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Abstract. In 1994-1996 the Sun and the Earth passed through the equatorial plane of Saturn and therefore through the orbital planes of its main satellites. During this period, phenomena involving seven of these satellites were observed. Light curves of eclipses by Saturn and of mutual eclipses and occultations were recorded by the observers of the international campaign PHESAT95 organized by the Institut de mécanique céleste, Paris, France. Herein, we report 66 observations of 43 mutual events from 16 sites. For each observation, information is given about the telescope, the receptor, the site and the observational conditions. This paper gathers together all these data and gives a first estimate of the precision providing accurate astrometric data useful for the development of dynamical models.

Key words. Saturn – satellites of Saturn – Astrometry

1. Introduction

Observations of mutual events of the natural satellites have been obtained since 1973 and are accurate way to obtain astrometric measurements. Many such events involving the Galilean satellites of Jupiter have been observed. In 1994-1996, similar events occurred in the Saturnian system and we organized and coordinated an international campaign in order to record these rare events. This campaign, named PHESAT95, allowed us to collect 66 lightcurves of 43 mutual events through international network of 16 sites.

We report in this paper the observations collected. A second paper will provide an analysis of the data and corrections to the theoretical models deduced from this set of observations. The aim of the present paper is to provide the photometric data and the observational parameters useful for future works on the improvement of dynamical models as well as for models of the surfaces of the satellites. These data can be accessed from the NSDC database dedicated to the natural satellites (`http://www.bdl.fr/nsdc.html`).

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⋆ Figure 1 is only available in electronic form via `http://www.edpsciences.org`

2. The mutual events and the eclipses

The Earth and the Sun cross the equatorial plane of Saturn every fifteen years (compared with six years for the Jovian one). The Saturnian declinations of the Earth and the Sun are then zero and since the orbital planes of seven of the main Saturnian satellites are very close to the equatorial plane of Saturn, the satellites occult and eclipse each other or with Saturn: transits, occultations, umbra and eclipses can be observed.

The 1995 period was favorable since it happened during the opposition of Saturn and the Sun. The phenomena involved S1-Mimas, S-2 Enceladus, S-3 Tethys, S-4 Dione, S-5 Rhea, S-6 Titan and S-7 Hyperion and they spanned a period of several months. The high inclination of S-8 Iapetus prevented us from observing any phenomena involving this satellite during the same period. Several eclipses by Saturn were in fact predicted by Soma (1992) but no observation was published to our knowledge.

Arlot & Thuillot (1993) made predictions of all the 1995 events using Dourneau's theory (Dourneau 1987, 1993) of the motion of the Saturnian satellites. 163 dates of eclipses by Saturn and 182 dates of mutual events were computed. Before 1995, very few events were observed during the previous occurrences; in their catalogue of astrometric observations of the Saturnian satellites, Strugnell & Taylor (1990) referred to 14 mutual events observations made in 1980. These observations, with older observations of 24 eclipses by Saturn and 2 mutual events made before 1980 and found in the literature, were used by Arlot & Thuillot (1993) to validate their predictions.

Since there is no thick atmosphere around the Saturnian satellites (the one on Titan is not troublesome for our observations), the photometric observations of such phenomena are very accurate for astrometric purposes. The results obtained after similar observations of the Galilean satellites (Arlot et al. 1997), show that a high astrometric accuracy may be obtained: an accuracy better than 30 mas is expected.

This allows us to provide data necessary for the improvement of the theoretical models of the orbital motions. Since 1995, a new dynamical model, TASS, has been available (Vienne & Duriez 1995). This model is based on a general theory of the motions of the Saturnian satellites (Duriez & Vienne 1991; Vienne & Duriez 1991, 1992) where, for the first time, all the gravitational interactions among them are considered and simultaneously analyzed. New accurate data could therefore be applied to determine the theoretical constants and consequently could also be applied to the interpretation of the space observations of the Saturnian system by the CASSINI space probe.

3. The PHESAT 95 campaign

The observation of these phenomena required an international campaign in order to collect a significant amount of data. These events occur over a short time period, so, numerous observers located in several sites are necessary in order to avoid meteorological problems and to observe from different longitudes to record different events. We thus invited observers previously involved in the PHEMU campaigns of observations of the mutual events of the Galilean satellites to join the PHESAT95 campaign.

This campaign, coordinated by the Institut de mécanique céleste involved the locations given in Table 1. This table gives the diameter of the telescope used at these sites, their names, longitudes and latitudes.

For the observations of the mutual events usually relative photometry is possible but is sufficient. Since the elevation of Saturn above the horizon may be very small, the air mass is often too large and absolute photometry is then not possible. Two kinds of devices were used to perform this photometry: photoelectric photometric single channel recorders and two-dimensional CCD cameras. These receptors, and references to their characteristics, are listed in Table 2.

4. Lightcurves reduction procedure

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

For observations made with CCD cameras in video mode, the digitized signal was computed by digitizing boards. The lightcurves were obtained by aperture photometry. For CCD observations, images were measured by Gaussian photometry of the ASTROL software (Colas 1996). Two dimensional measurements allow us to calibrate the signal of the involved satellite to the signal of a nearby satellite, to substract the sky background in real time and so to obtain data under very difficult conditions (see for example Arlot et al. 1997).

The determination of the date of the minimum of light and of the value of the magnitude drop was obtained from a fit of the lightcurve with a sample polynomial. The errors on these determinations are given in Table 3.

5. The catalogue

5.1. The data

Table 3 gives for each date, the data related to the prediction of the event, conditions of observation and the data measured for analysis of the lightcurve.

We give the predictions of the timing of these events in Terrestrial Time as computed with Vienne and Duriez's ephemerides TASS 1.7 (Vienne & Duriez 1995). These predictions include the estimated magnitude drops; an asterisk means infinite magnitude drop for the total eclipses. Note that the values computed from the Dourneau's ephemerides (Dourneau 1987, 1993) are available in Arlot & Thuillot (1993).

The phase effect, computed by means of the Aksnes et al. (1986) method, is given in seconds of time and is included in the O-C value.

Table 1. Main sites of observation

Main observatories	Reflector diameter cm	Longitude h	m	s		Latitude °	′	″		elevation meters
Almaty, Fesenkov Astrophys. Inst. (Kazakhstan)	60	5	7	49	E	43	11	10	N	1450
Assy, Fesenkov Astrophys. Inst. (Kazakhstan)	100	5	11	31	E	43	13	20	N	2750
Bordeaux (France)	60	0	2	6.6	W	44	50	7	N	73
Bucarest, Astron. Inst. of Acad. (Romania)	50	1	44	23.1	E	44	24	50	N	86
Calern, OCA/CERGA (France)	150	0	27	41.2	E	43	45	17	N	1282
Catania, M.G. Fracastoro Station (Italy)	91	0	59	55.0	E	37	41	30	N	1725
Charlottesville, Fan Mont. Obs. (USA)	80	5	22	11.3	W	38	2	0	N	100
Chelmsford (UK)	30	0	1	58.9	E	51	44	40	N	40
Crimean Lab., SAI Moscow Obs. station at Nauchny (Crimea)	60	2	16	4	E	44	43	37	N	600
ESO, La Silla (Chile)	50	4	42	55.1	W	29	15	26	S	2200
Itajuba, OPD/Lab. Nacional de Astrofisica (Brazil)	60	3	2	19.8	W	22	32	4	S	1864
Lumezzane, S. Zani Obs. (Italy)	40	0	40	57.8	E	45	39	59	N	830
Meudon, Paris-Meudon Obs. (France)	100	0	8	55.5	E	48	48	18	N	162
OHP, Haute-Provence Obs. (France)	80	0	22	52.0	E	43	55	46	N	665
Pic-du-Midi, Midi-Pyrénées Obs. (France)	105	0	0	34.2	E	42	56	12	N	2861
Stuttgart (Germany)	30	0	36	32.0	E	48	42	0	N	100

Table 2. Receptors used for the observations

Code as given in the tables	Description	references
	Single channel receptors	
PM1	photomultiplier EMI9789QA (Catania, Italia)	Blanco (1999)
PM2	photom. EMI9789QA (K2CsSb) (ESO, Chile)	–
PM3	photom. Hamamatsu R943-02 (GaAs) (ESO, Chile)	–
PM4	photom. EMI9502B (Bucarest, Romania)	–
PM5	photom. WBVR single ch. (Nauchny, Crimea)	Emelianov et al. (1999)
PM6	photom. 1P21 (Lumezzane, Italy)	–
PM7	photom. RCA 931B (Charlottesville, USA)	–
PMB	photom. TELOC II B channel (Calern, France)	Froeschlé et al. (1988)
PMV	photom. TELOC II V channel (Calern, France)	Froeschlé et al. (1988)
PMR	photom. TELOC II R channel (Calern, France)	Froeschlé et al. (1988)
	Two-dimensional receptors	
CCD1	CCD THX7863 target (Bordeaux, France)	Le Campion et al. (1992)
CCD2	CCD THX7863 target (OHP, France)	–
CCD3	CCD Astriane, THX7863 (Pic-du-Midi, France)	–
CCD4	CCD CAM2 (Itajuba, Brazil)	–
CCD5	CCD ST-6V (Assy and Almaty, Kazakhstan)	Emelianov et al. (1999)
CCD6	CCD Lynxx (Stuttgart, Germany)	–
CCD7	CCD Sony ICX027BL (Chelmsford, UK)	–
CCDV1	video mode uncooled intensified CCD MXRII HCS Vision Techn. (Meudon, France)	Arlot et al. (1989)

Under the predicted times and magnitude drop we show the observed ones in the UTC time scale. Observational data are sequentially given as explained in the caption. Note that two specific filters were used at the Pic du Midi observatory. The first one, labelled OG590, is a Schott long pass filter with transmittance of 0.99 above 640 nm. The second one, labelled DH710b, is a MTO interferential passband filter with spectral band from 530 nm to 900 nm.

The lightcurves shown in Fig. 1 give the magnitude drop versus UTC time for each observation described in Table 3.

These data and lightcurves are available through the Natural Satellite Data Center (NSDC) WEB server (`http://www.bdl.fr/nsdc.html`) and on the NSDC ftp anonymous server (`ftp://ftp.bdl.fr/pub/NSDC/saturn/raw_data/phenomena/mutual/`) of the Institut de mécanique céleste.

Table 3. Data from the observations of the Saturnian mutual events in 1995. One line gives the computed data i.e. the date and type of the phenomenon (for example 2E3 means mutual eclipse of S3 by S2, 5O4 means mutual occultation of S4 by S5), its timing, the predicted magnitude drop and also in Cols. 5 to 7, **Ph.**: phase effect included in the O-C; **Dist.**: apparent distance from the involved satellites to the center of Saturn in planetary radii. The folowing lines give the observed data i.e. the name of the location, the date of the maximum of the magnitude drop and its value and also in colums 8 to 17, **O-C**: Observed minus calculated dates of the maximum in seconds of time, C being issued from the TASS prediction; **Ap.**: aperture of the telescope in centimeters ; **Rec.**: code of the used receptor in column (cf. Table 2); **El. Sat.**: elevation of Saturn upon the horizon ; **El. Sun**: elevation of the Sun upon the horizon ; **Cd.**: observational conditions : [1] means very good conditions; [2] means acceptable and [3] very difficult conditions; **Filt.**: filter eventually used during the observations in column; no filter used is denoted by "-"; **T. int.**: integration time of the measurements in seconds; a variable integration time is denoted "v"; **Dia.**: size of the diaphragm when used; **Sat. in dia.**: satellites in the diaphragm or involved in the CCD measurements, i.e. the satellites, the global magnitude drop of which was observed

Dates Phenomena Locations	Begins h m s	Maxi. h m s	Ends h m s	Magn. drop	Ph. (s)	Dist. (Rs)	O-C (s)	Ap. (cm)	Rec.	El. Sat. (°)	El. Sun (°)	Cd.	Filt.	T. int. (s)	Dia. (")	Sat. in dia.
95/06/17 2E3 (Ann.)	1 53 28	1 57 25	2 0 41	0.277	-6	3.4										
OHP		1 56 42 ±15		0.224 ±0.036			12	80	CCD2	21	-16	1	-	7		2, 3
95/07/22 3E2 (Tot.)	0 3 0	0 5 28	0 8 13	(*)	-2	3.3										
OHP		0 4 32 ±10		0.310 ±0.042			3	80	CCD2	25	-26	1	-	7		2, 3
CATANIA		0 4 2 ±22		0.328 ±0.089			-27	90	PM1	34	-30	1	V	0.1	28	2, 3
PIC DU MIDI		0 4 23 ±7		0.062 ±0.010			-6	105	CCD3	22	-27	1	OG590	5		2, 3
95/07/28 4E3 (Part.)	9 21 20	9 24 0	9 26 25	0.523	-3	4.1										
ESO		9 22 48 ±4		0.139 ±0.011			-14	50	PM3	59	-28	3	V	2	23	4, 3
95/07/29 2O3 (Ann)	1 5 35	1 6 10	1 6 44	0.208	1	2.2										
CATANIA		1 5 39 ±4		0.458 ±0.133			31	90	PM1	45	-27	1	V	0.1	28	2, 3
95/08/02 3E1 (Part.)	9 45 47	9 46 8	9 46 29	0.488	-1	2.5										
ESO		9 45 13 ±8		0.071 ±0.019			6	50	PM3	52	-22	2	R	2	23	1, 3, 5
95/08/04 3E1 (Part.)	7 3 50	7 4 9	7 4 26	0.424	-1	2.5										
ESO		7 3 41 ± 3		0.040 ±0.022			32	50	PM3	64	-57	3	B	2	8	3, 1
95/08/06 5O4 (Part.)	21 34 44	21 35 46	21 36 50	0.114	1	3.9										
CATANIA		21 33 49 ± 1		0.411 ±0.085			-55	90	PM1	19	-31	2	V	0.1	28	4, 5
CRIMEA		21 34 49 ±13		0.089 ±0.057			5	60	PM	29	-29	1	V			4, 5
95/08/08 3E1(Part.)	1 39 31	1 40 24	1 41 18	0.206	0	2.5										
CATANIA		1 40 51 ± 6		0.143 ±0.077			87	90	PM1	48	-25	2	V	0.1	28	1, 3
GRASSE		1 39 34 ± 9		0.084 ±0.029			11	150	PMB	41	-24	2	B	0.2	8	1, 3
GRASSE		1 39 32 ±24		0.029 ±0.043			8	150	PMR	41	-24	2	R	0.2	8	1, 3
GRASSE		1 39 33 ± 18		0.056 ±0.040			9	150	PMV	41	-24	2	V	0.2	8	1, 3
95/08/09 3E1(Part.)	22 58 1	22 58 48	22 59 35	0.106	0	2.5										
CATANIA		22 58 11 ±17		0.103 ±0.118			24	90	PM1	35	-36	3	V	0.1	28	1, 3
GRASSE		22 57 47 ±24		0.025 ±0.022			0	150	PMB	27	-30	2	B	0.2	8	1, 3
GRASSE		22 57 41 ±12		0.099 ±0.024			-6	150	PMV	27	-30	2	V	0.2	8	1, 3
95/08/10 4O2 (Tot.)	23 7 36	23 8 29	23 9 22	0.197	0	3.4										
CATANIA		23 7 42 ± 7		0.378 ±0.086			14	90	PM1	37	-37	3	V	0.1	21	2, 3, 4
95/08/11 5O4(Part.)	22 11 40	22 12 37	22 13 32	0.119	1	2.2										
CATANIA		22 11 49 ±21		0.335 ±0.130			14	90	PM1	29	-36	3	V	0.1	28	4, 5
95/08/13 4O6 (Part.)	22 14 43	22 18 36	22 22 29	0.489	5	5.6										
BUCAREST		22 14 42 ±13		0.076 ±0.016			-168	90	PM4	33	-31	2	-	v	13	4, 6

Table 3. continued

Dates Phenomena Locations	Begins h m s	Maxi. h m s	Ends h m s	Magn. drop	Ph. (s)	Dist. (Rs)	O-C (s)	Ap. (cm)	Rec.	El. Sat. (°)	El. Sun (°)	Cd.	Filt.	T. int. (s)	Dia. (")	Sat. in dia.
95/08/15 4O6 (Ann.)	3 3 42	3 31 23	3 59 4	0.500	-60	4.5										
BORDEAUX		3 25 9 ±335		0.071 ±0.042			-373	60	CCD1	38	-16	3	R	2		4, 6
95/08/16 2O1 (Tot.)	3 45 59	3 46 29	3 46 59	0.456	0	2.9										
ESO		3 45 15 ± 6		0.360 ±0.082			-13	50	PM2	41	-69	3	y	1	8	1, 2
BORDEAUX		3 45 16 ±10		0.276 ±0.119			-11	60	CCD1	36	-13	1	R	5		1, 2
ITAJUBA		3 46 15 ±2		0.226 ±0.012			48	60	CCD4	64	-77	3	R	1		1, 2
PIC DU MIDI		3 45 10 ±2		0.442 ±0.029			-17	105	CCD3	37	-14	2	DH710B	1		1, 2
OHP		3 45 16 ±2		0.506 ±0.045			-11	80	CCD2	34	-10	1	-	8		1, 2
95/08/22 1O2 (Part.)	7 16 53	7 17 17	7 17 40	0.298	0	2.6										
ITAJUBA		7 15 28 ± 1		0.645 ±0.076			-47	60	CCD4	48	-30	2	I	1		1, 2
95/08/25 3O2 (Tot.)	1 48 43	1 49 22	1 50 1	0.170	0	3.0										
OHP		1 48 28 ± 3		0.184 ±0.032			7	80	CCD2	40	-28	1	-	5		2, 3
95/09/03 3O4 (Part.)	7 54 8	7 55 47	7 57 26	0.339	0	4.7										
CHARLOTTESVILLE		7 54 43 ± 9		0.300 ±0.048			-3	75	PM7	39	-31	1	-	1		3, 4
ESO		7 54 46 ± 4		0.201 ±0.018			0	50	PM3	48	-40	1	i	2	14	3, 4
95/09/14 3E2 (Part.)	18 2 1	18 3 21	18 4 41	(*)	0	3.3										
KAZAKHSTAN		18 1 9 ±2		0.130 ±0.009			78	100	CCD2	40	-42					2, 3
95/09/14 3O2 (Part.)	18 3 15	18 4 5	18 4 55	0.032	0	3.9										
KAZAKHSTAN		18 1 50 ±14		0.115 ±0.003			119	100	CCD2	40	-42					2, 3
95/09/21 4O3 (Part.)	3 12 23	3 15 29	3 18 34	0.270	0	4.9										
PIC DU MIDI		3 14 16 ± 9		0.351 ±0.038			-12	105	CCD3	20	-27	1	-			3, 4
ESO		3 13 44 ±62		0.135 ±0.056			-43	50	PM3	63	-56	3	i	2	14	3, 4
95/09/24 3E5 (Ann.)	1 15 1	1 16 56	1 18 53	0.681	1	4.1										
OHP		1 16 9 ±14		0.413 ±0.089			15	80	CCD2	31	-40	1	-	10		3, 5
ESO		1 16 1 ± 2		0.302 ±0.011			6	50	PM3	44	-34	1	i	2	14	3, 5
CHELMSFORD		1 16 6 ± 4		0.432 ±0.030			11	30	CCD7	27	-35	2	-	5		3, 5
BORDEAUX		1 15 58 ±3		0.340 ±0.016			4	60	CCD1	33	-42	1	R	10		3, 5
GRASSE		1 16 20 ± 9		0.181 ±0.024			26	150	PMB	31	-40	1	B	0.2	8	3, 5
GRASSE		1 15 51 ±10		0.202 ±0.035			-3	150	PMR	31	-40	1	R	0.2	8	3, 5
GRASSE		1 16 18 ±16		0.147 ±0.034			23	150	PMV	31	-40	1	V	0.2	8	3, 5
95/10/10 4E3	5 21 32	5 22 29	5 23 26	0.061	1	3.3										
CHARLOTTESVILLE		5 21 37 ±14		0.145 ±0.067			10	75	PM7	38	-58	2	I	1		3
95/10/25 4E5 (Part.)	19 17 35	19 18 25	19 19 28	0.146	2	5.3										
CATANIA		19 16 55 ±36		0.114 ±0.037			-28	90	PM1	44	-37	3	V	0.1	28	4, 5
OHP		19 17 51 ±30		0.048 ±0.022			29	80	CCD2	36	-30	2	-	4		5
95/10/25 6E1	19 41 53	19 43 29	19 44 56	2.320	1	2.4										
OHP		19 42 0 ± 6		3.151 ±0.133			33	80	CCD2	38	-34	2	-	10		1
95/10/29 2E3 (Ann.)	4 23 6	4 23 45	4 24 24	0.274	1	2.5										
ESO		4 23 8 ± 1		0.857 ±0.194			25	50	PM3	45	-47	3	R	2	14	2, 3
95/10/30 2E5	2 15 8	2 15 45	2 16 21	0.003	1	3.5										
ESO		2 14 45 ± 19		0.012 ±0.012			-75	50	PM3	65	-37	1	R	2	8	5

Table 3. continued

Dates Phenomena Locations	Begins h m s	Maxi. h m s	Ends h m s	Magn. drop	Ph. (s)	Dist. (Rs)	O-C (s)	Ap. (cm)	Rec.	El. Sat. (°)	El. Sun (°)	Cd.	Filt.	T. int. (s)	Dia. (")	Sat. in dia.
95/10/30 3E5 (Part.)	2 18 13	2 18 59	2 19 46	0.312	1	3.5										
ESO		2 18 5 ± 2		0.323 ±0.019			9	50	PM3	65	-37	1	R	2	8	5
95/11/03 4E3 (Part.)	19 39 48	19 40 36	19 41 24	0.942	1	2.8										
BORDEAUX		19 39 36 ± 2		1.318 ±0.129			2	60	CCD1	37	-31	1	R	10		3
95/11/05 5E3 (Part.)	18 52 58	18 53 47	18 54 37	1.422	1	1.9										
BORDEAUX		18 53 3 ± 4		4.155 ±0.453			19	60	CCD1	35	-23	1	R	10		3
95/11/09 6E2 (Tot.)	21 58 30	22 2 57	22 7 26	(*)	1	3.3										
PIC DU MIDI		22 2 17 ± 6		7.430 ±0.217			23	105	CCD3	34	-56	2	-	10		2
95/11/12 4E2 (Part.)	1 25 19	1 26 4	1 26 49	1.194	1	3.2										
ESO		1 24 57 ±11		0.149 ±0.029			-5	50	PM3	65	-26	2	i	2	8	2
95/11/14 4E2 (Part.)	19 8 24	19 9 25	19 10 27	4.050	1	3.2										
OHP		19 8 19 ± 2		3.993 ±0.341			-4	80	CCD2	39	-32	1	-	8		2
95/11/14 5E2	21 18 23	21 19 13	21 20 2	0.138	1	2.6										
OHP		21 18 15 ±18		0.244 ±0.079			5	80	CCD2	33	-54	1	-	5		2
95/11/18 5E6	18 44 37	18 49 51	18 55 5	0.095	8	4.8										
LUMEZZANE		18 47 14 ±33		0.249 ±0.079			-88	40	PM6	38	-31	2	-			6
MEUDON		18 48 24 ±55		0.271 ±0.151			-19	100	CCDV1	34	-26	2	-	0.04		6
95/11/18 5E4 (Part.)	20 25 11	20 26 3	20 26 55	1.227	1	3.1										
CHELMSFORD		20 25 7 ± 5		0.906 ±0.097			7	30	CCD7	30	-40	1	-	6		4
MEUDON		20 25 10 ± 4		1.605 ±0.219			10	100	CCDV1	33	-42	1	-	0.04		4
95/11/24 3E1 (Part.)	1 35 57	1 36 26	1 36 55	2.511	0	2.1										
ESO		1 35 20 ± 4		0.125 ±0.035			-4	50	PM2	57	-25	1	V	1	8	1
95/11/25 2E5	14 43 28	14 44 53	14 46 20	0.087	2	2.3										
KAZAKHSTAN		14 43 53 ± 5		0.110 ±0.017			3	60	CCD5	39	-36					
95/11/27 3E1 (Part.)	20 10 24	20 10 47	20 11 10	1.322	1	2.1										
CATANIA		20 9 49 ±10		0.232 ±0.059			4	90	PM1	36	-52	2	V	0.1	28	1, 3
95/11/27 5E2 (Tot.)	20 17 46	20 20 57	20 24 16	(*)	2	3.1										
MEUDON		20 19 59 ±49		0.161 ±0.070			-7	100	CCDV1	31	-42	2	-	0.04		2
95/11/28 5E1 (Tot.)	1 29 11	1 29 40	1 30 9	(*)	0	1.3										
ESO		1 28 41 ± 1		0.536 ±0.172			2	50	PM2	55	-23	2	V	1	8	1
95/11/29 3E1 (Part.)	17 27 37	17 27 56	17 28 16	1.014	1	2.1										
OHP		17 26 24 ± 5		0.044 ±0.011			-30	80	CCD2	38	-16	2	-	5		1
95/12/16 5E1 (Part.)	1 1 50	1 2 6	1 2 21	0.998	1	2.2										
ESO		1 1 3 ±12		0.272 ±0.056			-1	50	PM2	47	-16	1	V	2	8	1
96/02/16 4O5 (Part.)	17 49 59	17 52 43	17 55 27	0.389	-2	6.2										
STUTTGART		17 51 50 ±10		0.116 ±0.016			7	30	CCD6	16	-14	2	-	5		4, 5

5.2. Discussion

This catalogue intends to provide observational information and reduced data from the PHESAT95 campaign. A subsequent paper will provide an analysis by means of orbital longitude corrections for the two main theories used, Dourneau and TASS of Vienne and Duriez.

The conditions of observation of these phenomena were difficult because of the faintness of the magnitude drop of many of these events in combination with the closeness to Saturn and its bright ring. Furthermore, the local conditions of observation of phenomena affect the quality of the data and several poor quality lightcurve resulted from small elevations above the horizon.

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 from the appearance of the lightcurve itself.

We note that, as for the previous catalogue of such events, we computed the errors as following. The error on the lightflux drop is deduced from the standard deviation from the fit to the model light curve. The error on the date of the minimum is deduced from the error on the magnitude drop combined with the speed of the decrease of the lightflux during the event. Thus, this error depends on the number of points, on the integrating time and on the depth of the light curve. Therefore, the error bars may be compared only between events made with the same time constants and, preferably, with the same equipment, in order to determine an observational error and a measurement of the quality of the observation.

Partial analyses of some of these data have already been published. For example, Thuillot (1996), Thuillot & Descamps (1999) showed that an astrometric accuracy better than 48 mas can be deduced from this kind of data. Emelianov et al. (1997, 1999) published results obtained at the Crimean laboratory and at the two astronomical observatories in Kazakhstan. Workshops gathered many of the participants of this campaign, first in Bucharest (Arlot & Stavinschi 1996), and later in Catania in Italy; several partial results were also given there (Arlot & Blanco 1999).

6. Conclusion

We give in this paper the results of the PHESAT95 campaign. Unfortunately data from some observers could not be used, generally because of the faintness of the observed signal and its poor signal/noise ratio and sometimes because of the uncertainties in the time scale. The present catalogue gives the results obtained by all the participants of this campaign who obtained significant results. In order to record the maximum number of events, it was necessary to organize international campaigns such as the PHESAT95 campaign. For the first time, we have obtained numerous photometric observations of the Saturnian mutual events. These phenomena occur every 15 years and in the same way as for the Galilean satellites, they lead to very accurate astrometric measurements which are very difficult to obtain with other techniques from the ground. Furthermore, they may allow us to determine surface parameters by comparison of lightcurves with synthetic models.

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