitude				elevation
		°	′	″		°	′	″		meters
ASHEVILLE (USA)	T20	82	25	45	W	35	36	00	N	670
ALMA-ATA (Kazakhstan)	T60	77	52	45	E	43	13	20	N	2750
BARCELONA (Spain)	T16	02	12	07	E	41	25	18	N	40
BORDEAUX (France)	T62	00	32	00	W	44	50	00	N	73
BOSKOOP (The Netherlands)	T30	04	41	35	E	52	04	35	N	0
BOWIE (USA)	T20	76	48	00	W	39	00	00	N	50
BUCAREST (Romania)	L38	26	05	46	E	44	24	50	N	86
CACERES (Spain)	T25	06	23	00	W	39	27	00	N	440
CALERN, OCA/CERGA (France)	T150	06	55	18	E	43	45	17	N	1282
CATANIA1 (Italy)	T91	14	58	45	E	37	41	30	N	1725
CATANIA2 (Italy)	T20	15	03	20	E	37	39	43	N	300
CATANIA3 (Italy)	T20	14	57	40	E	37	39	43	N	1250
CHATEAUGIRON (France)	T21	01	30	01	O	48	02	41	N	70
COMTHUREY (Germany)	L18	13	11	31	E	53	16	04	N	150
ELLINBANK (Australia)	T32	145	57	30	E	38	14	47	S	138
ESO, La Silla (Chile)	T220	70	43	45	W	29	15	26	S	2200
ESSEN (Germany)	T36	07	04	15	E	41	24	35	N	40
FUNAHO (Japan)	T28	33	42	43	E	34	34	43	N	8
KAVALUR (India)	T235	78	49	49	E	12	34	49	N	725
LISBOA (Portugal)	T20	09	07	42	W	38	43	30	N	96
LUMEZZANE (Italy)	T40	09	08	22	E	45	28	11	N	122
MADRID (Spain)	—	03	49	09	W	40	17	49	N	680
MEUDON (France)	T100	02	14	00	E	48	48	00	N	162
MILAN (Italy)	L08	09	07	22	E	45	27	19	N	138
MUNCHEN (Germany	T28	11	34	30	E	48	11	17	N	520
NAUCHNY (Crimea)	T60	34	01	00	E	44	43	37	N	600
NEW-YORK (USA)	T20	78	00	00	W	43	00	00	N	200
OHP, Haute-Provence Obs. (France)	T80	05	43	00	E	43	56	00	N	665
OKAYAMA (Japan)	T35	33	52	36	E	34	36	25	N	3
OOSTDUINKERKE (Belgium)	T25	02	40	45	E	51	06	48	N	4
PIC-DU-MIDI, OMP (France)	T105	00	09	00	E	42	56	00	N	2861
PARIS (France)	L38	02	20	00	E	48	50	00	N	67
PRAHA (Czech Republic)	L15	14	28	41	E	50	08	30	N	325
RAGUSA (Italy)	T20	14	39	43	E	36	46	15	N	25
REUX (Belgium)	T30	05	05	27	E	50	14	43	N	317
SAN FERNANDO (Spain)	T33	06	12	21	W	36	27	40	N	30
SASSOEIROS (Portugal)	T25	09	19	34	W	38	42	01	N	64
SEVILLA (Spain)	T21	05	58	47	W	37	23	40	N	50
TENERIFE (Canarian Islands)	T20	16	30	38	W	28	17	45	N	2374
STUTTGART (Germany)	T30	09	08	15	E	48	42	00	N	441
TOPEKA (USA)	L38	95	44	58	W	39	00	03	N	313
TORINO (Italy)	T15	07	38	10	E	45	02	51	N	622
UCCLE (Belgium)	T85	04	21	29	E	50	47	55	N	105
WILP-ACHTERHOEKE (The Netherlands)	T20	06	03	52	E	52	12	29	N	6
ZARAGOZA (Spain)	T15	00	52	30	W	41	38	46	N	247

during the event. This explains that this error depends on the number of points, on the integrating time and on the depth of the light curve. Because of that, the error bars may be compared only between events recorded with the same time constants and, preferably, with the same equipment in order to obtain the observational error and a measurement of the quality of the observation.

6. Conclusion

We give in this paper the results of the PHEMU97 campaign. To record the maximum of events, it was necessary to organize an international campaign. The phenomena recorded occur every 6 years and they lead to very accurate astrometric measurements which are very difficult to obtain with ground-based techniques. Such data may allow us to determine surface parameters by comparison of lightcurves with synthetic models.

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[34] IIA, Bangalore, India

[35] Madrid, Spain

[36] OAIN, Scicli, Ragusa, Italy

[37] Topeka, Kansas, USA

[38] Ellinbank, Australia

[39] Farmington, New-York, USA

[40] GAC, Catania, Italy

[41] Barcelona, Spain

[42] Bowie, Maryland, USA

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[44] Tokyo, Japan

Online Material

Table 4. Observed data.

Dates Phenomena Locations (1)	Begins h m s (2)	Maxi. h m s (3)	Ends h m s (4)	Magn. drop (5)	Ph. (s) (6)	Dist. (Rj) (7)	C-O (s) (8)	Ap. (cm) (9)	Rec. (10)	El. Jup. (°) (11)	El. Sun (°) (12)	Cd. (13)	Filt. (14)	T. int. (s) (15)	Dia. ('') (16)
96/ 6/ 8 **1 O2(P)**	1 38 51	1 48 32	1 58 33	.040	–14.2	2.0									
OHP		1 50 6 ± 199		.111 ± .067			–94	T 80.	CCD1	24	–17	3	-	-	-
97/ 4/24 **4 O2(T)**	3 52 31	3 55 48	3 59 6	.295	5.7	4.4									
BORDEAUX		3 55 59 ± 6		1.346 ± .067			–11	T 62.	CCD1	14	–11	2	*R*	2.	-
OHP		3 55 56 ± 4		1.289 ± .064			–8	T 80.	CCD1	18	–8	2	I	1.	-
ZARAGOZA		3 55 57 ± 14		.817 ± .159			–9	T 15.	CCD	11	–18	1	-	10.	-
MADRID		3 56 21 ± 3		5.548 ± .245			–33	T 0.	VISU	15	–16	1	-	-	-
MUNICH		3 56 1 ± 15		1.225 ± .208			–13	T 28.	CCDM	17	–2	1	*4	-	-
97/ 4/25 **4 O3(P)**	2 43 49	3 15 39	3 48 19	.187	–87.5	5.3									
OHP		3 16 17 ± 443		.367 ± .129			–38	T 80.	CCD1	13	–14	3	I	2.	-
CATANIA		3 19 45 ± 102		.038 ± .005			122	T 91.	PM	22	–11	2	*V*	0.1	21.
97/ 5/ 2 **2 E1(p)**	22 36 46	22 38 28	22 40 12	.028	–3.3	4.9									
KAVALUR		22 38 1 ± 35		.044 ± .022			28	T 102.	CCDC	39	–25	3	*3	-	
97/ 5/12 **4 O3(P)**	2 33 38	2 37 39	2 41 40	.166	10.8	6.9									
BOSKOOP		2 37 36 ± 119		.119 ± .102			3	T 30.	CCDVX	11	–10	2	-	0.04	-
MUNICH		2 37 34 ± 36		.301 ± .104			5	T 28.	CCDM	20	–7	2	*4	-	-
97/ 5/13 **2 O3(A)**	2 20 15	2 23 29	2 26 44	.479	9.6	5.6									
RAGUSA		2 33 4 ± 38		.280 ± .076			–575	T 25.	CCDS	25	–16	2	*V*	0.2	-
97/ 5/15 **3 O1(P)**	20 57 6	21 0 8	21 3 10	.152	7.3	4.8									
KAVALUR		20 59 45 ± 3		.207 ± .006			23	T 235.	CCDC	28	–43	1	*3	2.	-
97/ 5/21 **3 O4(P)**	8 26 26	8 44 27	9 2 5	.279	39.6	14.6									
ASHEVILLE		8 43 28 ± 62		.168 ± .026			59	T 20.	CCDL	29	–17	2	*V*	0.5	20.
97/ 5/29 **1 E2(P)**	1 6 58	1 9 50	1 12 42	.809	–4.8	5.8									
LUMEZZANE		1 11 0 ± 10		.477 ± .087			–70	T 40.	PM1	15	–18	3	*V*	0.5	-
BOOSKOOP		1 10 2 ± 9		1.641 ± .377			–12	T 30.	CCDVX	8	–14	2	-	0.04	-
MUNICH		1 10 4 ± 4		1.945 ± .156			–14	T 28.	CCDM	13	–15	1	*4	-	-
97/ 5/29 **3 O2(P)**	23 3 16	23 6 60	23 10 44	.228	6.7	7.6									
KAVALUR		23 7 3 ± 2		.566 ± .009			–3	T 235.	CCDC	60	–16	1	*3	2.	-
97/ 5/30 **3 O1(T)**	3 0 18	3 5 18	3 10 22	.321	10.1	5									
PARIS		3 5 15 ± 59		.358 ± .122			3	L 38.	PM2	22	–7	2	*V*	0.3	-
RAGUSA		3 5 45 ± 14		.962 ± .157			–27	T 25.	CCDS	36	–7	1	*R*	0.2	-
TORINO		3 5 28 ± 4		.551 ± .210			–10	T 15.	CCD2	27	–6	2	-	3-6	-
BORDEAUX		3 5 14 ± 16		.728 ± .064			4	T 62.	CCD1	14	–11	2	*R*	3-2	-
OHP		3 5 17 ± 6		.665 ± .033			1	T 80.	CCD1	27	–8	1	-	-	-
97/ 5/31															

Table 4. continued.

Dates Phenomena Locations (1)	**Begins h m s (2)**	**Maxi. h m s (3)**	**Ends h m s (4)**	**Magn. drop (5)**	**Ph. (s) (6)**	**Dist. (Rj) (7)**	**C-O (s) (8)**	**Ap. (cm) (9)**	**Rec. (10)**	**El. Jup. (°) (11)**	**El. Sun (°) (12)**	**Cd. (13)**	**Filt. (14)**	**T. int. (s) (15)**	**Dia. ('') (16)**
3 O1(P)	0 19 39	0 30 14	0 40 8	.150	17.6	5.8									
STUTTGART		0 30 6 ± 75		.219 ± .053			8	T 30.	CCD3	8	–18	2	*R*	3-1	-
RAGUSA		0 27 6 ± 66		.429 ± .097			188	T 25.	CCDS	18	–27	2	*V*	0.2	-
MUNICH		0 30 42 ± 220		.227 ± .192			–28	T 28.	CCDM	9	–18	2	*4	-	-
97/ 6/ 6 **3 O2(P)**	2 15 10	2 18 49	2 22 28	.176	6.8	7.9									
TENERIFE		2 19 21 ± 1		.430 ± .003			–32	T 80.	CCDW	24	–36	0	*B*	5.	-
BORDEAUX		2 19 3 ± 9		.431 ± .028			–14	T 62.	CCD1	22	–15	2	*R*	3.	-
97/ 6/ 7 **3 O1(P)**	4 26 41	4 32 42	4 38 36	.239	9.9	5.9									
TENERIFE		4 32 29 ± 8		.365 ± .017			13	T 80.	CCDW	44	–18	0	*B*	1.	-
97/ 6/18 **2 E1(A)**	1 2 15	1 4 44	1 7 14	.647	–4.0	3									
OCA		1 4 35 ± 3		.834 ± .044			9	T 150.	PM7	23	–20	0	*B*	0.2	-
OCA		1 4 42 ± 3		.962 ± .048			2	T 150.	PM7	23	–20	0	*V*	0.2	-
OCA		1 4 36 ± 4		.956 ± .072			8	T 150.	PM7	23	–20	0	*R*	0.2	-
PRAHA		1 4 43 ± 10		.550 ± .208			1	L 15.	V	21	–12	3	-	0.02	-
CATANIA		1 4 45 ± 2		.103 ± .004			–1	T 91.	PM	32	–22	2	*V*	0.1	-
BOSKOOP		1 4 49 ± 21		.792 ± .352			–5	T 30.	CCDVX	16	–12	0	-	-	-
LISBOA		1 4 39 ± 10		1.155 ± .292			5	T 20.	CCD4	28	–24	0	-	-	-
BORDEAUX		1 4 46 ± 5		1.087 ± .085			–2	T 62.	CCD1	19	–20	2	*R*	0.2	-
97/ 6/19 **1 E2(P)**	7 53 56	7 56 57	7 59 58	.576	–4.6	6.1									
TOPEKA		7 57 19 ± 199		.055 ± .001			22	L 38.	CCD12	27	–23	1	-	-	-
97/ 6/22 **1 E2(P)**	21 2 36	21 5 35	21 8 34	.468	–4.4	6.1									
ALMA-ATA		21 5 50 ± 4		.755 ± .048			–15	T 60.	CCDST	29	–16	2	-	0.8	-
97/ 6/25 **2 E1(A)**	3 14 42	3 17 9	3 19 36	.640	–3.6	3.2									
TENERIFE		3 17 9 ± 1		1.105 ± .000			0	T 80.	CCDW	43	–30	0	*B*	1.	-
SEVILLA		3 17 17 ± 40		.848 ± .113			–8	T 21.	VISU	37	–17	1	-	-	-
LISBOA		3 17 8 ± 8		.781 ± .145			1	T 20.	CCD4	36	–8	0	-	0.04	-
OHP		3 17 9 ± 1		1.155 ± .024			0	T 80.	CCD1	31	–6	1	-	-	-
97/ 6/28 **2 E1(A)**	16 20 54	16 23 19	16 25 44	.601	–3.4	3.0									
ELLINBANK		16 23 16 ± 2		1.004 ± .043			3	T 32.	CCD2	35	–22	2	*V*	1.5	-
97/ 6/29 **1 E2(P)**	23 20 31	23 23 22	23 26 14	.272	–3.7	6.1									
STUTTGART		23 23 17 ± 11		.368 ± .068			5	T 30.	CCD3	14	–18	0	*R*	4.	-
BUCHAREST1		23 23 29 ± 5		.384 ± .044			–7	L 38.	CCDI	25	–21	3	*GG*	1.5	-
BUCHAREST2		23 23 28 ± 19		.338 ± .070			–6	T 50.	CCDST	25	–21	1	*V*	2.	-
97/ 6/30 **4 E2(p)**	5 34 55	5 39 35	5 44 14	.546	–3.7	2.4									
NEW-YORK		5 39 48 ± 5		.833 ± .050			–13	T 20.	CCD2	22	–24	2	*V*	3.	-
97/ 7/ 2															

Table 4. continued.

Dates Phenomena Locations (1)	**Begins h m s (2)**	**Maxi. h m s (3)**	**Ends h m s (4)**	**Magn. drop (5)**	**Ph. (s) (6)**	**Dist. (Rj) (7)**	**C-O (s) (8)**	**Ap. (cm) (9)**	**Rec. (10)**	**El. Jup. (°) (11)**	**El. Sun (°) (12)**	**Cd. (13)**	**Filt. (14)**	**T. int. (s) (15)**	**Dia. ('') (16)**
2 E1(A)	5 27 3	5 29 25	5 31 47	.539	–3.1	2.8									
TOPEKA		5 30 48 ± 35		.030 ± .008			83	L 38.	CCD12	14	–27	1	-	-	-
97/ 7/ 4 **3 O2(P)**	14 39 24	14 43 24	14 47 25	.123	5.5	8.7									
OKAYAMA		14 43 28 ± 29		.249 ± .061			–4	T 35.	PM3	23	–32	1	*V*	0.2	40.
97/ 7/ 5 **3 O1(T)**	15 57 42	16 1 4	16 4 24	.321	3.6	4.4									
ELLINBANK		16 0 58 ± 4		.532 ± .026			6	T 32.	CCD2	35	–25	2	*V*	1.	-
97/ 7/ 6 **3 E4(P)**	22 18 18	22 32 40	22 47 11	.547	–15.3	17.3									
CATANIA2		22 33 36 ± 18		.318 ± .023			–56	T 20.	VISU	22	–29	2	-	-	-
SEVILLA		22 34 24 ± 50		1.269 ± .530			–104	T 21.	VISU	9	–24	1	-	-	-
TORINO		22 32 50 ± 36		.796 ± .077			–10	T 15.	CCD2	14	–21	2	-	5.	-
97/ 7/ 7 **1 E2(p)**	1 39 36	1 42 14	1 44 52	.116	–2.7										
TENERIFE		1 42 33 ± 0		.156 ± .000			–19	T 80.	CCDW	38	–39	0	*B*	1.	-
SAN-FERN.		1 42 33 ± 62		.227 ± .377			–19	T 33.	PM4	35	–28	0	-	-	-
LISBOA		1 42 21 ± 20		.153 ± .046			–7	T 25.	CCD2	32	–27	0	-	-	-
BORDEAUX		1 42 31 ± 19		.126 ± .030			–17	T 62.	CCD1	29	–19	2	*R*	-	-
97/ 7/ 9 **2 E3(p)**	0 13 3	0 16 22	0 19 41	.095	–3.7	1.5									
SEVILLA		0 17 41 ± 21		.017 ± .002			–79	T 21.	VISU	26	–30	1	-	-	-
REUX		0 16 27 ± 193		.043 ± .269			–5	T 30.	CCD5	20	–17	0	-	0.04	-
97/ 7/12 **2 E1(P)**	20 45 35	20 47 45	20 49 53	.297	–2.2	2.3									
KAVALUR		20 47 43 ± 3		.254 ± .012			1	T 235.	CCDC	62	–45	1	*3	-	-
97/ 7/15 **1 O3(P)**	18 55 42	18 58 12	19 0 42	.169	3.5	3.1									
ALMA-ATA		18 56 6 ± 14		.132 ± .025			126	T 60.	CCDST	26	–25	2	-	0.8	-
97/ 7/16 **2 E3(A)**	3 25 16	3 28 57	3 32 37	.208	–3.4	1.5									
TENERIFE		3 28 58 ± 5		.214 ± .013			–1	T 80.	CCDW	45	–30	0	*B*	1.	-
SAN-FERN.		3 30 8 ± 4		2.153 ± .443			–71	T 33.	PM4	35	–18	0	-	-	-
97/ 7/18 **3 E2(p)**	18 51 31	18 56 37	19 1 43	.240	–3.1	8.6									
ALMA-ATA		18 56 44 ± 21		.222 ± .033			–6	T 60.	CCDST	27	–26	0	2	0.8	
KAVALUR		18 56 55 ± 5		.232 ± .010			–17	T 102.	CCDC	54	–56	0	1 *3	-	
97/ 7/18 **3 O2(P)**	20 42 49	20 47 48	20 52 48	.182	4.1	9.1									
TORINO		20 48 46 ± 4		1.325 ± .028			–58	T 15.	CCD2	6	–14	0	2	3.5	
ALMA-ATA		20 47 55 ± 7		.390 ± .018			–7	T 60.	CCDST	31	–21	0	2	0.5	
97/ 7/19 **3 O1(P)**	20 56 28	20 59 23	21 2 17	.293	2.1	3.4									
TORINO		20 59 17 ± 10		.977 ± .102			6	T 15.	CCD2	8	–16	0	2	2.	-
ALMA-ATA		20 59 15 ± 5		.520 ± .036			8	T 60.	CCDST	30	–20	0	2	0.5	-
OHP		20 59 15 ± 11		.620 ± .078			8	T 80.	CCD1	23	–25	0	2	-	-

Table 4. continued.

Dates Phenomena Locations (1)	**Begins h m s (2)**	**Maxi. h m s (3)**	**Ends h m s (4)**	**Magn. drop (5)**	**Ph. (s) (6)**	**Dist. (Rj) (7)**	**C-O (s) (8)**	**Ap. (cm) (9)**	**Rec. (10)**	**El. Jup. (°) (11)**	**El. Sun (°) (12)**	**Cd. (13)**	**Filt. (14)**	**T. int. (s) (15)**	**Dia. ('') (16)**
97/ 7/19 2 E1(p)	22 57 57	22 59 54	23 1 50	.149	–1.4	1.9									
REUX		23 0 8 ± 112		.115 ± .313			–14	T 30.	CCD5	17	–18	0	-	0.04	-
BORDEAUX		22 59 22 ± 49		.087 ± .069			33	T 62.	CCD1	19	–23	0	*R*	0.5	-
97/ 7/23 2 E3(A)	6 37 43	6 41 35	6 45 27	.313	–2.7	1.4									
TOPEKA		6 40 56 ± 151		.042 ± .017			0	L 38.	CCD12	33	–31	0	1	-	-
97/ 7/24 1 E4(p)	18 15 11	18 21 30	18 27 55	.000	–3.6	6.7									
ALMA-ATA		18 21 29 ± 21		.247 ± .038			1	T 60.	CCDST	26	–27	0	2	0.5	-
97/ 7/25 1 E4(A)	20 45 0	20 52 2	20 58 58	.300	–3.6	4.2									
NAUCHNY		20 51 50 ± 20		.396 ± .059			12	T 60.	PMW	23	–24	0	2 *V*	-	35.
ALMA-ATA		20 51 37 ± 13		.470 ± .039			25	T 60.	CCDST	30	–22	0	2	0.5	-
OHP		20 51 27 ± 43		.431 ± .120			35	T 80.	CCD1	9	–15	0	2	-	-
97/ 7/25 3 E2(P)	22 25 55	22 31 4	22 37 25	.330	–2.5	8.9									
SEVILLA		22 32 43 ± 10		.806 ± .050			–63	T 21.	VISU	21	–27	0	1	-	-
CATANIA		22 32 3 ± 29		.036 ± .006			–23	T 91.	PM	31	–32	0	1 *V*	0.1	21.
ALMA-ATA		22 32 0 ± 36		.321 ± .090			–20	T 60.	CCDST	21	–10	0	2	0.5	-
OCA		22 32 17 ± 22		.181 ± .063			–37	T 150.	PM7	23	–25	0	*B*	0.2	-
OCA		22 32 7 ± 19		.543 ± .141			–27	T 150.	PM7	23	–25	0	*R*	0.2	-
OCA		22 32 24 ± 23		.184 ± .071			–44	T 150.	PM7	23	–25	0	*V*	0.2	-
BUCHAREST1		22 31 59 ± 23		.302 ± .049			–19	L 38.	CCDI	28	–26	0	1 *GG*	1.	-
LISBOA		22 31 48 ± 69		.319 ± .253			–8	T 25.	CCD2	19	–24	0	-	-	-
OHP		22 32 18 ± 15		.453 ± .044			–38	T 80.	CCD1	22	–25	0	2	-	-
97/ 7/25 3 O2(P)	23 44 18	23 49 56	23 55 36	.228	2.9	9.2									
LUMEZZANE		23 50 23 ± 20		.484 ± .060			–27	T 40.	PM1	28	–25	0	*V*	0.01	-
NAUCHNY		23 50 6 ± 14		.459 ± .039			–10	T 60.	PMW	28	–20	0	1 *V*	-	35.
OCA		23 50 42 ± 14		.651 ± .055			–46	T 150.	PM7	29	–27	0	*B*	0.2	-
OCA		23 51 10 ± 16		1.032 ± .203			–74	T 150.	PM7	29	–27	0	*R*	0.2	-
OCA		23 50 49 ± 17		.643 ± .060			–53	T 150.	PM7	29	–27	0	*V*	0.2	-
SAN-FERN.		23 50 13 ± 50		.476 ± .163			–17	T 33.	PM4	32	–33	0	-	-	-
BOSKOOP		23 50 7 ± 53		.341 ± .108			–11	T 30.	CCDVX	21	–18	0	-	0.04	-
LISBOA		23 50 11 ± 31		.441 ± .066			–15	T 25.	CCD2	29	–31	0	-	-	-
OHP		23 51 29 ± 7		.466 ± .019			–93	T 80.	CCD1	29	–27	0	1	-	-
97/ 7/26 3 E4(p)	1 47 40	1 52 51	1 57 59	.067	–2.3	6.2									
CATANIA		1 54 17 ± 271		.002 ± .004			–86	T 91.	PM	31	–21	0	1 *V*	0.1	21.
97/ 7/26 3 O1(P)	23 20 33	23 23 21	23 26 8	.296	1.3	3.0									
CATANIA		23 23 17 ± 5		.038 ± .002			4	T 91.	PM	35	–33	0	2 *V*	0.1	21.
OCA		23 24 19 ± 15		.558 ± .119			–58	T 150.	PM7	28	–27	0	*B*	0.2	-
OCA		23 24 18 ± 6		.691 ± .132			–57	T 150.	PM7	28	–27	0	*R*	0.2	-
OCA		23 24 13 ± 7		.749 ± .112			–52	T 150.	PM7	28	–27	0	*V*	0.2	-
SAN-FERN.		23 23 16 ± 30		.438 ± .166			5	T 33.	PM4	29	–32	0	-	-	-

Table 4. continued.

Dates Phenomena Locations (1)	**Begins h m s (2)**	**Maxi. h m s (3)**	**Ends h m s (4)**	**Magn. drop (5)**	**Ph. (s) (6)**	**Dist. (Rj) (7)**	**C-O (s) (8)**	**Ap. (cm) (9)**	**Rec. (10)**	**El. Jup. (°) (11)**	**El. Sun (°) (12)**	**Cd. (13)**	**Filt. (14)**	**T. int. (s) (15)**	**Dia. ('') (16)**
OHP		23 23 9 ± 4		.533 ± .027			12	T 80.	CCD1	27	–27	0	1	-	-
97/ 7/27 2 E1(p)	1 10 26	1 12 3	1 13 41	.050	–.8	1.5									
SEVILLA		1 12 40 ± 18		.194 ± .022			–37	T 21.	VISU	36	–32	0	1	-	-
97/ 7/29 1 E3(p)	23 8 44	23 11 26	23 14 7	.035	–1.1	4.4									
TENERIFE		23 11 39 ± 21		.034 ± .008			–13	T 150.	PMIR	30	–35	0	*K*	2.5	20.
SEVILLA		23 10 55 ± 3		.327 ± .012			31	T 21.	VISU	29	–31	0	1	-	-
97/ 7/29 1 O3(P)	23 46 47	23 49 40	23 52 34	.206	1.8	4.1									
TENERIFE		23 49 58 ± 21		.118 ± .026			–18	T 150.	PMIR	36	–39	0	*K*	2.5	20.
CATANIA		23 49 24 ± 11		.016 ± .002			16	T 91.	PM	36	–33	0	2 *V*	0.1	21.
BUCHAREST1		23 49 41 ± 19		.231 ± .055			–1	L 38.	CCDI	29	–24	0	3 *GG*	0.5	-
BOSKOOP		23 49 23 ± 41		.112 ± .065			17	T 30.	CCDVX	21	–19	0	-	0.04	-
REUX		23 50 2 ± 48		.336 ± .144			–22	T 30.	CCD5	23	–21	0	-	0.04	-
COMTHUREY		23 49 24 ± 62		.217 ± .131			16	L 18.	CCD6	20	–18	0	2	0.04	-
OHP		23 49 42 ± 14		.193 ± .032			–2	T 80.	CCD1	29	–28	0	1	-	-
97/ 8/ 1 4 E3(A)	0 5 56	0 20 50	0 35 52	.601	–4.7	14.									
BARCELONA		0 21 15 ± 11		6.516 ± .495			–25	T 16.	VISU	32	–30	0	2	-	-
TENERIFE		0 20 45 ± 2		.926 ± .006			5	T 150.	PMIR	40	–42	0	*K*	4.	20.
SEVILLA		0 21 30 ± 15		2.210 ± .146			–40	T 21.	VISU	35	–35	0	1	-	-
CATANIA		0 20 54 ± 10		.079 ± .003			–4	T 91.	PM	35	–31	0	2 *V*	0.1	21.
SAN-FERN.		0 20 34 ± 68		.163 ± .280			16	T 33.	PM4	36	–35	0	-	-	-
LISBOA		0 20 17 ± 38		.936 ± .124			33	T 25.	CCD2	33	–33	0	-	-	-
OHP		0 21 7 ± 8		.947 ± .025			–17	T 80.	CCD1	30	–27	0	1	-	-
97/ 8/ 1 4 E2(p)	20 6 24	20 11 34	20 16 42	.191	–1.1	7.5									
KAVALUR		20 11 49 ± 3		.193 ± .004			–15	T 235.	CCDC	59	–54	0	1 *3	4.	-
97/ 8/ 2 3 E2(P)	2 4 40	2 11 6	2 17 31	.393	–1.5	9.2									
SEVILLA		2 13 46 ± 0		.541 ± .001			–161	T 21.	VISU	34	–30	0	1	-	-
TENERIFE		2 12 2 ± 37		.012 ± .005			–57	T 150.	PMIR	45	–42	0	*K*	4.	20.
CATANIA		2 11 9 ± 27		.046 ± .010			–4	T 91.	PM	25	–19	0	2 *V*	0.1	21.
97/ 8/ 2 3 O2(T)	2 46 44	2 53 4	2 59 27	.259	1.6	9.3									
TENERIFE		2 53 3 ± 24		.330 ± .042			1	T 150.	PMIR	42	–38	0	*K*	4.	20.
OCA		2 53 5 ± 23		.608 ± .056			–1	T 150.	PM7	19	–14	0	*B*	0.2	-
OCA		2 51 27 ± 37		.452 ± .232			97	T 150.	PM7	19	–24	0	*R*	0.2	-
OCA		2 52 55 ± 27		.600 ± .084			9	T 150.	PM7	19	–24	0	*V*	0.2	-
SAN-FERN.		2 54 30 ± 178		.164 ± .077			–86	T 33.	PM4	31	–26	0	-	-	-
CATANIA		2 53 14 ± 37		.590 ± .102			–10	T 91.	PM	19	–13	0	2 *V*	0.1	28.
OHP		2 53 20 ± 14		.512 ± .042			–16	T 80.	CCD1	20	–14	0	1	-	-
97/ 8/ 3 4 E1(A)	0 0 17	0 5 3	0 9 48	.770	–.8	3.7									
TENERIFE		0 5 2 ± 1		1.556 ± .013			1	T 150.	PMIR	40	–41	0	*K*	4.	20.

Table 4. continued.

Dates Phenomena Locations (1)	**Begins h m s (2)**	**Maxi. h m s (3)**	**Ends h m s (4)**	**Magn. drop (5)**	**Ph. (s) (6)**	**Dist. (Rj) (7)**	**C-O (s) (8)**	**Ap. (cm) (9)**	**Rec. (10)**	**El. Jup. (°) (11)**	**El. Sun (°) (12)**	**Cd. (13)**	**Filt. (14)**	**T. int. (s) (15)**	**Dia. (") (16)**
PRAHA		0 4 56 ± 12		.901 ± .107			7	T 30.	V1	23	–21	0	2	0.02	-
CATANIA2		0 5 9 ± 6		1.410 ± .080			–6	T 20.	VISU	35	–33	0	2	-	-
CATANIA		0 5 3 ± 7		.528 ± .079			0	T 91.	PM	35	–33	0	2 *V*	0.1	21.
NAUCHNY		0 5 3 ± 4		1.414 ± .066			0	T 60.	PMW	24	–20	0	*V*	-	35.
OCA		0 4 56 ± 4		1.163 ± .060			7	T 150.	PM7	30	–28	0	*B*	0.2	-
OCA		0 5 7 ± 5		1.457 ± .084			–4	T 150.	PM7	30	–28	0	*R*	0.2	-
OCA		0 5 1 ± 9		1.475 ± .166			2	T 150.	PM7	30	–28	0	*V*	0.2	-
COMTHUREY		0 5 5 ± 23		1.911 ± .404			–2	L 18.	CCD6	20	–18	0	2	0.04	-
97/ 8/ 3 3 O1(P)	1 42 20	1 45 4	1 47 48	.311	.6	2.5									
BOSKOOP		1 44 54 ± 28		.273 ± .094			10	T 30.	CCDVX	19	–16	0	-	-	-
97/ 8/ 6 1 O3(P)	2 14 14	2 17 26	2 20 40	.245	.7	4.5									
TENERIFE		2 17 29 ± 2		.169 ± .004			–3	T 150.	PMIR	44	–42	0	*K*	4.	20.
OCA		2 17 42 ± 12		.332 ± .049			–16	T 150.	PM7	21	–19	0	*B*	0.2	-
OCA		2 16 36 ± 71		.184 ± .050			50	T 150.	PM7	21	–19	0	*R*	0.2	-
OCA		2 17 35 ± 20		.412 ± .077			–9	T 150.	PM7	21	–19	0	*V*	0.2	-
MUNICH		2 17 13 ± 31		.257 ± .118			13	T 28.	CCDM	16	–14	0	2 *4	-	-
97/ 8/10 3 O1(T)	4 2 52	4 5 34	4 8 16	.320	–.1	2.0									
TENERIFE		4 5 26 ± 1		1.002 ± .018			8	T 150.	PMIR	28	–29	0	*K*	4.	20.
97/ 8/10 3 E4(A)	11 9 58	11 16 55	11 23 52	.597	.3	5.6									
ELLINBANK		11 16 48 ± 12		.188 ± .018			7	T 32.	CCD2	21	–21	0	2 *V*	2.	25.
97/ 8/13 1 O3(P)	4 44 2	4 47 38	4 51 15	.291	–.8	4.9									
TOPEKA		4 47 42 ± 69		.056 ± .023			4	L 38.	CCD12	31	–32	0	1	-	-
97/ 8/23 3 O2(P)	12 21 7	12 29 46	12 38 32	.259	–4.1	9.3									
OKAYAMA		12 29 56 ± 25		.495 ± .045			–10	T 35.	PM3	33	–31	0	2 *V*	0.2	40.
97/ 8/23 3 E2(P)	13 54 32	14 3 34	14 12 45	.284	4.0	9.2									
KAVALUR		14 4 24 ± 17		.314 ± .022			50	T 102.	CCDC	27	–16	0	1 *3	-	-
97/ 8/27 1 E3(A)	11 22 40	11 29 28	11 36 25	.452	5.2	4.9									
OKAYAMA		11 29 17 ± 27		.535 ± .100			12	T 35.	PM3	28	–22	0	1 *V*	0.2	40.
FUNAHO		11 29 20 ± 31		.449 ± .095			9	T 28.	PM3	28	–22	0	2 *V*	0.2	-
97/ 8/28 1 E3(P)	0 25 0	0 36 22	0 47 55	.199	–9.8	2.2									
TENERIFE		0 36 24 ± 10		.233 ± .006			–2	T 150.	PMIR	43	–51	0	*K*	4.	20.
CATANIA		0 36 45 ± 99		.021 ± .006			–23	T 91.	PM	22	–37	0	1 *V*	0.1	21.
97/ 8/28 1 E4(p)	2 41 7	2 52 10	3 3 39	.128	–7.5	4.8									
TENERIFE		2 52 40 ± 25		.106 ± .012			–30	T 150.	PMIR	26	–44	0	*K*	4.	20.
97/ 8/30 3 O2(P)	15 53 52	16 3 17	16 12 53	.184	–7.7	9.2									

Table 4. continued.

Dates Phenomena Locations (1)	Begins h m s (2)	Maxi. h m s (3)	Ends h m s (4)	Magn. drop (5)	Ph. (s) (6)	Dist. (Rj) (7)	C-O (s) (8)	Ap. (cm) (9)	Rec. (10)	El. Jup. (°) (11)	El. Sun (°) (12)	Cd. (13)	Filt. (14)	T. int. (s) (15)	Dia. ('') (16)
OKAYAMA		16 4 59 ± 63		.449 ± .104			–69	T 35.	PM3	28	–44	0	3 *V*	0.2	40.
ALMA-ATA		16 3 42 ± 16		.309 ± .015			–25	T 60.	CCDST	27	–26	0	2 *R*	2.	-
97/ 8/30 3 E2(p)	18 34 54	18 45 10	18 55 41	.111	6.5	8.8									
OHP		18 45 53 ± 150		.099 ± .064			–43	T 80.	CCD1	13	–6	0	2 I	3.	-
ALMA-ATA		18 44 40 ± 112		.074 ± .041			30	T 60.	CCDST	26	–38	0	2 *R*	0.5	-
KAVALUR		18 42 7 ± 34		.239 ± .030			183	T 102.	CCDC	53	–69	0	2 *3	-	-
97/ 9/ 3 1 E3(A)	15 15 3	15 26 7	15 37 50	.486	12										
ALMA-ATA		15 25 41 ± 14		.761 ± .034			26	T 60.	CCDST	25	–22	0	2 *R*	1.	-
97/ 9/ 4 1 E3(P)	13 7 9	13 13 13	13 19 13	.298	6.5	7.0									
OKAYAMA		13 13 5 ± 23		.324 ± .055			8	T 35.	PM3	38	–41	0	1 *V*	0.2	40.
97/ 9/ 8 3 E2(P)	10 52 60	11 4 5	11 14 58	.999	8.3	9.3									
FUNAHO		11 4 14 ± 3		2.857 ± .043			–9	T 28.	PM3	31	–21	0	1 *V*	1.	-
OKAYAMA		11 4 18 ± 4		3.214 ± .049			–13	T 35.	PM3	31	–21	0	2 *V*	1.	40.
97/ 9/10 1 O3(A)	16 8 49	16 17 16	16 26 3	.356	–16.2	5.8									
ALMA-ATA		16 17 28 ± 21		.363 ± .028			–12	T 60.	CCDST	29	–32	0	*R*	-	-
FUNAHO		16 17 37 ± 27		.314 ± .034			–21	T 28.	PM3	18	–47	0	2 *V*	1.	-
OKAYAMA		16 17 38 ± 27		.321 ± .039			–22	T 35.	PM3	18	–47	0	1 *V*	1.	40.
97/ 9/11 1 O3(P)	0 21 20	0 32 28	0 43 24	.204	17.7	1.4									
CATANIA		0 33 35 ± 159		.034 ± .012			–67	T 91.	PM	13	–42	0	2 *V*	0.1	28.
BORDEAUX		0 32 23 ± 178		.240 ± .140			5	T 62.	CCD1	17	–40	0	2	1.	-
97/ 9/11 1 O3(P)	14 3 50	14 8 15	14 12 36	.124	–6.9	5.8									
OKAYAMA		14 9 13 ± 13		.232 ± .028			–58	T 35.	PM3	34	–49	0	3 *V*	1.	40.
FUNAHO		14 8 4 ± 17		.385 ± .049			11	T 28.	PM3	34	–49	0	2 *V*	0.2	-
97/ 9/11 1 E3(A)	16 25 6	16 30 20	16 35 31	.422	6.9	6.9									
KAVALUR		16 30 2 ± 2		.951 ± .020			18	T 102.	CCDC	60	–54	0	1 *3	-	-
97/ 9/15 3 E2(P)	15 0 12	15 9 28	15 18 38	.986	8.4	9.2									
ALMA-ATA		15 9 34 ± 5		5.807 ± .250			–6	T 60.	CCDST	27	–24	0	2 *R*	1.	-
97/ 9/18 1 E3(A)	19 30 10	19 34 52	19 39 31	.472	7.1	6.7									
LUMEZZANE		19 34 57 ± 8		.696 ± .062			–5	T 11.	VISU	25	–23	0	2	-	20.
BARCELONA		19 34 45 ± 9		6.884 ± .610			7	T 16.	VISU	27	–19	0	-	-	-
MILANO		19 35 36 ± 0		.716 ± .003			–44	L 8.	VISU	25	–23	0	2	-	-
OCA		19 34 39 ± 6		.727 ± .044			13	T 150.	PM7	26	–22	0	*B*	0.2	-
OCA		19 34 29 ± 6		.678 ± .039			23	T 150.	PM7	26	–22	0	*R*	0.2	-
OCA		19 34 47 ± 13		.773 ± .111			5	T 150.	PM7	26	–22	0	*V*	0.2	-
NAUCHNY		19 34 39 ± 8		.651 ± .056			13	T 150.	PMW	27	–36	0	*V*	-	35.
PRAHA		19 34 51		.689			1	T 30.	V1	21	–23	0	2	0.00	8

Table 4. continued.

Dates Phenomena Locations (1)	**Begins h m s (2)**	**Maxi. h m s (3)**	**Ends h m s (4)**	**Magn. drop (5)**	**Ph. (s) (6)**	**Dist. (Rj) (7)**	**C-O (s) (8)**	**Ap. (cm) (9)**	**Rec. (10)**	**El. Jup. (°) (11)**	**El. Sun (°) (12)**	**Cd. (13)**	**Filt. (14)**	**T. int. (s) (15)**	**Dia. (") (16)**
		± 9		± .081											
TORINO		1934 39 ± 8		.655 ± .052			13	T 15.	CCD2	26	–22	0	1	1.	-
CATANIA		1934 37 ± 7		.059 ± .005			15	T 91.	PM	34	–30	0	2 *V*	0.1	21.
BUCHAREST1		1934 38 ± 14		.684 ± .099			14	L 38.	CCDI	28	–33	0	1 *GG*	0.4	-
BOSKOOP		1934 36 ± 21		.392 ± .082			16	T 30.	CCDVX	18	–17	0	-	0.04	-
REUX		1934 19 ± 21		.586 ± .127			33	T 30.	CCD5	20	–18	0	-	0.04	-
LISBOA		1934 37 ± 39		.414 ± .163			15	T 20.	CCD4	32	–25	0	-	0.04	-
OOSTERDUIN.		1934 43 ± 26		.045 ± .011			9	T 25.	CCD7	19	–16	0	2	0.04	-
BORDEAUX		1934 35 ± 11		.736 ± .076			17	T 62.	CCD1	23	–16	0	2 *R*	0.5	-
97/ 9/19 4 O3(P)	22 8 16	2214 47	222120	.061	–13.3	14.8									
UCCLE		2218 23 ± 177		.00.095 ± .063			12	T 85.	CCD8	19	–35	0	2	0.06	-
BORDEAUX		2215 13 ± 84		.092 ± .049			–26	T 62.	CCD1	25	–39	0	3 *R*	0.5	-
97/ 9/21 3 E1(P)	2027 45	2031 11	203438	.726	3.8	3.0									
MEUDON		2031 1 ± 2		1.533 ± .046			10	T 100.	V3	23	–26	0	1	0.04	-
PRAHA		2031 4 ± 6		1.259 ± .137			7	L 19.	V1	21	–31	0	2	0.00	8
STUTTGART		2034 3 ± 2		1.337 ± .045			46	T 30.	CCD11	23	–29	0	2 *R*	1.	-
CACERES		2031 0 ± 1		1.564 ± .028			11	T 25.	CCD	31	–25	0	*V*	2-7	-
CHATEAUGIRON		2031 2 ± 3		.518 ± .060			9	T 21.	CCD10	24	–24	0	2	1.2	-
PIC-DU-MIDI		2031 1 ± 2		.397 ± .011			10	T 100.	CCDI	29	–28	0	2 *V*	0.1	-
ZARAGOZA		2031 2 ± 3		1.263 ± .050			9	T 15.	CCD	29	–23	0	2	-	-
OCA		2031 7 ± 9		.969 ± .111			4	T 150.	PM7	28	–31	0	*B*	0.2	-
OCA		2030 52 ± 3		1.168 ± .068			19	T 150.	PM7	28	–31	0	*R*	0.2	-
OCA		2030 50 ± 7		1.288 ± .149			21	T 150.	PM7	28	–31	0	*V*	0.2	-
UCCLE		2030 59 ± 7		1.739 ± .0191			6	T 85.	CCD8	21	–26	0	2	0.06	-
BUCHAREST1		2031 0 ± 3		1.538 ± .082			11	L 38.	CCDI	25	–40	0	1 *GG*	0.4	-
BUCHAREST2		2030 56 ± 4		1.540 ± .127			15	L 38.	CCDST	25	–40	0	2 *V*	3.	-
BOSKOOP		2031 5 ± 10		1.100 ± .189			6	T 30.	CCDVX	20	–25	0	-	0.04	
REUX		2031 3 ± 9		3.789 ± .771			8	T 30.	CCD5	22	–26	0	-	0.04	-
WILP-ACHTER.		2031 0 ± 16		4.224 ± .935			11	T 20.	V2	20	–26	0	3	0.04	-
OOSTERDUIN.		2031 6 ± 16		1.529 ± .312			5	T 25.	CCD7	21	–25	0	2	0.04	-
LISBOA		2031 0 ± 2		1.612 ± .046			11	T 25.	CCD2	31	–23	0	-	-	-
MUNICH		2031 5 ± 9		1.568 ± .239			6	T 28.	CCDM	23	–31	0	1 *4	-	-
97/ 9/22 3 E2(P)	1854 22	19 1 56	19 9 24	.673	8.6	9.0									
OOSTERDUIN.		19 2 3 ± 110		.367 ± .267			–7	T 25.	CCD7	17	–13	0	3	0.04	-
MEUDON		19 2 3 ± 10		1.040 ± .059			–7	T 100.	CCDVX	19	–13	0	1	0.04	-
PRAHA		19 2 10 ± 30		.837 ± .154			–14	L 19.	V1	21	–20	0	2	0.00	8
CHATEAUGIRON		19 1 50 ± 19		1.001 ± .117			6	T 21.	CCD10	19	–11	0	2	0.6	-
ZARAGOZA		19 2 3 ± 3		1.062 ± .022			–7	T 15.	CCD	22	–7	0	2	-	-
UCCLE		19 2 7 ± 22		1.402 ± .020			–8	T 85.	CCD8	18	–14	0	2 *1	0.06	-
BUCHAREST1		19 2 6 ± 12		1.087 ± .072			–10	L 38.	CCDI	28	–30	0	1 *GG*	0.4	-
BUCHAREST2		19 2 19 ± 11		1.013 ± .069			–23	L 38.	CCDST	28	–30	0	1 *V*	2.	-
BOSKOOP		19 1 59 ± 24		.919 ± .140			–3	T 30.	CCDVX	17	–13	0	-	0.04	-
REUX		19 1 56 ± 29		1.171 ± .217			0	T 30.	CCD5	19	–14	0	-	0.04	-

Table 4. continued.

Dates Phenomena Locations (1)	Begins h m s (2)	Maxi. h m s (3)	Ends h m s (4)	Magn. drop (5)	Ph. (s) (6)	Dist. (Rj) (7)	C-O (s) (8)	Ap. (cm) (9)	Rec. (10)	El. Jup. (°) (11)	El. Sun (°) (12)	Cd. (13)	Filt. (14)	T. int. (s) (15)	Dia. (") (16)
WILP-ACHTER.		19 1 56 ± 59		2.956 ± .961			0	T 20.	V2	17	–14	0	3	0.04	-
BORDEAUX		19 2 2 ± 7		1.082 ± .038			–6	T 62.	CCD1	22	–12	0	2 *R*	1.5	-
MUNICH		19 2 4 ± 10		1.049 ± .062			–8	T 28.	CCDM	22	–19	0	1 *4	-	-
KAVALUR		19 2 7 ± 10		1.422 ± .109			–11	T 102.	CCDC	31	–76	0	1 *3	-	-
97/ 9/23 1 O2(P)	22 6 6	22 7 10	22 8 14	.002	–2.0	5.9									
CATANIA		22 8 39 ± 282		.001 ± .006			–89	T 91.	PM	25	–51	0	2 *V*	0.1	21.
97/ 9/25 1 O3(P)	1951 50	1954 25	1956 58	.063	–5.7	5.2									
LUMEZZANE		1955 45 ± 8		.130 ± .036			–80	T 40.	PM	26	–28	0	2	0.1	129.
OHP		1953 56 ± 60		.167 ± .047			29	T 80.	CCD1	28	–26	0	2	1.5	-
MEUDON		1954 32 ± 45		.082 ± .048			–7	T 100.	V3	23	–22	0	1	0.04	-
PARIS		1954 21 ± 100		.061 ± .096			4	L 38.		23	–22	0	3 *V*	0.3	-
UCCLE		1954 34 ± 136		0.070 ± .162			–22	T 85.	CCD8	21	–22	0	3 *1	0.06	-
BOSKOOP		1954 28 ± 145		.075 ± .101			–3	T 30.	CCDVX	20	–22	0	-	0.04	-
MUNICH		1954 44 ± 72		.061 ± .070			–19	T 28.	CCDM	24	–28	0	3 *4	-	-
97/ 9/25 1 E3(A)	2228 21	2232 35	2236 48	.449	7.1	6.5									
MUNICH		2232 22 ± 15		.614 ± .116			13	T 28.	CCDM	15	–42	0	1 *4	-	-
BOSKOOP		2232 17 ± 23		.492 ± .147			18	T 30.	CCDVX	14	–38	0	-	0.04	-
REUX		2232 15 ± 27		.541 ± .197			20	T 30.	CCD5	16	–39	0	-	0.04	-
WILP-ACHTER.		2232 13 ± 67		.603 ± .433			22	T 20.	V2	14	–38	0	-	0.04	-
BORDEAUX		2232 25 ± 8		.668 ± .057			10	T 62.	CCD1	22	–43	0	2 *R*	0.5	-
PRAHA		2232 27 ± 28		.650 ± .184			8	L 19.	V1	12	–41	0	2	0.00	8
STUTTGART		2232 14 ± 9		.666 ± .076			21	T 30.	CCD11	15	–42	0	2 *R*	2.	-
LUMEZZANE		2233 26 ± 36		.161 ± .055			–51	T 40.	PM	17	–45	0	2	0.1	129.
OHP		2232 17 ± 8		.651 ± .053			18	T 80.	CCD1	21	–46	0	2	1.5	-
PARIS		2232 17 ± 11		.609 ± .069			18	L 38.		18	–40	0	1 *V*	0.3	-
PIC-DU-MIDI		2232 31 ± 5		.641 ± .026			4	T 100.	CCDI	24	–45	0	2 *K*	0.1	-
OCA		2232 11 ± 8		.659 ± .056			24	T 150.	PM7	20	–46	0	*B*	0.2	-
OCA		2232 23 ± 21		.667 ± .126			12	T 150.	PM7	20	–46	0	*R*	0.2	-
OCA		2232 7 ± 19		.674 ± .118			28	T 150.	PM7	20	–46	0	*V*	0.2	-
UCCLE		2232 24 ± 20		.847 ± .212			12	T 85.	CCD8	15	–39	0	3 *1	0.06	-
ESSEN		2232 16 ± 11		.669 ± .095			19	T 36.	PM6	14	–38	0	1 *V*	0.2	105.
97/ 9/28 3 E1(P)	2314 4	2317 26	2320 47	.483	4.3	3.7									
PIC-DU-MIDI		2317 18 ± 5		.753 ± .055			8	T 100.	CCDI	18	–49	0	3 *K*	0.1	-
CATANIA		2318 1 ± 14		.063 ± .011			–35	T 91.	PM	12	–54	0	1 *V*	0.1	21.
97/ 9/29 3 O2(P)	1835 38	1842 19	1848 56	.196	–9.8	9.3									
CHATEAUGIRON		1842 28 ± 45		.394 ± .013			–9	T 21.	CCD10	20	–10	0	3	0.6	-
MEUDON		1840 49 ± 27		.973 ± .129			90	T 100.	V3	20	–12	0	2	0.04	-
PIC-DU-MIDI		1842 52 ± 33		.173 ± .033			–33	T 100.	CCDI	25	–12	0	2 *K*	0.1	-
CATANIA		1842 39 ± 19		.070 ± .006			–20	T 91.	PM	33	–24	0	1 *V*	0.1	21.
UCCLE		1842 42 ± 55		.355 ± .103			–24	T 85.	CCD8	19	–13	0	2	0.06	-
BUCHAREST1		1842 45 ± 39		.345 ± .059			–26	L 38.	CCDI	28	–29	0	1 *GG*	0.4	-

Table 4. continued.

Dates Phenomena Locations (1)	**Begins h m s (2)**	**Maxi. h m s (3)**	**Ends h m s (4)**	**Magn. drop (5)**	**Ph. (s) (6)**	**Dist. (Rj) (7)**	**C-O (s) (8)**	**Ap. (cm) (9)**	**Rec. (10)**	**El. Jup. (°) (11)**	**El. Sun (°) (12)**	**Cd. (13)**	**Filt. (14)**	**T. int. (s) (15)**	**Dia. (") (16)**
BUCHAREST2		18 42 18 ± 21		.409 ± .050			1	L 38.	CCDST	28	–29	0	1 *V*	2.	-
OHP		18 43 2 ± 24		.476 ± .041			–43	T 80.	CCD1	25	–15	0	3 *V*	5.	-
97/ 9/29 3 E2(P)	22 40 42	22 46 24	22 52 7	.229	7.1	8.7									
PIC-DU-MIDI		22 46 32 ± 29		.173 ± .029			–8	T 100.	CCDI	21	–47	0	2 *K*	0.1	-
BORDEAUX		22 46 33 ± 31		.226 ± .047			–9	T 62.	CCD1	19	–46	0	2 *R*	1.	-
MUNICH		22 46 34 ± 60		.235 ± .119			–10	T 28.	CCDM	12	–44	0	2 *4	-	-
97/10/ 2 1 O3(P)	22 38 13	22 40 14	22 42 16	.041	–5.0	4.7									
CATANIA		22 41 15 ± 79		.005 ± .011			–61	T 91.	PM	16	–56	0	1 *V*	0.1	22.
BORDEAUX		22 40 35 ± 55		.181 ± .086			–21	T 62.	CCD1	19	–46	0	3 *R*	1.	-
97/10/ 3 1 E3(A)	1 21 36	1 25 21	1 29 9	.335											
NEW-YORK		1 25 2 ± 9		.448 ± .056			19	T 20.	CCD2	29	–29	0	2 *V*	1.	10.
BOWIE		1 25 3 ± 4		.444 ± .023			18	T 20.	CCD2	33	–31	0	2 *V*	4.	14.
97/10/ 5 3 O1(P)	23 23 48	23 26 4	23 28 20	.141	–4.6	2.4									
ESO		23 26 2 ± 3		.356 ± .017			2	T 220.	CCD3	69	–10	0	1 *2	0.5	-
97/10/ 6 3 O2(P)	22 6 22	22 12 30	22 18 36	.217	–9.5	9.3									
TENERIFE		22 12 41 ± 17		.358 ± .035			–11	T 80.	CCDW	41	–46	0	*B*	1.	-
CATANIA		22 13 9 ± 45		.031 ± .007			–39	T 91.	PM	18	–57	0	2 *V*	0.1	42.
97/10/ 7 4 O1(P)	19 34 6	19 35 43	19 37 20	.028	–3.9	3.7									
PARIS		19 37 6 ± 28		.211 ± .102			–83	L 38.	PM2	23	–23	0	3 *V*	0.3	-
NAUCHNY		19 35 18 ± 35		.464 ± .338			25	T 125.	PM5	22	–44	0	3 *V*	-	28.
97/10/16 2 O3(P)	17 33 46	17 36 23	17 39 1	.208	–7.6	2.0									
TORINO		17 36 33 ± 15		.232 ± .032			–10	T 15.	CCD2	25	–11	0	1	1.5	-
97/10/18 1 O2(P)	18 20 40	18 22 22	18 24 4	.024	–4.1	5.7									
UCCLE		18 23 12 ± 599		.012 ± .091			75	T 85.	CCD8	21	–16	0	2 *1	0.06	-
97/10/20 3 O1(P)	4 43 24	4 45 53	4 48 21	.138	–5.6	3.6									
TOPEKA		4 47 2 ± 58		.004 ± .004			69	L 38.	CCD12	17	–56	0	2	-	-
97/10/23 2 O3(P)	20 40 18	20 42 58	20 45 39	.219	–8.0	2.4									
TENERIFE		20 43 33 ± 28		.083 ± .027			–35	T 80.	CCDW	42	–30	0	*B*	1.	-
97/10/24 4 O3(P)	9 58 32	10 3 7	10 7 41	.445	–10.7	4.8									
FUNAHO		10 3 19 ± 4		.707 ± .033			–12	T 28.	PM3	37	–22	0	2 *V*	0.2	-
97/11/ 3 3 O1(P)	10 24 20	10 27 29	10 30 40	.190	–7.3	4.8									
FUNAHO		10 27 37 ± 9		.272 ± .023			–8	T 28.	PM3	35	–29	0	2 *V*	0.2	-
OKAYAMA		10 27 38 ± 5		.274 ± .013			–9	T 35.	PM3	35	–29	0	2 *V*	1.	40.
97/11/ 9															

Table 4. continued.

Dates Phenomena Locations (1)	**Begins h m s (2)**	**Maxi. h m s (3)**	**Ends h m s (4)**	**Magn. drop (5)**	**Ph. (s) (6)**	**Dist. (Rj) (7)**	**C-O (s) (8)**	**Ap. (cm) (9)**	**Rec. (10)**	**El. Jup. (°) (11)**	**El. Sun (°) (12)**	**Cd. (13)**	**Filt. (14)**	**T. int. (s) (15)**	**Dia. ('') (16)**
4 O2(P)	16 39 24	16 49 27	16 59 49	.139	–24.9	9.1									
BOSKOOP		16 50 58 ± 112		.489 ± .185			–91	T 30.	CCDVX	20	–8	0	-	0.04	-
97/11/11 3 O2(T)	15 33 37	15 38 11	15 42 44	.259	–7.3	8.3									
KAVALUR		15 38 29 ± 9		.675 ± .045			–18	T 102.	CCDC	34	–49	0	1 *3	-	-
97/11/11 3 E1(p)	15 41 53	15 47 53	15 53 48	.181	9.7	5.6									
KAVALUR		15 48 7 ± 11		.198 ± .017			–14	T 102.	CCDC	32	–51	0	2 *3	-	-
97/11/17 3 O1(P)	16 42 40	16 47 27	16 52 18	.278	–10.4	5.7									
CATANIA		16 47 43 ± 10		.038 ± .003			–16	T 91.	PM	35	–12	0	2 *V*	0.1	42.
97/11/18 3 O2(P)	19 4 57	19 9 8	19 13 19	.259	–6.8	8.0									
CATANIA		19 9 25 ± 27		.045 ± .010			–17	T 91.	PM	22	–40	0	2 *V*	0.1	21.
CHATEAUGIRON		19 9 28 ± 45		.443 ± .129			–20	T 21.	CCD10	21	–27	0	3	1.2	-
OCA		19 9 32 ± 24		.399 ± .095			–24	T 150.	PM7	21	–33	0	2 *B*	0.2	-
OCA		19 9 42 ± 30		.535 ± .190			–34	T 150.	PM7	21	–33	0	2 *R*	0.2	-
OCA		19 9 32 ± 24		.451 ± .111			–24	T 150.	PM7	21	–33	0	2 *V*	0.2	-
97/11/18 3 E1(p)	19 15 22	19 17 46	19 20 10	.007	3.9										
CATANIA		19 18 39 ± 141		.002 ± .008			–54	T 91.	PM	21	–42	0	2 *V*	0.1	21.
97/11/24 3 O1(P)	20 25 2	20 32 5	20 39 20	.312	–15.4	5.9									
TENERIFE		20 32 17 ± 2		1.022 ± .009			–13	T 150.	PMIR	32	–31	0	*K*	4.	20.
TENERIFE		20 32 26 ± 8		.473 ± .022			–22	T 80.	CCDW	32	–31	0	*B*	1.	-
97/11/25 3 O1(P)	18 34 39	18 39 19	18 43 55	.106	–8.9	5.8									
UCCLE		18 39 39 ± 85		.184 ± .135			–19	T 85.	CCD8	17	–27	0	2	0.06	-
CATANIA		18 38 56 ± 12		.028 ± .012			23	T 91.	PM	23	–35	0	2 *V*	0.1	21.

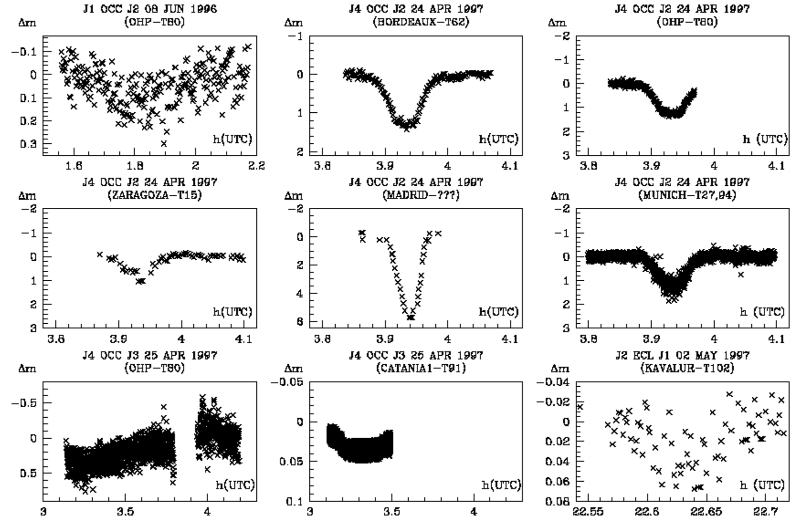

Fig. 1. Lightcurves from the observations of the mutual events of the Galilean satellites in 1996–1997.

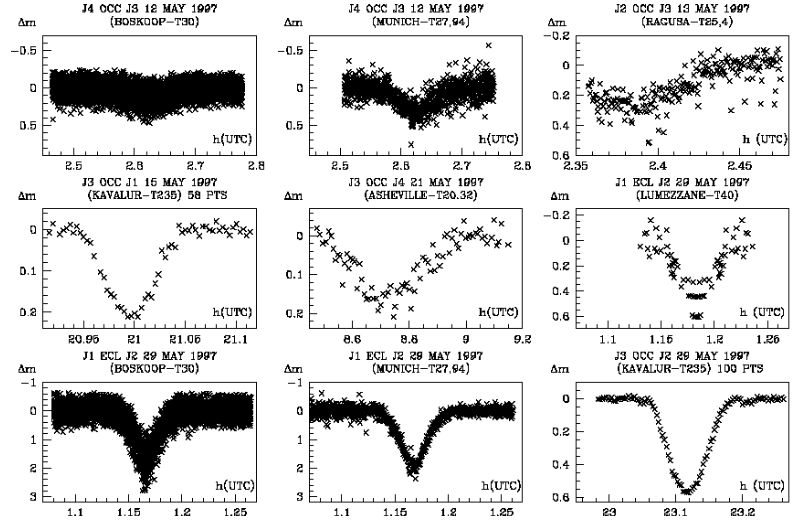

Fig. 2. Lightcurves from the observations of the mutual events of the Galilean satellites in 1996–1997.

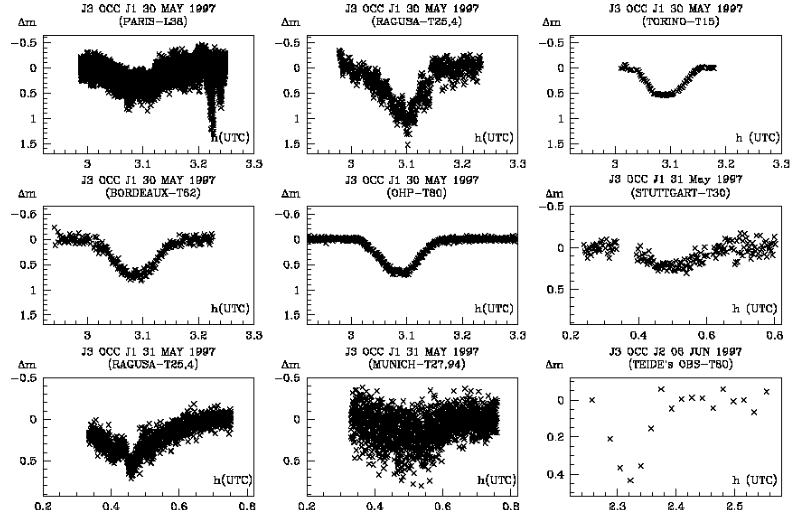

Fig. 3. Lightcurves from the observations of the mutual events of the Galilean satellites in 1996–1997.

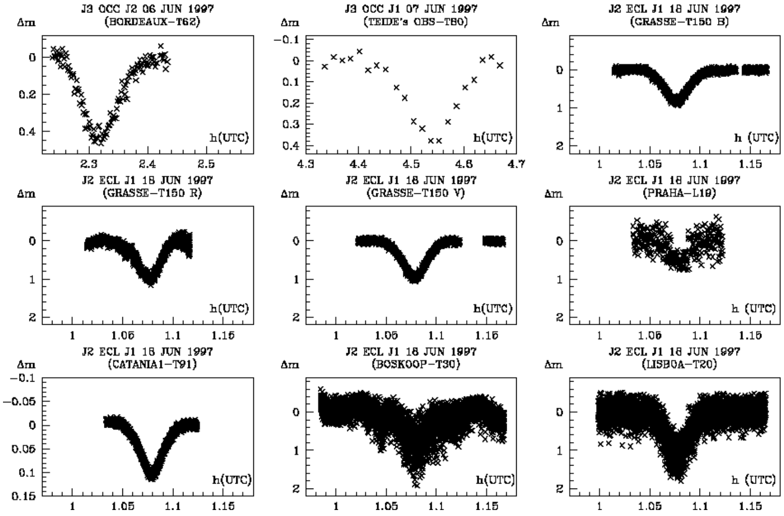

Fig. 4. Lightcurves from the observations of the mutual events of the Galilean satellites in 1996–1997.

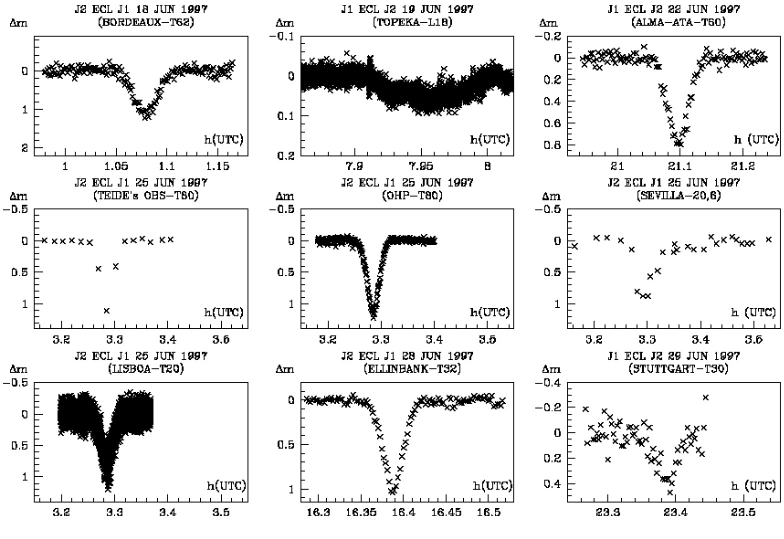

Fig. 5. Lightcurves from the observations of the mutual events of the Galilean satellites in 1996–1997.

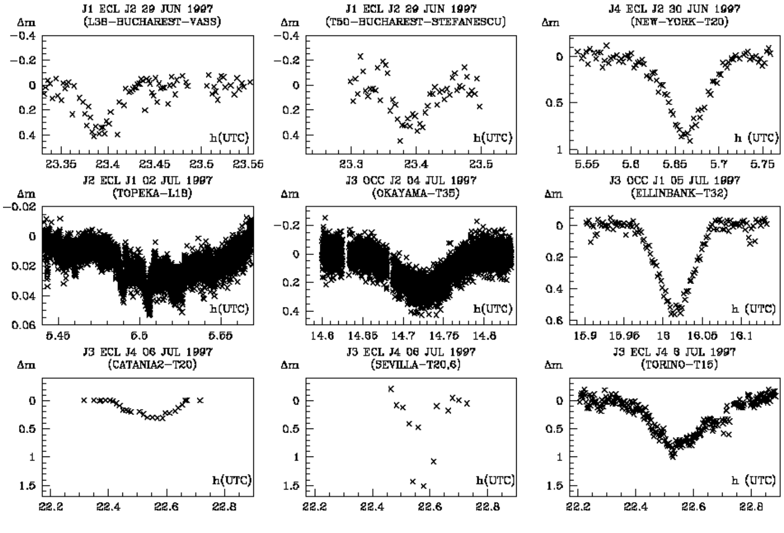

Fig. 6. Lightcurves from the observations of the mutual events of the Galilean satellites in 1996–1997.

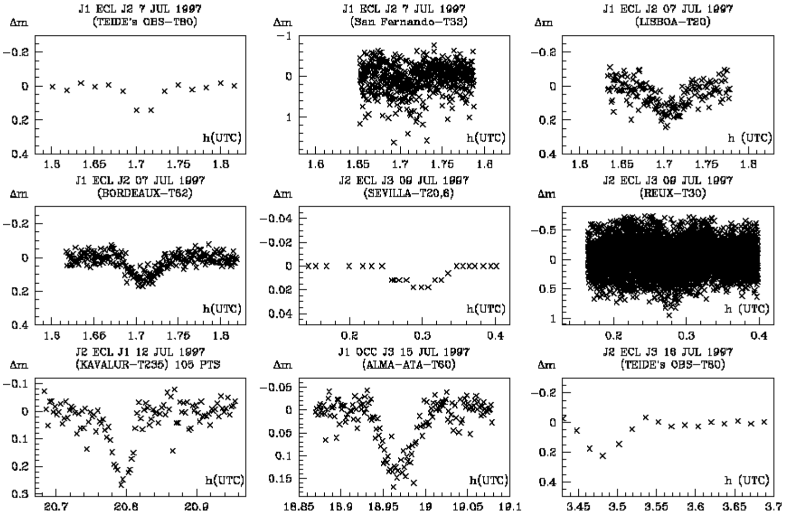

Fig. 7. Lightcurves from the observations of the mutual events of the Galilean satellites in 1996–1997.

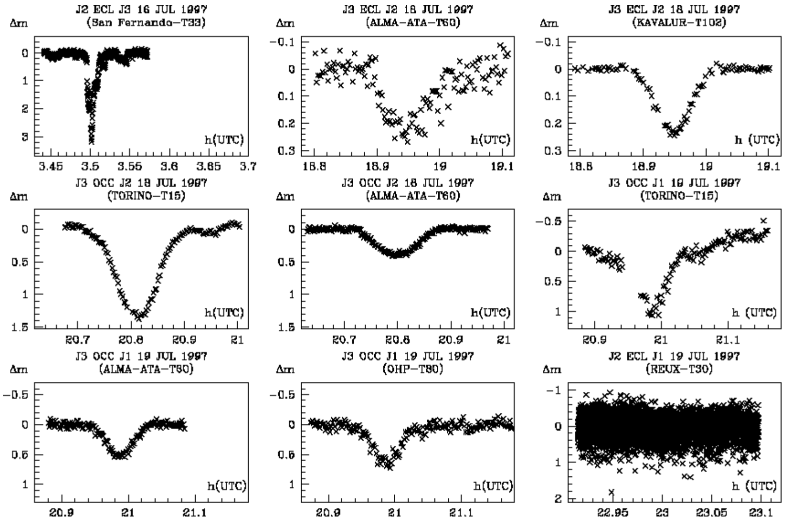

Fig. 8. Lightcurves from the observations of the mutual events of the Galilean satellites in 1996–1997.

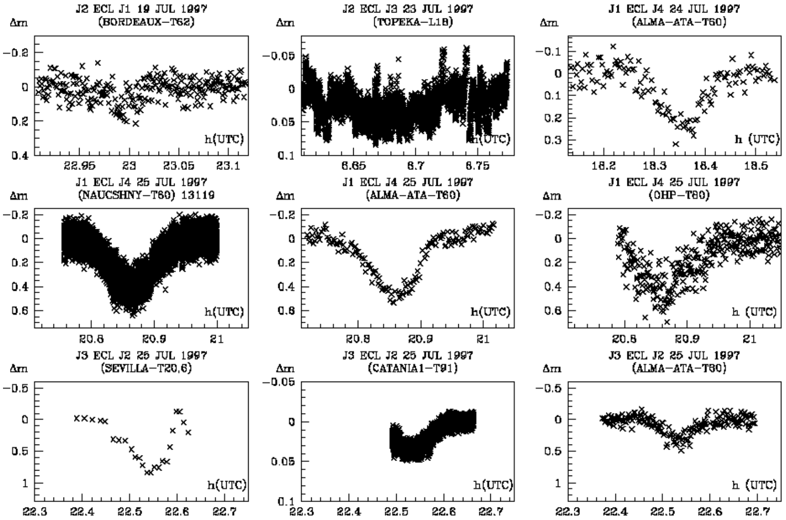

Fig. 9. Lightcurves from the observations of the mutual events of the Galilean satellites in 1996–1997.

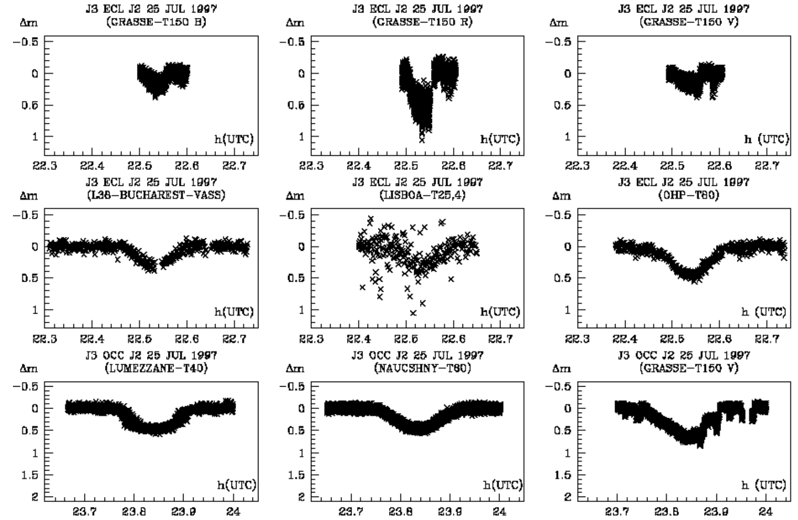

Fig. 10. Lightcurves from the observations of the mutual events of the Galilean satellites in 1996–1997.

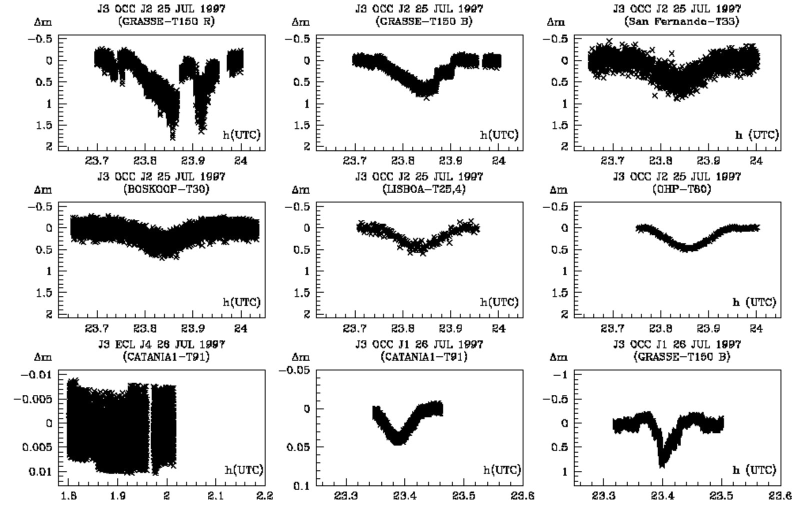

Fig. 11. Lightcurves from the observations of the mutual events of the Galilean satellites in 1996–1997.

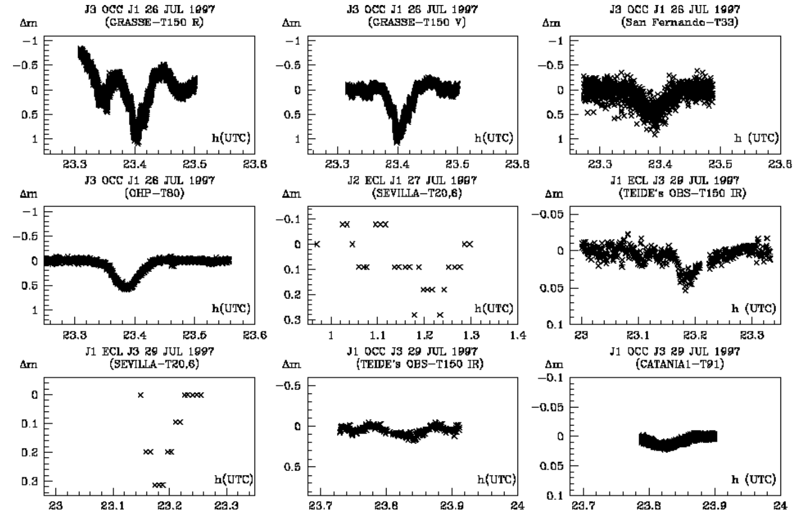

Fig. 12. Lightcurves from the observations of the mutual events of the Galilean satellites in 1996–1997.

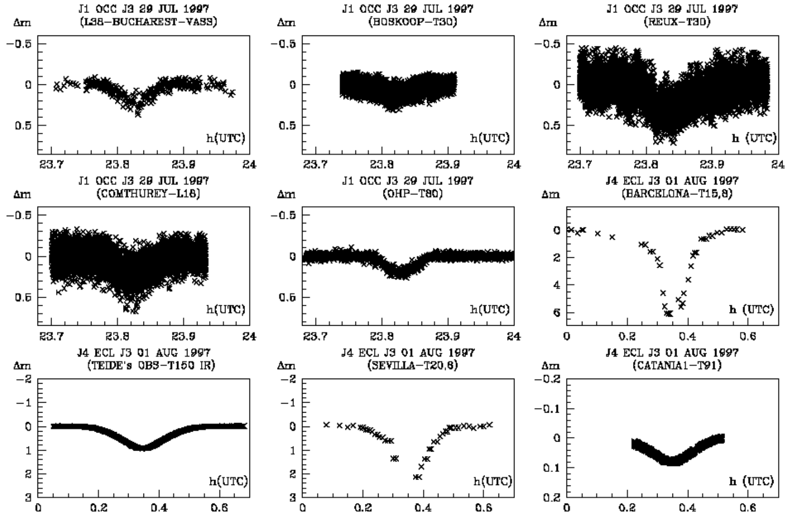

Fig. 13. Lightcurves from the observations of the mutual events of the Galilean satellites in 1996–1997.

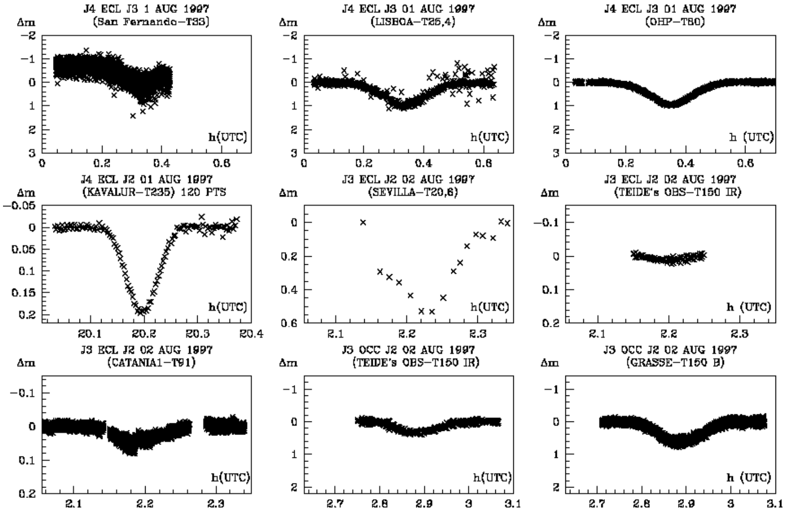

Fig. 14. Lightcurves from the observations of the mutual events of the Galilean satellites in 1996–1997.

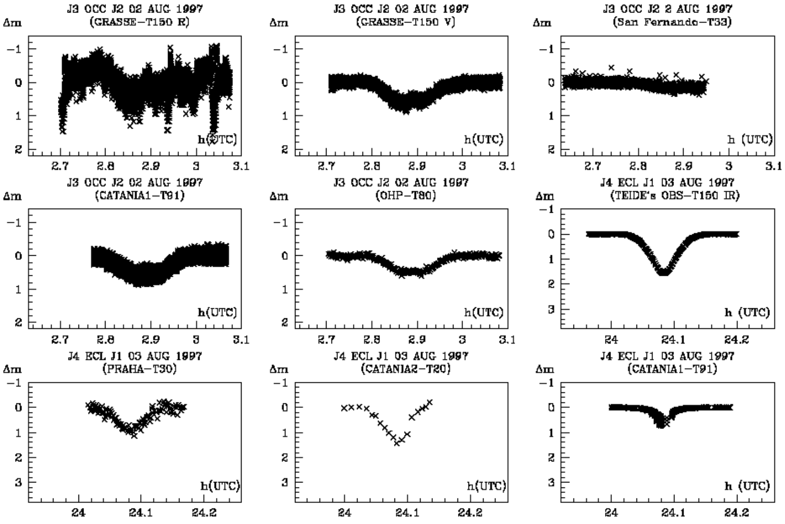

Fig. 15. Lightcurves from the observations of the mutual events of the Galilean satellites in 1996–1997.

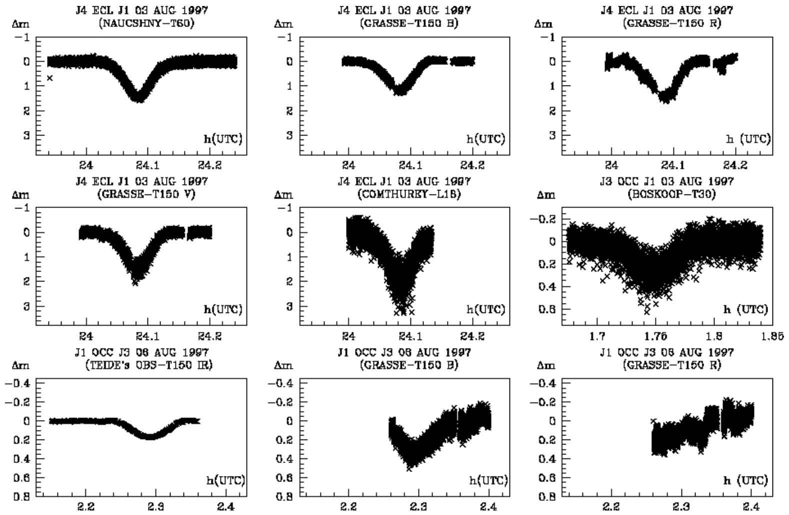

Fig. 16. Lightcurves from the observations of the mutual events of the Galilean satellites in 1996–1997.

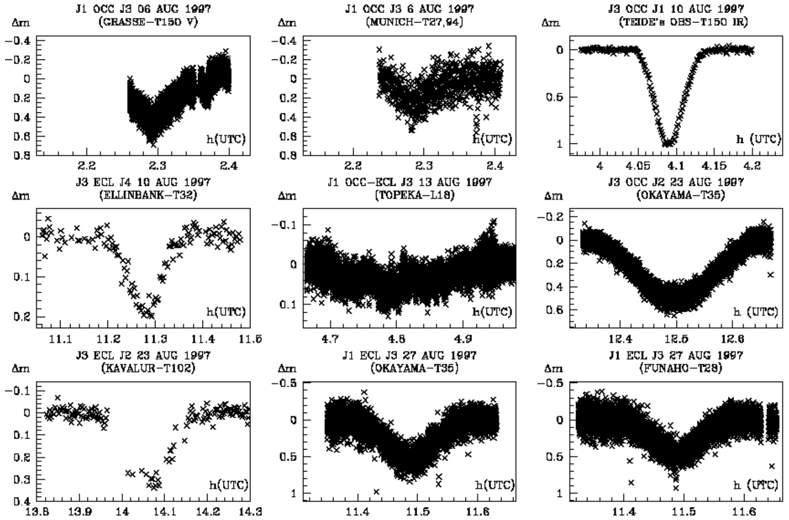

Fig. 17. Lightcurves from the observations of the mutual events of the Galilean satellites in 1996–1997.

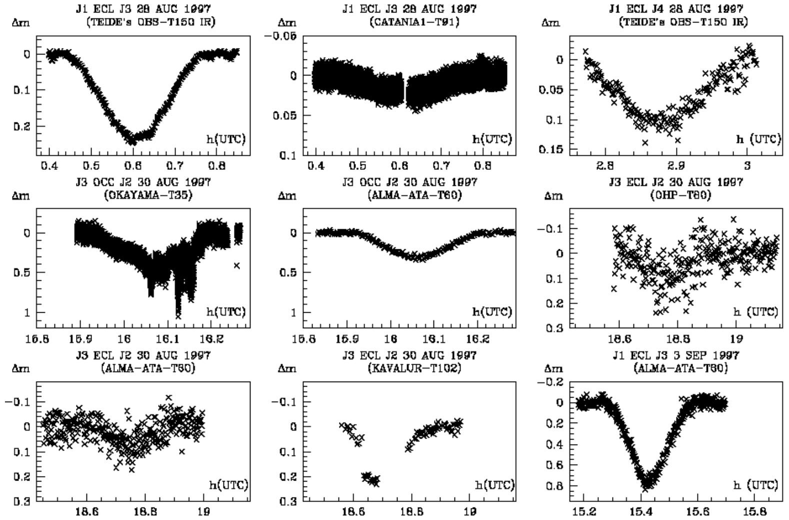

Fig. 18. Lightcurves from the observations of the mutual events of the Galilean satellites in 1996–1997.

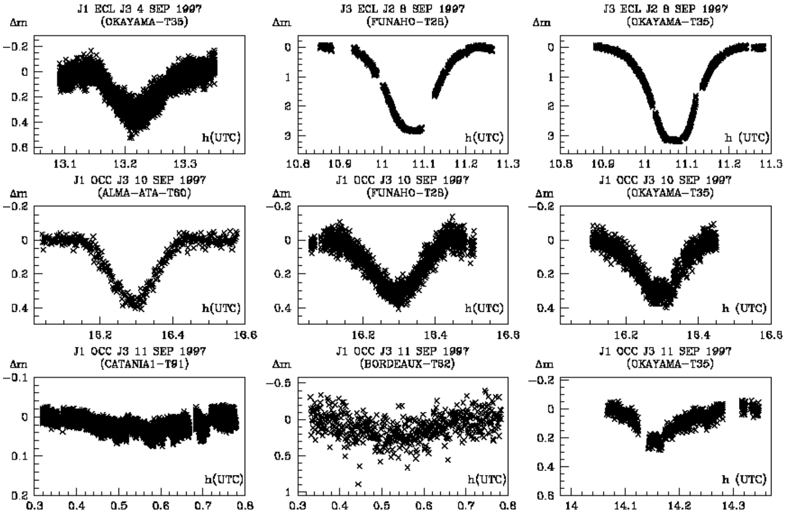

Fig. 19. Lightcurves from the observations of the mutual events of the Galilean satellites in 1996–1997.

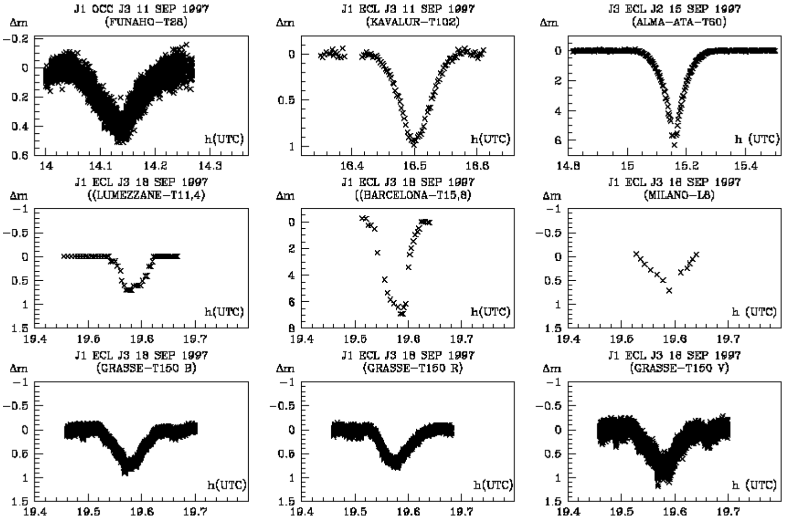

Fig. 20. Lightcurves from the observations of the mutual events of the Galilean satellites in 1996–1997.

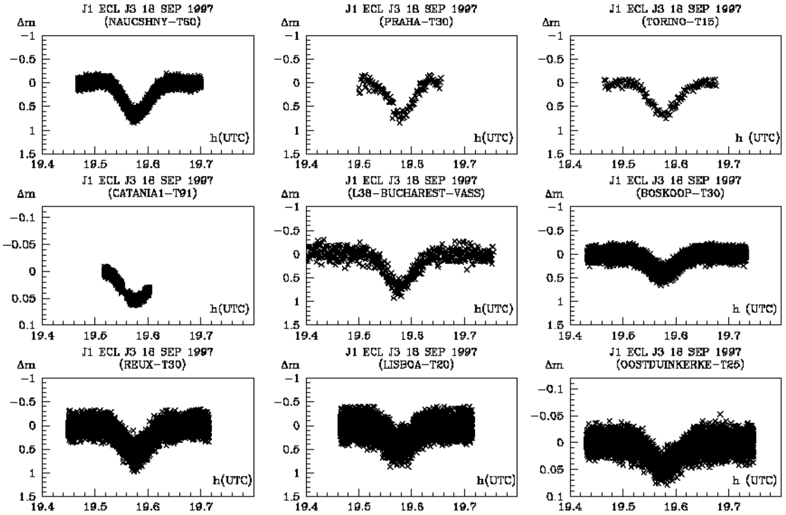

Fig. 21. Lightcurves from the observations of the mutual events of the Galilean satellites in 1996–1997.

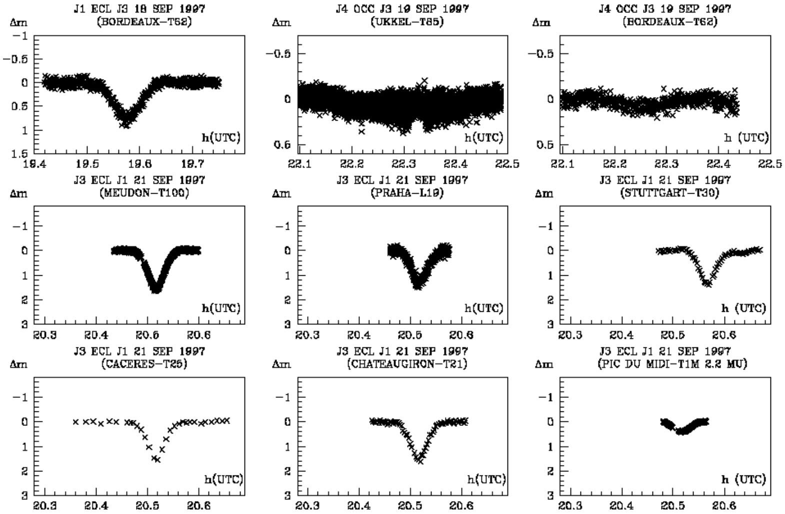

Fig. 22. Lightcurves from the observations of the mutual events of the Galilean satellites in 1996–1997.

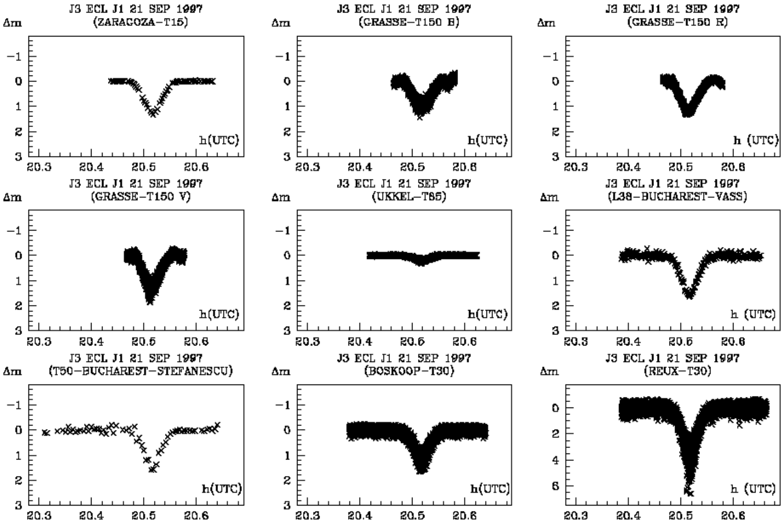

Fig. 23. Lightcurves from the observations of the mutual events of the Galilean satellites in 1996–1997.

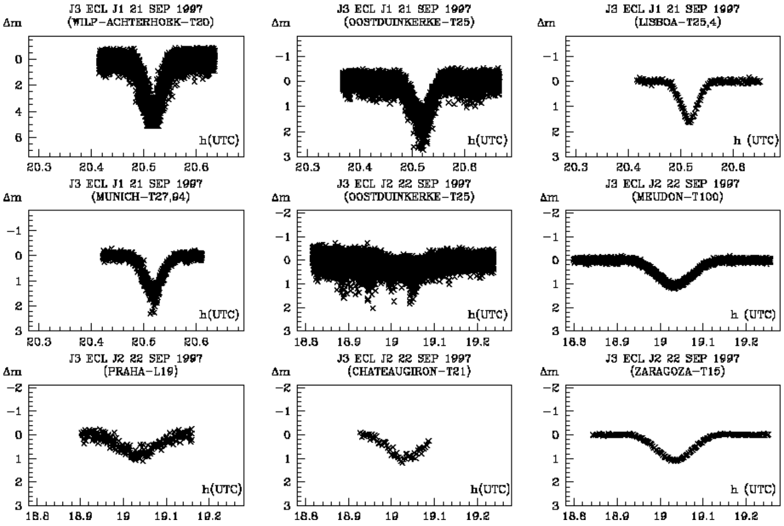

Fig. 24. Lightcurves from the observations of the mutual events of the Galilean satellites in 1996–1997.

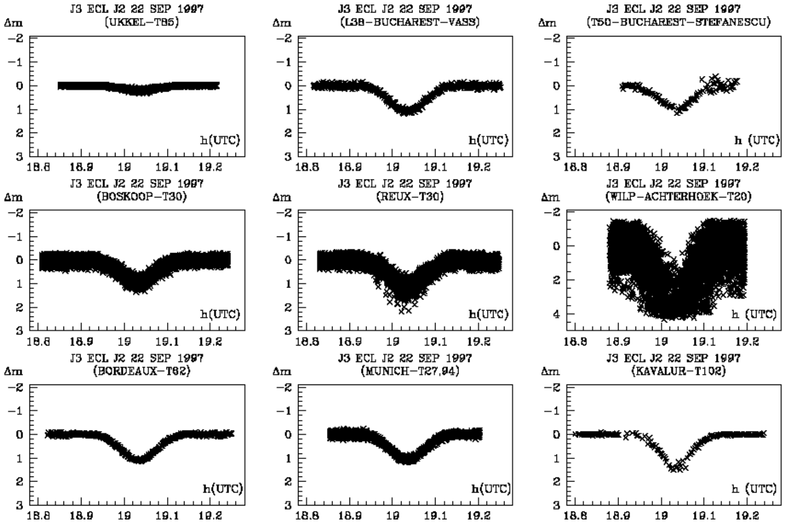

Fig. 25. Lightcurves from the observations of the mutual events of the Galilean satellites in 1996–1997.

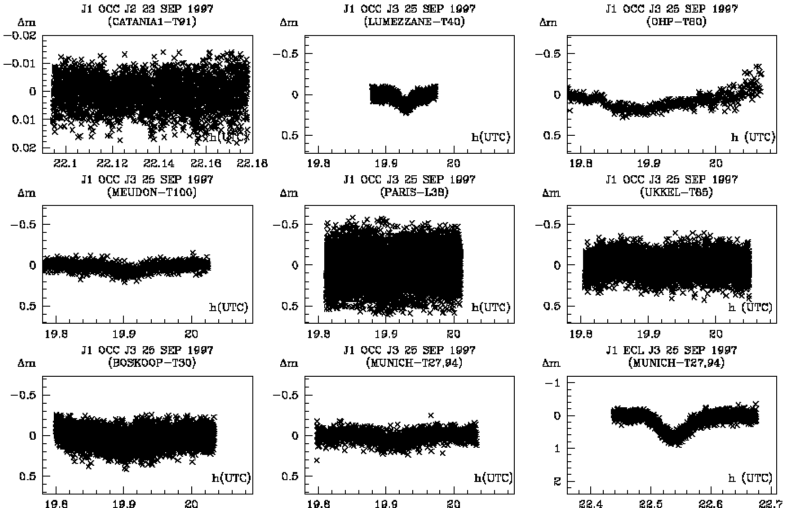

Fig. 26. Lightcurves from the observations of the mutual events of the Galilean satellites in 1996–1997.

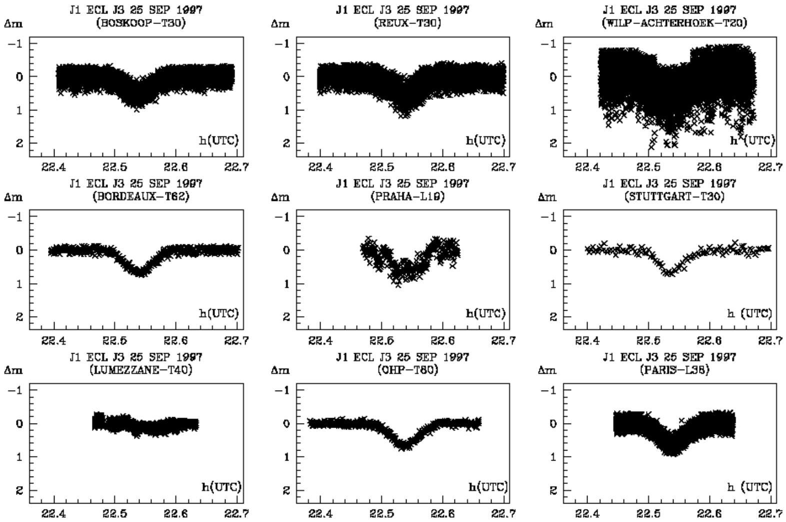

Fig. 27. Lightcurves from the observations of the mutual events of the Galilean satellites in 1996–1997.

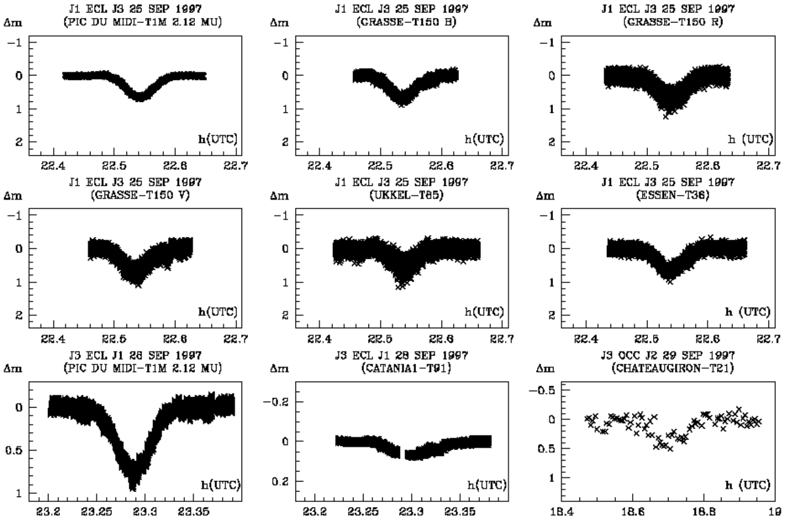

Fig. 28. Lightcurves from the observations of the mutual events of the Galilean satellites in 1996–1997.

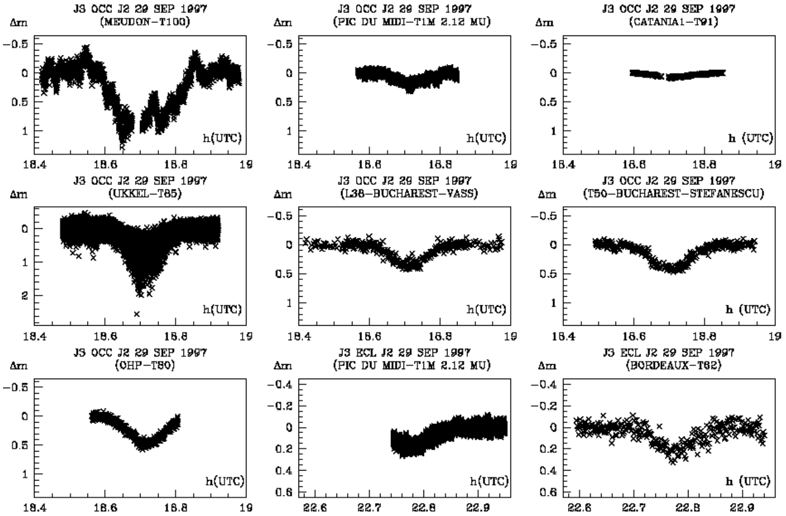

Fig. 29. Lightcurves from the observations of the mutual events of the Galilean satellites in 1996–1997.

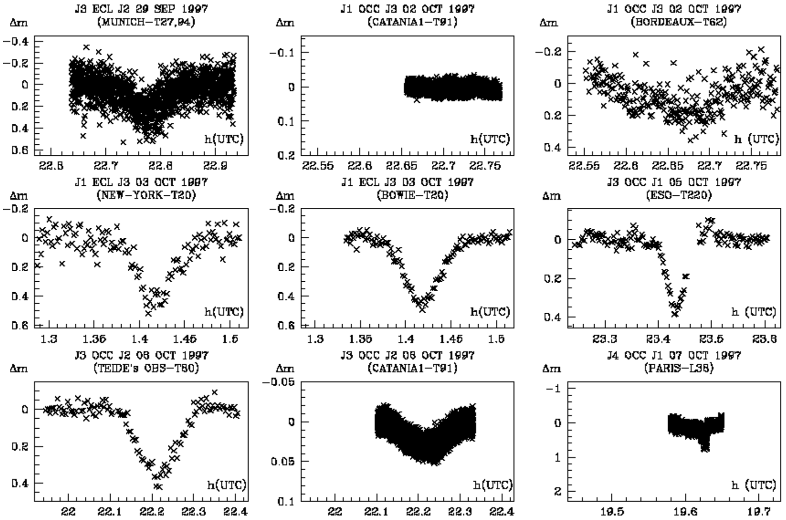

Fig. 30. Lightcurves from the observations of the mutual events of the Galilean satellites in 1996–1997.

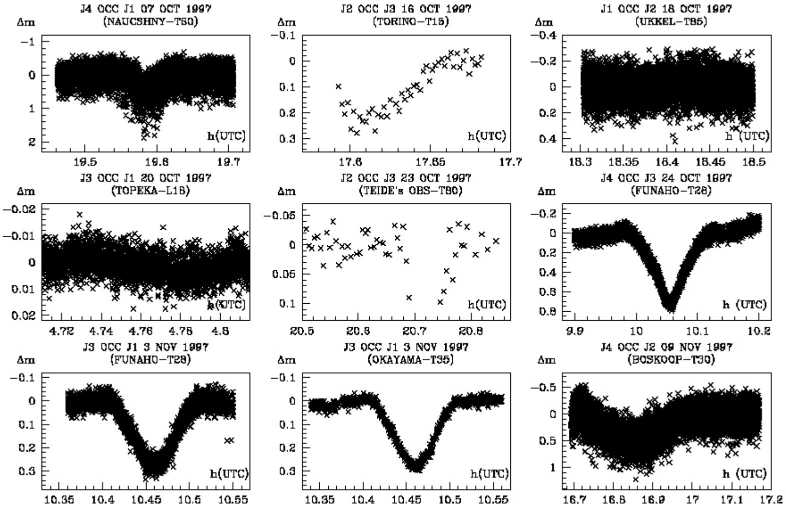

Fig. 31. Lightcurves from the observations of the mutual events of the Galilean satellites in 1996–1997.

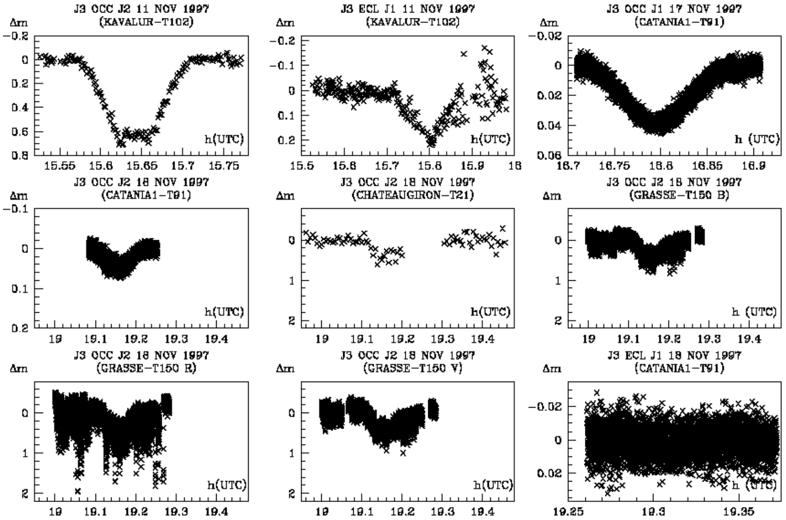

Fig. 32. Lightcurves from the observations of the mutual events of the Galilean satellites in 1996–1997.

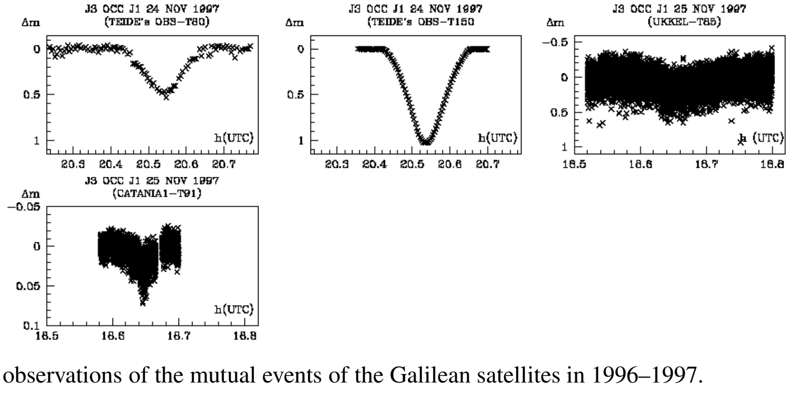

Fig. 33. Lightcurves from the observations of the mutual events of the Galilean satellites in 1996–1997.