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Predictions of the mutual phenomena of the Galilean Satellites of Jupiter for 1985–1986

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Summary. In 1985 and 1986, the Earth and the Sun will be in the equatorial plane of Jupiter, so that mutual phenomena (occultations and eclipses) will occur between the Galilean Satellites. The present paper gives the calculated dates, the durations and the magnitudes of each observable phenomenon for three different ephemerides of the Galilean Satellites. The instrumental possibilities of observations are given and the significance of those observations is explained.

Key words: mutual phenomena – galilean satellites

Introduction

The configuration of the orbits of the Galilean Satellites of Jupiter induces, two times each jovian year of 11.6 yr, phenomena between the satellites themselves. The four satellites have orbits which are nearly in the equatorial plane of Jupiter. When the Earth goes through this plane, i.e. when the jovian declination of the Earth becomes zero, the satellites may occult one another for a terrestrial observer. Similarly, when the Sun goes through the equatorial plane of Jupiter, i.e. when the jovian declination of the Sun becomes zero, the satellites may enter the umbra or the penumbra of the other satellites. Because of the small size of the satellites and the very small inclination of their orbits on the jovian equator, mutual phenomena do not occur for each geocentric conjunction (for the occultations) or heliocentric one (for the eclipses) during the favorable period. This favorable period occurs when the jovicentric declinations of the Earth and the Sun are smaller than a defined quantity. These phenomena are easily predictable with modern computers and their observation – which presents no major difficulties – gives interesting information about the Galilean Satellites themselves. In 1985, the most favorable period for the phenomena will occur during the opposition of Jupiter with the Sun so that the observations will be easier. Figure 1 shows the variations of the jovicentric declinations of Earth and Sun for 1979, 1985, and 1992 periods. We may see that the 1992 period is more favorable than the 1979 one but less than the 1985 one. Further, the value of the equatorial geocentric declination of Jupiter is also important to determine the observational conditions: the observatories are more numerous in the northern than in the southern hemisphere.

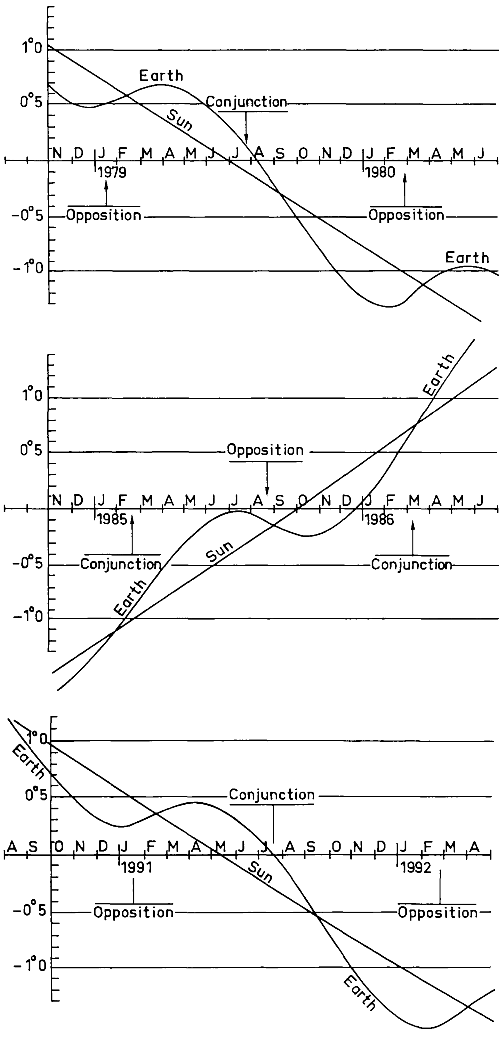

Fig. 1. Jovicentric declination of the Earth and the Sun for the periods of 1979, 1985, and 1991

The predictions for 1985 and 1986

For the calculations, we used the same algorithm as for the previous period (Arlot, 1978). This algorithm gives a precision which varies with each phenomenon: the faster the relative

Table 1. Dates and elements of the mutual phenomena of 1985–86 for 3 ephemerides, G–5, E–2, and SV 2

Year {1}	m. {2}	day {3}	Phenomenon {4}	Dates of the beginning {5} h m s	{6} h m s	Date of the maximum: G-5 {7} h m s	E-2 {8} m s	SV2 {9} m s	Duration(^{s}): G-5 {10}	E-2 {11}	SV2 {12}	Magnitude : G-5 {13}	E-2 {14}	SV2 {15}	Impact parameter(") G-5 {16}	E-2 {17}	SV2 {18}	DJ (R_J) {19}	Notes: {20}
1985	2	4	2 OCC 3 P		20 45 47.	20 54 58.	55 4.	47 21.	1136	1276	2328	0.021	0.027	0.108	0.926	0.919	0.822	7.8	(1)(2)
1985	2	5	2 OCC 3 P		2 13 10.	2 56 56.	55 33.	64 37.	4714	4722	4756	0.377	0.377	0.433	0.499	0.499	0.433	4.6	(1)
1985	2	5	2 ECL 3 P	5 33 18.	5 39 14.	5 58 21.	58 6.	63 55.	2269	2261	2343	11.9%	11.8%	13.7%	0.539	0.543	0.502	3.3	(1)
1985	5	27	3 OCC 2 P		3 56 34.	3 58 43.	58 45.	58 58.	258	267	339	0.238	0.256	0.450	1.020	1.003	0.827	7.2	
1985	5	27	3 OCC 1 P		8 9 42.	8 11 36.	11 38.	11 59.	228	225	194	0.149	0.145	0.106	1.162	1.166	1.208	5.1	
1985	5	29	2 OCC 4 A		4 6 51.	4 12 20.	12 6.	14 30.	660	662	670	0.687	0.708	0.789	0.192	0.162	0.047	8.8	
1985	5	30	2 OCC 4 P		10 24 42.	10 38 11.	38 40.	33 59.	1631	1622	1641	0.524	0.512	0.546	0.426	0.445	0.395	3.6	
1985	6	3	3 OCC 2 P		7 4 32.	7 7 51.	7 53.	8 3.	400	404	438	0.634	0.652	0.848	0.674	0.657	0.474	7.5	
1985	6	3	3 OCC 1 P		11 5 2.	11 8 28.	8 31.	8 44.	413	411	396	0.404	0.400	0.367	0.905	0.910	0.946	5.5	
1985	6	6	4 OCC 2 P		17 54 52.	17 56 47.	56 36.	57 30.	230	247	322	0.189	0.221	0.407	1.031	1.002	0.826	6.3	
1985	6	6	4 OCC 1 P		22 2 43.	22 5 34.	5 23.	6 34.	343	345	333	0.386	0.392	0.359	0.867	0.860	0.896	4.7	
1985	6	7	4 OCC 1 P		16 15 54.	16 21 49.	22 6.	22 24.	716	719	953	0.230	0.232	0.458	1.044	1.042	0.788	2.9	
1985	6	8	4 OCC 1			0 1 34.	1 14.	2 45.	0	0	450	0.0	0.0	0.134	1.399	1.402	1.152	5.9	(2)
1985	6	10	3 OCC 2 P		10 10 27.	10 14 21.	14 24.	14 34.	470	472	486	0.972	0.990	1.189	0.366	0.349	0.159	7.7	
1985	6	10	3 OCC 1 P		14 9 38.	14 14 36.	14 41.	14 44.	602	601	591	0.606	0.602	0.579	0.697	0.701	0.727	5.8	
1985	6	11	3 OCC 1 P		3 14 7.	3 20 25.	20 5.	23 54.	759	752	972	0.173	0.170	0.298	1.189	1.193	1.048	1.3	(3)
1985	6	16	1 OCC 4 P		4 8 31.	4 10 19.	10 8.	12 1.	216	215	274	0.133	0.131	0.226	1.131	1.133	0.990	4.0	
1985	6	17	3 OCC 4 P		1 41 3.	1 45 50.	45 43.	47 28.	575	571	669	0.359	0.352	0.545	1.046	1.056	0.764	12.5	
1985	6	17	3 OCC 2 T		13 14 34.	13 18 47.	18 50.	18 55.	508	509	507	1.254	1.272	1.237	0.099	0.081	0.115	8.0	(6)
1985	6	17	3 OCC 1 P		17 36 17.	17 44 14.	44 24.	43 49.	974	974	964	0.746	0.742	0.737	0.550	0.554	0.560	5.8	
1985	6	18	3 OCC 1 P		1 51 24.	2 1 13.	0 50.	4 40.	1169	1167	1257	0.441	0.438	0.540	0.903	0.906	0.789	1.3	(3)
1985	6	22	4 OCC 3 P		19 26 28.	19 28 48.	28 40.	29 36.	283	293	289	0.075	0.081	0.079	1.490	1.480	1.484	11.9	
1985	6	24	4 OCC 1 P		6 4 18.	6 6 36.	6 27.	7 33.	275	275	292	0.454	0.453	0.531	0.830	0.831	0.739	1.9	
1985	6	24	3 OCC 2 T		16 16 6.	16 20 30.	20 33.	20 39.	529	528	513	1.230	1.212	1.008	0.125	0.143	0.345	8.2	(7)
1985	6	26	2 OCC 1			0 8 8.	8 8.	8 52.	0	0	17	0.0	0.0	0.003	1.197	1.182	1.087	2.3	(2)
1985	6	29	2 OCC 1			13 8 35.	8 34.	9 18.	0	0	23	0.0	0.0	0.005	1.201	1.187	1.094	2.2	(2)
1985	7	1	3 OCC 2 T		19 15 39.	19 20 9.	20 12.	20 21.	540	539	511	1.053	1.035	0.828	0.305	0.324	0.532	8.4	(8)
1985	7	2	3 OCC 1			21 19 12.	19 14.	19 13.	0	0	116	0.0	0.0	0.036	1.494	1.502	1.424	5.2	(2)
1985	7	8	3 OCC 2 P		22 13 33.	22 18 8.	18 12.	18 24.	550	548	507	0.922	0.904	0.695	0.444	0.463	0.676	8.6	
1985	7	9	3 OCC 1 P		23 55 15.	23 55 45.	55 47.	55 55.	62	40	136	0.012	0.005	0.060	1.472	1.481	1.414	4.8	(2)
1985	7	10	4 OCC 1 P		9 35 21.	9 38 18.	38 8.	39 16.	353	354	352	0.892	0.896	0.878	0.327	0.322	0.343	2.8	
1985	7	12	4 OCC 3 P		0 34 40.	0 40 47.	40 34.	40 59.	732	730	774	0.597	0.590	0.766	0.636	0.648	0.339	12.7	
1985	7	13	1 OCC 3 P		0 30 51.	0 33 5.	33 4.	33 24.	269	268	260	0.344	0.339	0.314	0.888	0.896	0.941	2.2	
1985	7	15	3 ECL 2	23 36 13.		23 38 59.	39 4.	39 25.				0 %	0 %	0 %	1.574	1.556	1.327	8.3	(2)
1985	7	16	3 OCC 2 P		1 10 33.	1 15 14.	15 18.	15 34.	563	559	507	0.830	0.813	0.602	0.544	0.563	0.781	8.8	
1985	7	17	3 OCC 1 P		2 26 7.	2 26 41.	26 43.	26 56.	70	54	123	0.018	0.011	0.057	1.481	1.490	1.433	4.3	(2)
1985	7	17	3 OCC 4 P		19 4 15.	19 7 47.	7 37.	8 57.	425	430	413	0.204	0.209	0.190	1.368	1.359	1.390	11.7	
1985	7	17	2 ECL 4			21 55 42.	49 57.	52 44.	0			0 %	0 %	0 %	1.544	1.883	1.795	8.3	(2)
1985	7	18	1 OCC 4 A		12 9 47.	12 13 55.	13 41.	15 47.	498	498	496	0.780	0.785	0.736	0.165	0.157	0.235	5.0	
1985	7	19	1 OCC 4 P		4 13 16.	4 21 1.	21 17.	19 55.	936	937	982	0.563	0.565	0.710	0.515	0.511	0.278	1.6	
1985	7	19	1 OCC 4 P		14 21 22.	14 26 6.	25 49.	28 25.	565	564	642	0.322	0.319	0.465	0.907	0.910	0.674	5.8	
1985	7	20	1 OCC 3 P		2 53 33.	2 55 54.	55 52.	56 12.	281	280	272	0.357	0.353	0.326	0.873	0.880	0.928	2.7	
1985	7	23	3 ECL 2	3 4 21.		3 9 17.	9 22.	9 37.			284	0 %	0 %	10.9%	1.117	1.099	0.870	8.7	(2)
1985	7	23	3 OCC 2 P		4 7 45.	4 12 35.	12 39.	12 52.	581	577	515	0.769	0.752	0.541	0.613	0.631	0.851	8.9	
1985	7	24	3 OCC 1			4 53 60.	54 1.	54 14.	0	0	79	0.0	0.0	0.026	1.521	1.531	1.483	3.9	(2)
1985	7	26	4 OCC 2 T		12 30 56.	12 34 58.	34 45.	35 40.	485	486	485	1.174	1.206	1.172	0.114	0.080	0.115	7.4	(9)
1985	7	26	4 OCC 1 P		17 5 30.	18 1 53.	1 30.	3 15.	6930	7005	6860	0.876	0.957	0.800	0.208	0.175	0.200	4.7	(5)
1985	7	27	1 OCC 3 P		5 16 16.	5 18 40.	18 39.	18 57.	289	288	279	0.351	0.346	0.319	0.890	0.897	0.946	3.2	
1985	7	27	4 OCC 1 P		17 6 38.	17 9 12.	9 1.	10 11.	307	306	349	0.357	0.354	0.494	0.999	1.002	0.829	4.3	
1985	7	30	3 ECL 2 P	6 36 36.	6 39 28.	6 42 58.	43 3.	43 18.	419	425	483	31.1%	32.9%	57.8%	0.665	0.647	0.421	9.0	
1985	7	30	3 OCC 2 P		7 5 29.	7 10 32.	10 37.	10 50.	607	603	532	0.731	0.714	0.503	0.656	0.674	0.895	9.1	
1985	8	3	1 OCC 3 P		7 39 42.	7 42 9.	42 7.	42 26.	295	293	284	0.329	0.324	0.298	0.931	0.939	0.987	3.7	
1985	8	4	2 OCC 4 P			3 55 55.	55 46.	57 21.	0	73	213	0.000	0.017	0.134	1.345	1.317	1.126	4.5	(2)
1985	8	4	1 OCC 4 P		19 17 10.	19 19 6.	18 55.	20 40.	233	232	249	0.230	0.230	0.270	1.066	1.067	1.001	1.9	
1985	8	5	3 OCC 4 P		23 22 19.	23 27 53.	27 46.	29 44.	669	665	743	0.463	0.456	0.645	0.960	0.972	0.662	13.0	
1985	8	6	3 OCC 2 P		10 5 38.	10 10 58.	11 4.	11 11.	642	637	558	0.705	0.688	0.480	0.684	0.702	0.921	9.2	(4)
1985	8	6	3 ECL 2 P	10 14 9.	10 16 49.	10 21 35.	21 40.	21 45.	570	572	581	84.0%	86.1%	100 %	0.223	0.205	0.013	9.2	(4)
1985	8	10	1 OCC 3 P		10 4 49.	10 7 18.	7 17.	7 35.	299	297	286	0.296	0.292	0.266	0.988	0.996	1.043	4.1	
1985	8	13	3 OCC 2 P		13 8 27.	13 14 9.	14 16.	14 23.	687	681	594	0.684	0.668	0.462	0.704	0.721	0.937	9.3	
1985	8	13	3 ECL 2 P	13 57 20.	14 0 7.	14 5 31.	5 37.	5 42.	649	647	611	89.6%	87.6%	62.6%	0.198	0.215	0.423	9.3	
1985	8	17	1 OCC 3 P		12 33 2.	12 35 33.	35 32.	35 44.	303	302	289	0.261	0.257	0.231	1.048	1.055	1.100	4.5	
1985	8	17	1 ECL 3	13 23 16.		13 25 41.	25 36.	25 52.				0 %	0 %	0 %	1.622	1.628	1.677	4.1	(2)
1985	8	20	3 OCC 2 P		16 16 14.	16 22 23.	22 31.	22 41.	741	736	638	0.658	0.642	0.441	0.727	0.743	0.954	9.3	
1985	8	20	3 ECL 2 P	17 49 0.	17 52 14.	17 57 43.	57 48.	57 53.	659	653	554	45.3%	43.6%	23.3%	0.592	0.607	0.801	9.4	
1985	8	20	1 OCC 4 P		22 35 38.	22 37 1.	36 49.	38 36.	167	169	138	0.101	0.104	0.067	1.265	1.261	1.320	2.6	
1985	8	21	1 ECL 4	0 14 19.		0 16 25.	16 15.	18 1.				0 %	0 %	0 %	1.879	1.873	1.940	2.0	(2)
1985	8	24	1 OCC 3 P		15 5 17.	15 7 52.	7 51.	7 58.	312	310	295	0.228	0.223	0.200	1.098	1.105	1.146	4.9	
1985	8	24	1 ECL 3	16 24 46.		16 28 34.	28 34.	28 39.				0 %	0 %	0 %	1.263	1.268	1.309	4.3	(2)
1985	8	27	1 ECL 2	5 27 53.		6 2 0.	1 50.	0 39.			2656	0 %	0 %	3.3%	1.073	1.063	0.949	5.0	(2)
1985	8	27	3 OCC 2 P		19 31 9.	19 37 52.	38 1.	38 16.	809	802	688	0.617	0.602	0.406	0.762	0.778	0.980	9.4	
1985	8	27	3 ECL 2 P	21 53 28.	21 57 51.	22 2 27.	2 37.	2 42.	552	538	212	11.5%	10.4%	0.5%	0.950	0.964	1.139	9.2	
1985	8	29	4 OCC 1 P		0 16 32.	0 17 43.	17 31.	18 41.	143	149	74	0.063	0.068	0.016	1.341	1.334	1.398	4.5	
1985	8	29	3 ECL 2 P	0 46 39.	0 57 7.	1 19 7.	18 12.	23 20.	2754	2619	2087	15.5%	13.4%	6.1%	1.012	1.037	1.133	5.4	
1985	8	29	4 ECL 1	3 17 28.		3 23 34.	23 19.	24 35.				0 %	0 %	0 %	1.116	1.106	1.151	5.7	(2)
1985	8	29	4 OCC 1			20 19 29.	19 47.	19 58.	0	0	909	0.0	0.0	0.197	1.452	1.453	1.175	3.7	(2)
1985	8	30	4 ECL 1	6 0 55.		6 3 47.	3 37.	4 48.				0 %	0 %	0 %	1.834	1.838	1.630	5.0	(2)
1985	8	30	1 ECL 2	16 9 20.		16 12 10.	12 15.	15 53.			1063	0 %	0 %	5.3%	1.197	1.179	0.916	3.1	(2)
1985	8	30	1 ECL 2 P	20 49 45.	20 54 2.	21 4 49.	4 34.	3 3.	1237	1269	1570	21.7%	23.6%	51.5%	0.670	0.649	0.380	6.0	
1985	8	30	4 OCC 3 P		21 16 29.	21 18 30.	18 17.	18 41.	245	220	529	0.040	0.033	0.205	1.610	1.622	1.321	13.4	
1985	8	31	4 ECL 3	1 53 29.		2 0 13.	59 58.	0 28.				0 %	0 %	0 %	1.632	1.643	1.335	12.1	(2)
1985	8	31	1 OCC 3 P		17 44 1.	17 46 47.	46 46.	46 41.	333	329	314	0.203	0.199	0.178	1.129	1.135	1.172	5.3	
1985	8	31	1 ECL 3 P	19 38 18.	19 41 21.	19 43 41.	43 46.	43 31.	286	284	267	3.5%	3.4%	2.8%	0.936	0.940	0.968	4.3	
1985	9	1	1 ECL 3	10 35 6.		10 43 13.	42 42.	46 15.			147	0 %	0 %	0.0%	1.450	1.456	1.277	3.8	(2)
1985	9	1	1 ECL 3			17 19 9.	19 23.	21 8.	0	0		0 %	0 %	0 %	1.519	1.525	1.715	3.8	(2)
1985	9	3	1 ECL 2			3 42 15.	42 26.	45 29.	0	0		0 %	0 %	0 %	1.102	1.088	1.083	3.8	(2)
1985	9	3	1 ECL 2 P	10 43 37.	10 46 26.	10 54 6.	53 56.	53 46.	903	920	1071	29.9%	32.0%	60.9%	0.567	0.546	0.281	6.3	
1985	9	3	3 OCC 2 P		22 56 58.	23 4 23.	4 34.	4 53.	895	887	746	0.554	0.540	0.353	0.817	0.831	1.022	9.3	
1985	9	4	3 ECL 2	2 21 12.		2 29 56.	30 12.	30 17.				0 %	0 %	0 %	1.264	1.275	1.425	8.9	(2)
1985	9	4	3 ECL 2 T	21 22 22.	21 26 30.	21 47 50.	47 14.	50 1.	2561	2564	2571	100 %	100 %	100 %	0.103	0.083	0.022	1.7	(10)
1985	9	5	3 OCC 2 P		2 51 23.	3 25 50.	24 26.	29 51.	4669	4490	4056	0.365	0.342	0.256	1.008	1.032	1.118	5.7	
1985	9	5	3 ECL 4	21 22 7.		21 26 32.	26 22.	27 43.				0 %	0 %	0 %	2.016	2.007	2.036	9.0	(2)
1985	9	6	1 OCC 4 P		5 45 33.	5 57 33.	56 37.	3 57.	1571	1577	1605	0.173	0.179	0.153	1.118	1.109	1.149	5.6	
1985	9	6	1 OCC 4 P		8 30 30.	8 46 52.	47 39.	41 59.	1815	1819	2006	0.204	0.209	0.219	1.069	1.060	1.045	4.4	
1985	9	6	1 OCC 2 P		21 40 56.	21 50 34.	50 13.	48 52.	1108	1176	1858	0.141	0.159	0.428	0.965	0.946	0.674	5.2	
1985	9	7	1 ECL 2 P	0 22 6.	0 24 22.	0 30 39.	30 29.	30 39.	748	759	852	36.7%	38.9%	67.8%	0.485	0.464	0.206	6.6	
1985	9	7	1 ECL 4	9 27 23.		9 30 54.	30 39.	32 31.				0 %	0 %	0 %	1.275	1.276	1.196	5.7	(2)
1985	9	7	1 OCC 3 P		20 31 32.	20 34 40.	34 41.	34 25.	378	375	359	0.191	0.187	0.171	1.134	1.140	1.168	5.6	
1985	9	7	1 ECL 3 P	23 14 55.	23 18 15.	23 23 14.	23 19.	22 34.	604	603	597	11.2%	11.1%	11.0%	0.662	0.666	0.669	4.2	
1985	9	8	1 OCC 3			12 44 12.	43 39.	48 1.	0	0	454	0.0	0.0	0.020	1.602	1.610	1.426	3.0	(2)
1985	9	8	1 ECL 3	21 25 17.		21 27 16.	27 21.	27 31.				0 %	0 %	0 %	1.712	1.720	1.613	7.4	(2)
1985	9	10	1 OCC 2 P		11 27 35.	11 33 57.	33 41.	33 12.	748	789	1190	0.155	0.173	0.442	0.943	0.925	0.655	5.5	
1985	9	10	1 ECL 2 P	13 51 15.	13 53 13.	13 58 45.	58 35.	58 50.	659	667	729	42.9%	45.2%	73.5%	0.413	0.392	0.143	6.7	
1985	9	11	3 OCC 2 P		2 40 19.	2 48 40.	48 54.	49 7.	1012	1002	811	0.457	0.444	0.271	0.902	0.915	1.089	9.2	
1985	9	11	3 ECL 2	7 49 27.		7 54 55.	55 26.	49 45.			0	0 %	0 %	0 %	1.506	1.512	1.359	8.0	(2)
1985	9	11	3 ECL 2 P	18 31 7.	18 38 31.	18 56 6.	55 26.	58 48.	2083	2117	2162	22.7%	23.9%	26.0%	0.917	0.905	0.885	1.9	
1985	9	12	3 OCC 2 T		23 45 25.	0 9 57.	9 17.	12 11.	2978	2974	2974	1.315	1.295	1.242	0.039	0.059	0.113	1.8	(11)(18)
1985	9	14	1 OCC 2 P		1 0 25.	1 5 11.	4 58.	4 52.	564	597	911	0.145	0.164	0.431	0.945	0.926	0.660	5.7	
1985	9	14	1 ECL 2 P	3 16 55.	3 18 40.	3 23 41.	23 31.	23 51.	594	600	641	49.0%	51.3%	78.2%	0.345	0.324	0.083	6.8	
1985	9	14	4 OCC 2			6 22 58.	22 42.	23 40.	0	0	172	0.0	0.0	0.070	1.415	1.384	1.208	8.0	(2)
1985	9	14	4 ECL 2	12 22 51.		12 30 34.	30 13.	31 29.				0 %	0 %	0 %	0.921	0.952	1.106	9.3	(2)
1985	9	14	1 OCC 3 P		23 34 31.	23 38 34.	38 37.	38 2.	489	486	474	0.196	0.192	0.184	1.106	1.112	1.126	5.8	
1985	9	15	1 ECL 3	5 11 59.		5 30 37.	30 32.	31 46.				0 %	0 %	0 %	1.570	1.604	1.304	2.8	(2)(5)
1985	9	15	4 ECL 2 P	14 29 59.	14 37 38.	14 44 15.	44 50.	43 19.	801	815	787	23.1%	24.5%	21.7%	0.558	0.542	0.572	2.7	

Table 1 (continued)

				Dates of the		Date of the maximum:			Duration(^{s}):			Magnitude :			Impact parameter(")			DJ	
Year	m.	day	Phenomenon	beginning		G-5	E-2	SV2	G-5	E-2	SV2	G-5	E-2	SV2	G-5	E-2	SV2	(R_J)	Notes:
{1}	{2}	{3}	{4}	{5}	{6}	{7}	{8}	{9}	{10}	{11}	{12}	{13}	{14}	{15}	{16}	{17}	{18}	{19}	{20}
				h m s	h m s	h m s	m s	m s											
1985	9	16	1 ECL 3	0 47 44.		0 50 50.	50 55.	51 15.				0 %	0 %	0 %	1.492	1.499	1.422	7.4	(2)
1985	9	17	1 OCC 2 P		14 24 38.	14 28 21.	28 9.	28 16.	443	474	751	0.124	0.142	0.406	0.958	0.939	0.679	5.8	
1985	9	17	1 ECL 2 P	16 38 27.	16 40 4.	16 44 42.	44 32.	44 57.	547	551	577	54.9%	57.2%	78.0%	0.280	0.259	0.026	6.9	
1985	9	18	3 OCC 2 P		6 53 57.	7 3 53.	4 14.	4 30.	1207	1191	879	0.325	0.314	0.162	1.016	1.027	1.177	8.9	
1985	9	18	3 OCC 2 P		21 48 23.	22 10 26.	9 46.	12 1.	2629	2643	2659	0.783	0.797	0.815	0.563	0.550	0.531	1.0	(3)
1985	9	19	3 ECL 1 P	2 12 59.	2 15 16.	2 16 0.	16 5.	16 31.	93	90	59	2.4%	2.2%	0.6%	0.908	0.914	0.967	2.1	
1985	9	21	1 OCC 2 P		3 46 14.	3 49 6.	48 54.	49 10.	344	374	636	0.097	0.115	0.376	0.975	0.957	0.702	5.8	
1985	9	21	1 ECL 2 P	5 58 33.	6 0 5.	6 4 19.	4 14.	4 39.	508	510	524	60.8%	63.1%	75.6%	0.215	0.195	0.032	6.9	
1985	9	22	1 OCC 3 P		3 12 48.	3 19 55.	20 4.	18 41.	873	869	869	0.219	0.216	0.223	1.046	1.051	1.040	5.7	
1985	9	22	1 OCC 3 P		9 52 28.	10 0 45.	0 19.	4 13.	984	975	1148	0.157	0.153	0.227	1.149	1.155	1.032	2.2	
1985	9	23	2 ECL 4	3 13 36.		3 19 23.	19 13.	20 54.				0 %	0 %	0 %	0.503	0.535	0.662	3.3	(2)
1985	9	23	1 ECL 3	3 55 9.		3 58 41.	58 41.	59 7.				0 %	0 %	0 %	1.231	1.239	1.187	7.2	(2)
1985	9	23	1 ECL 4	14 19 45.		14 24 13.	24 3.	25 49.				0 %	0 %	0 %	0.030	0.038	0.013	1.3	(2)(3)
1985	9	24	1 OCC 2 P		17 4 7.	17 6 16.	6 5.	6 24.	259	292	550	0.067	0.085	0.342	0.995	0.977	0.728	5.9	
1985	9	24	1 ECL 2 P	19 16 7.	19 17 35.	19 21 34.	21 24.	21 55.	476	477	482	66.5%	68.6%	72.6%	0.151	0.131	0.086	7.0	
1985	9	25	3 ECL 4 A	5 0 59.	5 6 12.	5 9 59.	9 54.	11 45.	454	452	468	7.1%	7.1%	7.0%	0.240	0.251	0.043	16.1	
1985	9	25	3 OCC 2 P		12 42 50.	13 0 31.	1 34.	0 24.	2251	2229	1181	0.157	0.152	0.043	1.158	1.164	1.270	7.7	
1985	9	25	3 OCC 2 P		18 31 5.	19 0 27.	59 11.	3 8.	3317	3358	3097	0.266	0.270	0.234	1.053	1.049	1.083	4.6	
1985	9	26	3 ECL 1 P	4 57 35.	4 59 23.	5 0 59.	0 59.	1 25.	190	189	178	22.1%	21.8%	17.5%	0.571	0.576	0.635	2.9	
1985	9	28	1 OCC 2 P		6 21 23.	6 22 49.	22 38.	23 2.	173	212	478	0.035	0.054	0.308	1.014	0.997	0.753	5.9	
1985	9	28	1 ECL 2 P	8 33 3.	8 34 27.	8 38 13.	38 2.	38 38.	446	447	443	70.9%	71.4%	65.9%	0.087	0.067	0.143	7.0	
1985	9	30	1 ECL 3 P	6 54 21.	6 57 6.	6 58 4.	58 4.	58 39.	116	111	135	0.7%	0.6%	1.1%	0.947	0.953	0.924	6.9	(2)
1985	9	30	4 ECL 3 A	23 22 8.	23 27 36.	23 30 37.	30 32.	31 28.	364	367	366	1.1%	1.1%	1.1%	0.452	0.442	0.443	13.2	(2)
1985	10	1	4 ECL 1 P	16 59 33.	17 3 51.	17 5 14.	5 4.	6 15.	170	169	185	3.5%	3.2%	4.3%	0.576	0.585	0.551	5.5	
1985	10	1	4 ECL 2 A	19 2 28.	19 6 13.	19 7 35.	7 25.	8 11.	166	164	118	1.2%	1.2%	1.2%	0.123	0.151	0.382	5.6	(2)
1985	10	1	1 OCC 2 P		19 36 49.	19 37 18.	37 8.	37 32.	58	129	420	0.005	0.023	0.273	1.033	1.016	0.779	5.9	(2)
1985	10	1	1 ECL 2 A	21 48 13.	21 49 34.	21 53 5.	53 0.	53 30.	420	421	410	69.5%	69.5%	58.7%	0.024	0.011	0.198	7.0	
1985	10	2	4 ECL 1 A	8 58 39.	9 3 52.	9 9 26.	9 37.	10 7.	676	676	629	33.8%	33.8%	30.3%	0.069	0.070	0.322	2.5	
1985	10	2	4 ECL 1 A	19 28 27.	19 33 31.	19 37 2.	36 41.	38 2.	415	415	409	12.3%	12.3%	12.3%	0.061	0.063	0.149	5.4	
1985	10	3	3 ECL 1 P	7 43 11.	7 44 52.	7 46 51.	46 51.	47 16.	234	234	229	47.4%	47.1%	42.3%	0.258	0.262	0.322	3.5	
1985	10	5	1 OCC 2			8 51 45.	51 35.	52 2.	0	0	369	0.0	0.0	0.239	1.050	1.033	0.801	5.9	(2)
1985	10	5	1 ECL 2 A	11 3 6.	11 4 25.	11 7 42.	7 37.	8 12.	395	395	377	67.6%	67.6%	51.1%	0.043	0.061	0.255	7.0	
1985	10	6	2 ECL 1	18 50 44.		18 52 27.	52 22.	53 3.				0 %	0 %	0 %	0.905	0.893	0.914	2.1	(2)
1985	10	7	1 ECL 3 P	9 48 45.	9 50 49.	9 52 30.	52 35.	53 6.	208	207	209	5.1%	5.0%	5.2%	0.649	0.655	0.645	6.5	
1985	10	8	1 OCC 2			22 4 47.	4 37.	5 5.	0	0	325	0.0	0.0	0.208	1.064	1.047	0.822	5.9	(2)
1985	10	9	1 ECL 2 P	0 16 37.	0 17 56.	0 21 3.	20 53.	21 29.	372	371	348	65.0%	63.5%	43.7%	0.106	0.125	0.311	7.0	
1985	10	10	2 ECL 1	7 57 13.		7 59 7.	59 2.	59 42.				0 %	0 %	0 %	0.809	0.797	0.820	2.3	(2)
1985	10	10	3 ECL 1 A	10 30 34.	10 32 16.	10 34 24.	34 29.	34 54.	258	258	258	56.6%	56.6%	56.6%	0.030	0.029	0.036	4.1	
1985	10	10	2 ECL 4	11 48 49.		11 53 36.	53 26.	54 47.				0 %	0 %	0 %	0.065	0.086	0.274	3.4	(2)
1985	10	10	1 ECL 4	23 36 11.		23 40 36.	40 26.	42 12.				0 %	0 %	0 %	0.567	0.566	0.655	8.1	(2)
1985	10	12	1 OCC 2			11 18 4.	17 54.	18 25.	0	0	287	0.0	0.0	0.179	1.074	1.057	0.839	5.8	(2)
1985	10	12	1 ECL 2 P	13 30 0.	13 31 18.	13 34 12.	34 7.	34 42.	348	346	317	57.8%	55.7%	36.2%	0.171	0.190	0.369	7.0	
1985	10	13	2 ECL 1 P	21 3 47.	21 5 33.	21 5 46.	5 41.	6 22.	20	33		0.0%	0.1%	0 %	0.715	0.703	0.729	2.4	(2)
1985	10	14	1 ECL 3 A	12 39 27.	12 41 14.	12 43 14.	43 14.	43 50.	240	240	239	4.7%	4.7%	4.7%	0.345	0.350	0.358	6.0	
1985	10	16	1 OCC 2			0 30 21.	30 11.	30 43.	0	0	254	0.0	0.0	0.154	1.080	1.064	0.852	5.8	(2)
1985	10	16	1 ECL 2 P	2 42 21.	2 43 39.	2 46 23.	46 12.	46 53.	325	322	288	49.7%	47.5%	29.0%	0.236	0.255	0.426	6.9	
1985	10	17	2 ECL 1 P	10 10 22.	10 11 50.	10 12 28.	12 23.	13 3.	73	78	66	1.8%	2.1%	1.3%	0.624	0.612	0.640	2.6	(2)
1985	10	17	3 ECL 1 P	13 20 30.	13 22 18.	13 24 33.	24 33.	24 58.	266	266	270	47.7%	48.1%	52.9%	0.284	0.280	0.226	4.7	
1985	10	19	1 OCC 2			13 43 1.	42 51.	43 25.	0	0	226	0.0	0.0	0.134	1.082	1.066	0.861	5.7	(2)
1985	10	19	1 ECL 2 P	15 54 38.	15 55 57.	15 58 27.	58 17.	58 57.	300	297	257	41.3%	39.2%	22.0%	0.301	0.321	0.484	6.9	
1985	10	20	4 ECL 3	7 23 47.		7 31 35.	31 25.	31 55.				0 %	0 %	0 %	1.040	1.030	1.304	10.6	(2)
1985	10	20	2 ECL 1 P	23 17 3.	23 18 21.	23 19 10.	19 10.	19 51.	101	104	95	4.6%	5.1%	3.9%	0.535	0.523	0.554	2.7	
1985	10	21	1 ECL 3 A	15 27 57.	15 29 37.	15 31 37.	31 37.	32 13.	244	244	244	4.1%	4.1%	4.1%	0.046	0.050	0.072	5.5	
1985	10	23	1 OCC 2			2 54 57.	54 48.	55 22.	0	0	204	0.0	0.0	0.118	1.080	1.063	0.865	5.7	(2)
1985	10	23	1 ECL 2 P	5 6 7.	5 7 27.	5 9 41.	9 36.	10 17.	275	270	224	33.0%	31.0%	15.4%	0.367	0.386	0.543	6.8	
1985	10	24	2 ECL 1 P	12 23 44.	12 24 57.	12 25 57.	25 52.	26 32.	120	123	116	7.7%	8.2%	7.0%	0.449	0.438	0.470	2.8	
1985	10	24	3 ECL 1 P	16 14 11.	16 16 11.	16 18 21.	18 26.	18 51.	260	260	269	28.8%	29.1%	33.5%	0.501	0.498	0.450	5.2	
1985	10	26	3 ECL 4	2 44 15.		2 52 10.	52 0.	53 21.				0 %	0 %	0 %	0.892	0.902	0.871	7.4	(2)
1985	10	26	1 OCC 2			16 7 15.	7 6.	7 42.	0	0	187	0.0	0.0	0.108	1.072	1.056	0.865	5.6	(2)
1985	10	26	1 ECL 2 P	18 17 33.	18 18 55.	18 20 59.	20 49.	21 30.	247	242	187	25.0%	23.1%	9.4%	0.433	0.452	0.602	6.8	
1985	10	27	1 ECL 4	4 35 4.		4 36 27.	36 11.	37 58.				0 %	0 %	0 %	1.696	1.702	1.672	3.1	(2)
1985	10	27	2 ECL 4	21 3 40.		21 8 50.	8 40.	10 11.				0 %	0 %	0 %	0.011	0.011	0.208	9.6	(2)
1985	10	28	2 ECL 1 P	1 30 30.	1 31 40.	1 32 45.	32 45.	33 25.	136	137	132	10.3%	10.4%	9.7%	0.367	0.354	0.389	2.9	
1985	10	28	1 ECL 3 A	18 14 30.	18 16 11.	18 18 3.	18 3.	18 34.	224	224	228	3.7%	3.7%	3.7%	0.252	0.248	0.215	4.9	
1985	10	30	1 OCC 2			5 19 2.	18 52.	19 28.	0	0	176	0.0	0.0	0.103	1.060	1.044	0.859	5.6	(2)
1985	10	30	1 ECL 2 P	7 28 18.	7 29 43.	7 31 29.	31 24.	32 5.	217	210	144	17.5%	15.7%	4.4%	0.499	0.518	0.661	6.7	
1985	10	31	2 ECL 1 A	14 37 16.	14 38 24.	14 39 39.	39 34.	40 15.	147	149	144	10.6%	10.6%	10.6%	0.286	0.274	0.310	3.1	
1985	10	31	3 ECL 1 P	19 13 34.	19 15 57.	19 17 59.	18 4.	18 25.	243	245	258	14.5%	14.7%	17.8%	0.676	0.673	0.636	5.5	
1985	11	2	1 OCC 2			18 31 10.	31 1.	31 38.	0	0	171	0.0	0.0	0.105	1.042	1.026	0.848	5.5	(2)
1985	11	2	1 ECL 2 P	20 39 1.	20 40 34.	20 42 2.	41 57.	42 38.	182	174	75	10.7%	9.1%	0.7%	0.565	0.584	0.721	6.6	
1985	11	3	4 OCC 2 P		5 52 1.	5 59 9.	58 46.	0 6.	862	868	889	0.905	0.935	1.056	0.323	0.297	0.193	9.3	
1985	11	4	4 OCC 2 T		2 42 2.	2 53 36.	54 5.	52 44.	1385	1386	1382	1.034	1.041	1.026	0.211	0.206	0.219	0.9	(3)(12)
1985	11	4	2 ECL 1 A	3 44 8.	3 45 14.	3 46 32.	46 27.	47 8.	156	157	154	10.8%	10.8%	10.8%	0.209	0.197	0.234	3.2	
1985	11	4	4 ECL 3	18 17 14.		18 20 42.	20 37.	21 12.				0 %	0 %	0 %	1.841	1.840	2.006	2.8	(2)
1985	11	4	1 ECL 3 A	20 59 55.	21 1 43.	21 3 13.	3 13.	3 48.	177	178	186	3.5%	3.5%	3.5%	0.537	0.533	0.491	4.2	
1985	11	5	4 ECL 1	3 11 30.		3 24 39.	24 59.	24 44.				0 %	0 %	0 %	1.092	1.091	1.342	4.6	(2)
1985	11	5	4 ECL 1	8 8 24.		8 20 8.	19 43.	21 39.				0 %	0 %	0 %	1.231	1.228	1.448	5.8	(2)
1985	11	5	4 ECL 2 A	12 49 6.	12 53 23.	12 55 25.	55 10.	56 6.	247	247	230	6.6%	6.6%	6.6%	0.018	0.014	0.195	6.4	
1985	11	6	1 OCC 2			7 42 55.	42 46.	43 24.	0	0	171	0.0	0.0	0.114	1.019	1.003	0.832	5.4	(2)
1985	11	6	1 ECL 2 P	9 49 13.	9 50 54.	9 52 6.	51 56.	52 36.	140	129		4.9%	3.7%	0 %	0.631	0.650	0.781	6.6	
1985	11	7	2 ECL 1 A	16 51 1.	16 52 6.	16 53 27.	53 22.	54 3.	163	163	161	10.9%	10.9%	10.9%	0.134	0.123	0.160	3.3	
1985	11	7	3 ECL 1 P	22 21 14.	22 24 11.	22 26 4.	26 9.	26 24.	223	225	239	5.9%	6.1%	7.6%	0.802	0.800	0.776	5.8	
1985	11	9	3 ECL 2	0 42 28.		0 42 53.	44 51.	42 23.		0		0 %	0 %	0 %	1.444	1.455	1.441	7.1	(2)
1985	11	9	1 OCC 2			20 55 1.	54 52.	55 31.	0	0	176	0.0	0.0	0.130	0.990	0.974	0.809	5.4	(2)
1985	11	9	1 ECL 2 P	22 59 27.	23 1 27.	23 2 6.	1 56.	2 36.	74	50		0.7%	0.2%	0 %	0.698	0.716	0.841	6.5	(2)
1985	11	11	2 ECL 1 A	5 57 58.	5 59 3.	6 0 27.	0 22.	1 3.	167	167	166	11.1%	11.1%	11.1%	0.062	0.051	0.089	3.4	
1985	11	11	2 OCC 4			20 13 45.	13 31.	15 16.	0	0	178	0.0	0.0	0.051	1.116	1.090	1.002	7.8	(2)
1985	11	13	1 OCC 2			10 6 49.	6 40.	7 18.	0	0	184	0.0	0.0	0.153	0.955	0.940	0.782	5.3	(2)
1985	11	13	1 ECL 2	12 9 11.		12 11 32.	11 27.	12 8.				0 %	0 %	0 %	0.764	0.783	0.902	6.4	(2)
1985	11	14	2 ECL 4	2 36 0.		2 46 41.	46 21.	49 18.				0 %	0 %	0 %	0.124	0.109	0.233	13.7	(2)
1985	11	14	2 ECL 1 A	19 4 59.	19 6 3.	19 7 29.	7 24.	8 4.	169	169	169	11.3%	11.3%	11.3%	0.010	0.021	0.022	3.5	
1985	11	14	3 OCC 1 P		21 57 16.	21 58 47.	58 52.	59 14.	177	173	140	0.087	0.082	0.053	1.113	1.117	1.146	5.1	
1985	11	15	3 ECL 1 P	1 44 35.	1 48 25.	1 50 23.	50 33.	50 28.	236	239	242	2.8%	2.9%	3.1%	0.865	0.863	0.859	5.9	
1985	11	15	3 ECL 1 P	14 21 23.	14 24 33.	14 34 56.	34 20.	38 13.	1244	1243	1252	96.7%	96.2%	100 %	0.097	0.102	0.034	2.0	
1985	11	15	3 ECL 1 P	23 42 48.	23 46 1.	23 52 26.	52 36.	51 30.	759	758	762	91.2%	91.5%	84.5%	0.030	0.026	0.089	5.8	
1985	11	16	3 ECL 2	4 5 27.		4 8 34.	8 29.	8 4.				0 %	0 %	0 %	1.172	1.179	1.161	6.8	(2)
1985	11	16	1 OCC 2			23 18 56.	18 47.	19 26.	0	0	194	0.0	0.0	0.184	0.915	0.900	0.748	5.2	(2)
1985	11	17	1 ECL 2	1 18 58.		1 21 6.	20 56.	21 41.				0 %	0 %	0 %	0.831	0.850	0.963	6.3	(2)
1985	11	18	2 ECL 1 A	8 12 2.	8 13 7.	8 14 34.	14 29.	15 10.	170	170	171	11.5%	11.5%	11.5%	0.075	0.085	0.046	3.6	
1985	11	18	2 ECL 3	18 33 18.		18 35 30.	35 30.	35 30.				0 %	0 %	0 %	1.275	1.290	1.427	1.6	(2)
1985	11	20	4 OCC 1 P		9 23 21.	9 29 46.	29 22.	30 52.	785	795	784	0.238	0.246	0.236	0.890	0.882	0.891	5.9	
1985	11	20	1 OCC 2 P		12 30 12.	12 30 48.	30 39.	31 20.	72	96	205	0.025	0.044	0.222	0.870	0.854	0.709	5.1	(2)
1985	11	20	1 ECL 2	14 28 23.		14 30 11.	30 1.	30 46.				0 %	0 %	0 %	0.897	0.916	1.024	6.2	(2)
1985	11	20	4 OCC 1 P		15 3 7.	15 11 49.	12 7.	12 32.	1023	1030	1151	0.308	0.314	0.410	0.822	0.816	0.723	3.5	
1985	11	21	2 ECL 1 A	21 19 9.	21 20 15.	21 21 37.	21 37.	22 12.	169	168	171	11.7%	11.7%	11.7%	0.138	0.149	0.110	3.7	
1985	11	22	3 OCC 1 P		1 12 4.	1 15 17.	15 24.	15 42.	387	385	374	0.316	0.312	0.294	0.870	0.874	0.891	5.6	
1985	11	22	3 ECL 1 P	5 45 32.	5 51 11.	5 55 31.	55 51.	54 55.	535	541	482	6.3%	6.6%	4.6%	0.821	0.818	0.847	5.5	
1985	11	22	3 ECL 1 P	12 32 38.	12 36 45.	12 48 53.	48 13.	52 16.	1431	1435	1378	80.2%	80.7%	65.9%	0.220	0.217	0.330	1.2	(3)
1985	11	23	3 ECL 1 P	3 28 10.	3 30 39.	3 34 33.	34 39.	34 13.	460	460	454	49.1%	49.5%	45.8%	0.335	0.331	0.363	5.3	
1985	11	23	3 ECL 2	7 28 14.		7 32 13.	32 13.	31 48.				0 %	0 %	0 %	0.893	0.898	0.872	6.5	(2)
1985	11	24	1 OCC 2 P		1 41 58.	1 42 60.	42 50.	43 32.	122	136	217	0.078	0.097	0.270	0.818	0.803	0.664	5.0	
1985	11	24	1 ECL 2	3 37 55.		3 39 18.	39 8.	39 20.			0	0 %	0 %	0 %	0.964	0.983	1.137	6.1	(2)
1985	11	25	2 ECL 1 A	10 26 20.	10 27 26.	10 28 47.	28 47.	29 23.	166	165	169	12.0%	12.0%	12.0%	0.199	0.210	0.170	3.8	
1985	11	27	1 OCC 2 P		14 53 38.	14 54 57.	54 48.	55 30.	157	167	229	0.140	0.159	0.325	0.761	0.746	0.614	4.9	
1985	11	27	1 ECL 2	16 47 8.		16 48 1.	47 56.	48 5.			0	0 %	0 %	0 %	1.031	1.050	1.213	6.0	(2)
1985	11	28	2 ECL 1 A	23 33 34.	23 34 42.	23 36 2.	36 2.	36 38.	162	160	165	12.2%	12.2%	12.2%	0.257	0.269	0.227	3.8	

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Table 1 (continued)

Year {1}	m. {2}	day {3}	Phenomenon {4}	Dates of the beginning {5} h m s	{6} h m s	Date of the maximum: G-5 {7} h m s	E-2 {8} m s	SV2 {9} m s	Duration(^{s}): G-5 {10}	E-2 {11}	SV2 {12}	Magnitude : G-5 {13}	E-2 {14}	SV2 {15}	Impact parameter(") G-5 {16}	E-2 {17}	SV2 {18}	DJ (R_J) {19}	Notes: {20}
1985	11	29	3 OCC 1 P		4 49 30.	4 54 57.	55 8.	55 14.	659	658	656	0.543	0.539	0.541	0.639	0.643	0.642	5.9	
1985	11	29	3 OCC 1 P		16 13 4.	16 19 54.	19 20.	22 30.	821	811	1002	0.233	0.227	0.369	0.931	0.937	0.803	0.3	(3)
1985	11	30	3 ECL 1 P	6 45 22.	6 47 54.	6 50 6.	50 11.	50 6.	267	268	264	14.3%	14.6%	13.8%	0.634	0.631	0.640	4.8	
1985	11	30	3 ECL 2 P	10 49 55.	10 52 46.	10 54 26.	54 21.	54 0.	198	196	214	9.5%	9.2%	12.3%	0.608	0.611	0.577	6.2	
1985	12	1	1 OCC 2 P		4 5 38.	4 7 11.	7 2.	7 44.	185	192	240	0.210	0.229	0.389	0.699	0.683	0.557	4.8	
1985	12	2	2 ECL 1 P	12 40 53.	12 42 3.	12 43 20.	43 20.	43 55.	155	153	161	12.4%	12.1%	12.5%	0.313	0.325	0.283	3.9	
1985	12	4	1 OCC 2 P		17 17 30.	17 19 14.	19 5.	19 48.	207	213	250	0.288	0.308	0.461	0.631	0.615	0.495	4.7	
1985	12	6	2 ECL 1 P	1 48 14.	1 49 28.	1 50 40.	50 35.	51 16.	148	145	154	10.6%	10.1%	11.8%	0.367	0.378	0.337	4.0	
1985	12	6	3 OCC 1 P		9 41 15.	9 57 42.	58 25.	56 56.	2164	2178	2157	0.715	0.711	0.757	0.468	0.472	0.429	5.4	
1985	12	6	3 OCC 1 P		13 25 36.	13 46 31.	45 31.	49 52.	2345	2355	2419	0.591	0.586	0.685	0.584	0.588	0.496	3.3	
1985	12	7	3 ECL 1	9 50 12.		9 53 42.	53 47.	53 52.				0 %	0 %	0 %	0.930	0.927	0.919	4.2	(2)
1985	12	7	3 ECL 2 P	14 10 46.	14 13 10.	14 15 30.	15 30.	15 9.	282	282	289	41.6%	41.4%	47.0%	0.317	0.318	0.278	5.9	
1985	12	7	4 OCC 1 P		16 38 44.	16 41 3.	40 53.	42 1.	278	279	278	0.491	0.495	0.489	0.617	0.613	0.619	1.2	(3)
1985	12	8	1 OCC 2 P		6 29 38.	6 31 31.	31 22.	32 6.	226	231	259	0.376	0.396	0.543	0.557	0.542	0.428	4.6	
1985	12	9	4 OCC 3 P		5 5 14.	5 11 13.	11 1.	11 28.	718	715	782	0.487	0.480	0.658	0.623	0.632	0.397	13.0	
1985	12	9	2 ECL 1 P	14 55 39.	14 56 57.	14 58 14.	57 59.	58 40.	136	134	144	7.9%	7.6%	9.6%	0.423	0.429	0.388	4.1	
1985	12	10	2 OCC 3 P		1 7 57.	1 9 36.	9 36.	9 24.	199	206	270	0.116	0.125	0.232	0.895	0.883	0.741	4.9	
1985	12	10	1 OCC 3 P		8 19 59.	8 21 43.	21 42.	22 6.	207	205	192	0.197	0.193	0.166	0.859	0.864	0.900	1.0	(3)
1985	12	11	1 OCC 2 P		19 41 41.	19 43 42.	43 33.	44 16.	241	245	266	0.473	0.493	0.633	0.478	0.463	0.355	4.5	
1985	12	13	2 ECL 1 P	4 3 9.	4 4 31.	4 5 30.	5 30.	6 11.	124	121	134	5.7%	5.2%	7.2%	0.466	0.477	0.438	4.2	
1985	12	14	3 OCC 1 P		10 10 15.	10 11 33.	11 37.	11 45.	157	150	184	0.068	0.062	0.094	1.048	1.054	1.025	5.1	
1985	12	14	3 ECL 1	12 48 13.		12 50 18.	50 23.	50 33.				0 %	0 %	0 %	1.221	1.219	1.195	3.6	(2)
1985	12	14	3 ECL 2 A	17 30 52.	17 33 8.	17 35 35.	35 35.	35 20.	298	298	298	74.6%	74.6%	74.6%	0.022	0.024	0.028	5.6	
1985	12	15	3 OCC 4 P		1 6 54.	1 11 16.	11 7.	12 27.	525	528	517	0.331	0.337	0.320	0.855	0.848	0.869	11.6	
1985	12	15	1 OCC 2 P		8 53 55.	8 56 1.	55 53.	56 37.	253	256	271	0.578	0.599	0.732	0.394	0.378	0.276	4.4	
1985	12	15	1 OCC 4 A		20 4 54.	20 8 27.	8 14.	10 10.	427	427	427	0.880	0.874	0.849	0.001	0.008	0.038	4.2	
1985	12	16	2 ECL 1 P	17 10 44.	17 12 11.	17 13 7.	13 2.	13 42.	109	104	120	3.5%	3.0%	4.8%	0.513	0.523	0.484	4.2	
1985	12	16	1 OCC 4 P		20 9 57.	20 33 45.	32 51.	39 32.	2521	2549	2505	0.543	0.541	0.699	0.401	0.404	0.216	5.8	
1985	12	17	2 OCC 3 P		4 37 57.	4 40 52.	40 52.	40 40.	349	352	373	0.435	0.445	0.552	0.466	0.453	0.314	5.3	
1985	12	17	1 OCC 3 P		11 15 2.	11 17 26.	17 26.	17 50.	288	287	280	0.433	0.430	0.399	0.539	0.543	0.583	1.8	
1985	12	18	1 OCC 2 P		22 6 5.	22 8 16.	8 7.	8 52.	262	264	274	0.692	0.713	0.840	0.305	0.289	0.192	4.3	
1985	12	20	2 ECL 1 P	6 18 25.	6 19 58.	6 20 42.	20 37.	21 18.	88	81	101	1.6%	1.2%	2.7%	0.556	0.567	0.528	4.3	(2)
1985	12	21	3 OCC 1 P		13 22 35.	13 25 3.	25 5.	25 14.	296	294	297	0.358	0.353	0.362	0.773	0.777	0.770	4.5	
1985	12	21	3 ECL 2 P	20 50 40.	20 53 1.	20 55 10.	55 10.	54 49.	262	262	251	42.4%	42.2%	34.8%	0.279	0.281	0.335	5.3	
1985	12	22	1 OCC 2 P		11 18 24.	11 20 37.	20 29.	21 14.	267	269	274	0.815	0.836	0.956	0.210	0.194	0.103	4.2	
1985	12	23	2 ECL 1 P	19 26 8.	19 27 57.	19 28 20.	28 20.	28 55.	53	33	78	0.3%	0.1%	1.0%	0.598	0.609	0.571	4.4	(2)
1985	12	24	4 OCC 1 P		1 8 16.	1 18 51.	18 23.	20 5.	1322	1312	1301	0.627	0.618	0.593	0.474	0.482	0.504	5.8	
1985	12	24	4 OCC 1 P		6 3 31.	6 17 18.	17 42.	17 46.	1595	1588	1520	0.770	0.765	0.645	0.346	0.351	0.458	3.7	
1985	12	24	2 OCC 3 A		8 11 5.	8 14 26.	14 26.	14 16.	402	402	399	0.769	0.779	0.701	0.031	0.018	0.119	5.7	
1985	12	24	1 OCC 3 P		14 12 46.	14 15 34.	15 34.	15 58.	336	336	333	0.680	0.678	0.646	0.215	0.217	0.259	2.6	
1985	12	25	4 OCC 1 T		2 35 12.	2 38 49.	38 38.	39 51.	433	433	425	1.018	1.019	0.907	0.125	0.125	0.224	4.3	(13)
1985	12	26	1 OCC 2 P		0 30 41.	0 32 56.	32 47.	33 32.	269	270	272	0.946	0.968	1.081	0.110	0.094	0.009	4.1	
1985	12	27	2 ECL 1	8 33 59.		8 36 10.	36 5.	36 46.			26	0 %	0 %	0.0%	0.637	0.648	0.611	4.4	(2)
1985	12	28	3 OCC 1 P		16 29 38.	16 32 31.	32 33.	32 45.	345	344	342	0.708	0.703	0.691	0.454	0.457	0.469	3.8	
1985	12	29	3 ECL 2 P	0 9 30.	0 12 21.	0 13 36.	13 31.	13 10.	143	141	88	5.4%	5.2%	1.2%	0.582	0.585	0.646	5.0	
1985	12	29	1 OCC 2 T		13 43 5.	13 45 19.	45 11.	45 56.	267	267	265	1.086	1.079	0.972	0.006	0.011	0.090	3.9	(14)
1985	12	30	2 OCC 1			20 29 34.	29 34.	30 11.	0	20	0	0.0	0.003	0.0	0.817	0.809	0.851	3.7	(2)
1985	12	30	2 ECL 1	21 41 53.		21 44 1.	43 56.	44 36.				0 %	0 %	0 %	0.674	0.685	0.649	4.5	(2)
1985	12	31	2 OCC 3 P		11 47 1.	11 50 11.	50 11.	50 3.	380	377	346	0.474	0.463	0.356	0.404	0.418	0.553	6.1	
1985	12	31	1 OCC 3 A		17 13 49.	17 16 49.	16 49.	17 13.	361	361	362	0.765	0.766	0.797	0.105	0.103	0.064	3.3	
1986	1	2	1 OCC 2 P		2 55 28.	2 57 38.	57 30.	58 15.	261	260	255	0.953	0.930	0.830	0.104	0.121	0.195	3.8	
1986	1	2	1 OCC 4 P		6 7 37.	6 9 16.	9 5.	10 50.	199	197	188	0.166	0.164	0.148	0.823	0.826	0.844	1.3	(3)
1986	1	3	2 OCC 4 P		23 58 8.	0 0 28.	0 15.	2 20.	280	269	398	0.096	0.088	0.210	0.834	0.843	0.703	8.5	(19)
1986	1	3	2 OCC 1 P		9 40 60.	9 42 3.	42 0.	42 40.	125	130	102	0.108	0.117	0.071	0.712	0.704	0.745	3.9	
1986	1	3	3 OCC 4 P		10 39 18.	10 44 19.	44 13.	45 59.	603	607	459	0.394	0.401	0.206	0.753	0.745	0.969	12.5	
1986	1	3	2 ECL 1	10 49 58.		10 51 57.	51 57.	52 37.				0 %	0 %	0 %	0.709	0.719	0.685	4.6	(2)
1986	1	4	3 OCC 1 T		19 33 46.	19 36 42.	36 44.	36 56.	353	353	352	1.108	1.105	1.074	0.099	0.102	0.129	3.1	(15)
1986	1	5	3 ECL 2	3 27 59.		3 31 13.	31 13.	30 53.				0 %	0 %	0 %	0.889	0.893	0.960	4.7	(2)
1986	1	5	1 OCC 2 P		16 7 56.	16 10 1.	9 53.	10 39.	249	247	240	0.797	0.774	0.680	0.218	0.235	0.304	3.7	
1986	1	6	2 OCC 1 P		22 53 11.	22 54 39.	54 37.	55 17.	177	180	163	0.224	0.233	0.187	0.608	0.599	0.639	4.0	
1986	1	6	2 ECL 1	23 58 3.		23 59 57.	59 57.	0 33.				0 %	0 %	0 %	0.741	0.752	0.718	4.6	(2)
1986	1	7	2 OCC 3 P		15 26 18.	15 28 13.	28 12.	28 7.	231	221	51	0.125	0.113	0.006	0.837	0.851	0.985	6.5	
1986	1	7	1 OCC 3 P		20 19 22.	20 22 22.	22 22.	22 46.	362	362	367	0.520	0.521	0.548	0.410	0.409	0.375	4.0	
1986	1	9	1 OCC 2 P		5 20 25.	5 22 21.	22 13.	22 59.	231	229	217	0.633	0.609	0.522	0.337	0.354	0.418	3.5	
1986	1	9	4 OCC 3 P		5 37 5.	5 41 28.	41 21.	42 24.	527	521	522	0.280	0.273	0.275	0.846	0.855	0.853	12.0	
1986	1	10	2 OCC 1 P		12 5 50.	12 7 37.	7 34.	8 14.	214	216	205	0.340	0.349	0.305	0.504	0.496	0.535	4.1	
1986	1	10	2 ECL 1	13 6 21.		13 8 10.	8 10.	8 46.				0 %	0 %	0 %	0.771	0.782	0.750	4.7	(2)
1986	1	11	4 OCC 2 P		4 41 43.	5 13 28.	14 41.	9 7.	4303	4380	4078	0.864	0.893	0.795	0.305	0.284	0.355	7.0	
1986	1	11	4 OCC 2 T		9 23 19.	10 2 50.	1 26.	7 20.	4196	4233	4061	1.170	1.146	1.248	0.081	0.098	0.024	8.6	(16)
1986	1	11	3 OCC 1 P		22 35 45.	22 38 28.	38 29.	38 44.	325	325	328	0.892	0.895	0.941	0.284	0.282	0.242	2.3	
1986	1	12	3 OCC 2			4 53 37.	53 32.	53 18.	0	0	112	0.0	0.0	0.053	1.020	1.019	0.949	5.6	(2)
1986	1	12	3 ECL 2	6 46 4.		6 47 56.	47 51.	47 36.				0 %	0 %	0 %	1.199	1.204	1.278	4.5	(2)
1986	1	12	1 OCC 2 P		18 33 1.	18 34 43.	34 35.	35 22.	205	201	185	0.461	0.437	0.356	0.461	0.478	0.537	3.4	
1986	1	14	2 OCC 1 P		1 18 43.	1 20 44.	20 42.	21 22.	242	244	236	0.456	0.466	0.423	0.402	0.394	0.431	4.3	
1986	1	14	2 ECL 1	2 14 40.		2 16 21.	16 21.	17 2.				0 %	0 %	0 %	0.799	0.810	0.779	4.8	(2)
1986	1	14	1 OCC 3 P		23 31 41.	23 34 26.	34 27.	34 45.	332	333	341	0.294	0.295	0.315	0.686	0.685	0.660	4.7	
1986	1	16	1 OCC 2 P		7 45 39.	7 47 2.	46 54.	47 41.	166	160	137	0.282	0.258	0.183	0.588	0.606	0.660	3.3	
1986	1	17	2 OCC 1 P		14 32 2.	14 34 14.	34 12.	34 52.	265	266	261	0.570	0.581	0.540	0.302	0.293	0.329	4.4	
1986	1	17	2 ECL 1	15 23 14.		15 24 53.	24 48.	25 29.				0 %	0 %	0 %	0.825	0.835	0.807	4.8	(2)
1986	1	19	3 OCC 1 P		1 36 51.	1 38 54.	38 56.	39 14.	246	247	260	0.419	0.420	0.480	0.688	0.687	0.636	1.5	(1)
1986	1	19	3 OCC 2 P		8 28 13.	8 30 53.	30 49.	30 38.	321	322	341	0.596	0.601	0.708	0.548	0.545	0.468	5.1	(1)
1986	1	19	1 OCC 2 P		20 58 31.	20 59 21.	59 13.	59 57.	100	87	12	0.096	0.071	0.002	0.721	0.738	0.788	3.1	(1)
1986	1	21	2 OCC 1 P		3 45 32.	3 47 53.	47 51.	48 31.	283	284	280	0.684	0.695	0.656	0.204	0.195	0.228	4.5	(1)
1986	1	21	2 ECL 1	4 31 53.		4 33 22.	33 17.	33 57.				0 %	0 %	0 %	0.848	0.859	0.832	4.9	(1)(2)
1986	1	22	1 OCC 3 P		2 54 1.	2 56 5.	56 6.	56 17.	248	249	258	0.103	0.104	0.113	0.915	0.914	0.904	5.3	(1)
1986	1	22	1 ECL 3 P	20 28 34.	20 35 15.	20 45 28.	44 52.	47 54.	1244	1252	915	6.3%	6.5%	2.4%	0.687	0.682	0.790	4.2	(1)
1986	1	23	1 ECL 3	1 15 24.		1 26 28.	26 44.	26 18.				0 %	0 %	0 %	1.010	1.008	1.062	6.5	(1)(2)
1986	1	24	2 OCC 1 P		16 59 27.	17 1 56.	1 54.	2 33.	297	297	295	0.796	0.806	0.770	0.108	0.099	0.129	4.6	(1)
1986	1	24	2 ECL 1	17 40 45.		17 42 4.	42 4.	42 40.				0 %	0 %	0 %	0.869	0.880	0.855	4.9	(1)(2)
1986	1	26	3 OCC 2 T		12 4 56.	12 8 5.	8 1.	7 53.	378	378	378	1.295	1.302	1.292	0.043	0.038	0.045	4.7	(1)(17)
1986	1	28	2 OCC 1 A		6 13 33.	6 16 6.	16 4.	16 43.	307	307	306	0.906	0.917	0.883	0.014	0.005	0.033	4.7	(1)
1986	1	28	2 ECL 1	6 49 38.		6 50 49.	50 49.	51 25.				0 %	0 %	0 %	0.889	0.899	0.876	5.0	(1)(2)
1986	1	30	1 OCC 3 P		4 29 24.	4 37 44.	37 52.	37 53.	982	982	972	0.564	0.566	0.533	0.347	0.344	0.384	5.9	(1)
1986	1	31	2 OCC 1 P		19 28 8.	19 30 44.	30 42.	31 22.	313	313	314	0.832	0.821	0.851	0.077	0.086	0.061	4.9	(1)
1986	1	31	2 ECL 1	19 58 52.		19 59 56.	59 56.	60 32.				0 %	0 %	0 %	0.905	0.915	0.895	5.1	(1)(2)
1986	2	2	3 OCC 2 P		15 42 29.	15 45 8.	45 3.	44 57.	318	317	294	0.663	0.653	0.529	0.495	0.502	0.590	4.2	(1)
1986	2	15	2 OCC 1 P		0 29 40.	0 32 12.	32 10.	32 49.	303	301	304	0.443	0.432	0.445	0.404	0.414	0.403	5.3	(1)
1986	2	18	2 OCC 1 P		13 45 54.	13 48 19.	48 18.	48 56.	291	287	290	0.358	0.346	0.354	0.476	0.486	0.479	5.4	(1)
1986	2	22	2 OCC 1 P		3 2 57.	3 5 14.	5 13.	5 51.	274	270	270	0.280	0.268	0.270	0.542	0.552	0.550	5.4	(1)
1986	2	25	2 OCC 1 P		16 20 11.	16 22 16.	22 15.	22 52.	252	245	243	0.207	0.195	0.191	0.604	0.614	0.617	5.5	(1)
1986	3	1	2 OCC 1 P		5 38 25.	5 40 16.	40 15.	40 52.	223	213	205	0.142	0.131	0.120	0.659	0.669	0.678	5.6	(1)
1986	3	4	2 OCC 1 P		18 56 58.	18 58 29.	58 28.	59 4.	183	169	149	0.084	0.072	0.055	0.710	0.720	0.735	5.7	(1)
1986	3	8	2 OCC 1 P		8 16 53.	8 17 56.	17 55.	18 31.	127	102	0	0.035	0.024	0.0	0.753	0.763	0.784	5.7	(1)
1986	3	11	2 ECL 1	20 56 30.		20 57 9.	56 22.	56 58.		0	0	0 %	0 %	0 %	0.921	1.101	1.122	5.6	(1)(2)
1986	3	15	2 ECL 1	10 9 51.		10 10 53.	10 53.	10 40.			0	0 %	0 %	0 %	0.903	0.913	1.104	5.7	(1)(2)
1986	3	18	2 ECL 1	23 23 28.		23 24 51.	24 51.	24 36.			0	0 %	0 %	0 %	0.884	0.893	1.084	5.7	(1)(2)
1986	3	22	2 ECL 1	12 38 36.		12 40 27.	40 27.	41 3.				0 %	0 %	0 %	0.859	0.868	0.902	5.8	(2)
1986	3	26	2 ECL 1	1 54 14.		1 56 33.	56 33.	57 4.				0 %	0 %	0 %	0.831	0.840	0.881	5.8	(2)
1986	3	28	2 OCC 3 P		13 19 29.	13 52 59.	51 30.	53 40.	4277	4287	4411	0.519	0.533	0.596	0.341	0.324	0.246	4.7	
1986	3	28	2 OCC 3 A		20 54 31.	21 27 42.	28 34.	28 46.	3696	3687	3741	0.628	0.638	0.684	0.206	0.193	0.135	8.3	
1986	3	29	2 ECL 1	15 11 51.		15 14 54.	14 54.	15 24.				0 %	0 %	0 %	0.796	0.805	0.853	5.8	(2)

Table 1 (continued)

Year {1}	m. {2}	day {3}	Phenomenon {4}	Dates of the beginning {5} h m s	{6} h m s	Date of the maximum: G-5 {7} h m s	E-2 {8} m s	SV2 {9} m s	Duration($^{\mathrm{s}}$): G-5 {10}	E-2 {11}	SV2 {12}	Magnitude : G-5 {13}	E-2 {14}	SV2 {15}	Impact parameter(") G-5 {16}	E-2 {17}	SV2 {18}	DJ (R_J) {19}	Notes: {20}
1986	4	2	2 ECL 1	4 30 32.		4 34 15.	34 15.	34 45.				0 %	0 %	0 %	0.759	0.768	0.824	5.9	(2)
1986	4	4	2 ECL 3 P	14 15 56.	14 22 51.	14 49 49.	48 28.	50 50.	3379	3411	3579	16.3%	17.0%	18.9%	0.450	0.432	0.356	2.6	
1986	4	4	2 ECL 3 A	22 20 55.	22 29 32.	22 55 48.	56 34.	56 39.	2970	2970	3023	14.9%	14.9%	14.9%	0.219	0.204	0.148	6.7	
1986	4	5	2 OCC 3 P		3 59 28.	4 8 44.	9 2.	9 47.	1103	1114	1175	0.234	0.240	0.274	0.704	0.696	0.653	9.2	
1986	4	5	2 ECL 1	17 52 30.		17 57 18.	57 18.	57 39.				0 %	0 %	0 %	0.713	0.722	0.787	5.9	(2)
1986	4	5	2 OCC 1 P		19 56 35.	19 58 45.	58 47.	58 57.	262	180	0	0.023	0.011	0.0	0.788	0.798	0.899	5.6	(2)
1986	4	6	2 OCC 1 P		3 27 30.	3 34 51.	34 50.	37 12.	883	819	0	0.113	0.096	0.0	0.709	0.724	0.914	0.7	(3)
1986	4	6	2 ECL 1	5 47 52.		5 53 12.	53 7.	55 9.			0	0 %	0 %	0 %	0.832	0.847	1.197	1.2	(2)(3)
1986	4	9	2 ECL 1 P	7 16 42.	7 20 8.	7 22 30.	22 30.	22 55.	287	263		1.4%	1.1%	0 %	0.663	0.672	0.747	5.9	(2)
1986	4	9	2 OCC 1 P		9 50 16.	9 56 38.	56 42.	56 23.	785	733	0	0.092	0.080	0.0	0.731	0.742	0.862	5.3	
1986	4	9	2 OCC 1 P		14 43 41.	14 56 11.	56 7.	58 51.	1463	1412	0	0.203	0.187	0.0	0.634	0.648	0.830	2.1	
1986	4	9	2 ECL 1 P	17 17 46.	17 21 35.	17 28 4.	27 59.	30 10.	794	728	0	3.4%	2.5%	0 %	0.671	0.686	1.008	0.1	(3)
1986	4	12	2 ECL 3 P	4 39 33.	4 44 23.	4 53 46.	54 6.	54 37.	1111	1122	1169	9.8%	10.2%	11.4%	0.513	0.502	0.459	7.4	
1986	4	12	2 ECL 1 P	20 47 8.	20 50 16.	20 54 45.	54 45.	55 6.	540	522	261	5.3%	4.8%	0.6%	0.601	0.610	0.697	5.8	
1986	4	13	2 ECL 1 P	4 52 6.	4 54 55.	5 4 59.	4 54.	7 11.	1192	1161	362	13.0%	11.8%	0.2%	0.541	0.555	0.750	1.3	(3)
1986	4	16	2 ECL 1 P	10 24 41.	10 28 5.	10 35 22.	35 27.	35 27.	899	881	620	11.1%	10.4%	3.6%	0.531	0.540	0.642	5.7	
1986	4	16	2 ECL 1 P	16 24 49.	16 27 53.	16 41 6.	40 56.	43 23.	1552	1529	1015	21.9%	20.7%	5.5%	0.443	0.456	0.643	2.4	
1986	4	19	2 ECL 3 P	9 22 5.		9 30 17.	30 27.	31 7.		75	277	0 %	0.0%	0.4%	0.862	0.854	0.819	7.5	(2)
1986	4	20	2 ECL 1 P	0 24 39.	0 29 22.	0 46 2.	46 17.	45 22.	2275	2254	1750	20.5%	19.6%	9.2%	0.435	0.445	0.571	5.4	
1986	4	20	2 ECL 1 P	3 16 1.	3 23 3.	3 49 36.	49 36.	52 33.	2885	2861	2218	28.8%	27.6%	12.1%	0.369	0.381	0.553	3.8	
1986	4	26	2 ECL 3			13 37 10.	37 19.	40 50.	0	0		0 %	0 %	0 %	1.381	1.375	1.213	3.8	(2)

Notes to Table 1

(1) The apparent distance between the Sun and Jupiter is smaller than 25° but larger than 10°.

(2) Grazing phenomena, the magnitude is less than 0.03 for occultations and less than 2% for eclipses.

(3) The distance between the eclipsed or occulted satellite and the limb of Jupiter is less than 0.3 jovian radius (the event may occur in front of Jupiter).

(4) Double phenomenon, occultation and eclipse (of J 2 by J 3) successively.

(5) The relative velocity between the 2 involved satellites is too small to allow a good precision on the date of the phenomenon.

(6) 1985/6/17: total occultation of J 2 by J 3 from $13^{\mathrm{h}}17^{\mathrm{m}}43^{\mathrm{s}}$ to $13^{\mathrm{h}}19^{\mathrm{m}}51^{\mathrm{s}}$

(7) 1985/6/24: total occultation of J 2 by J 3 from $16^{\mathrm{h}}19^{\mathrm{m}}25^{\mathrm{s}}$ to $16^{\mathrm{h}}21^{\mathrm{m}}35^{\mathrm{s}}$

(8) 1985/7/01: total occultation of J 2 by J 3 from $19^{\mathrm{h}}19^{\mathrm{m}}30^{\mathrm{s}}$ to $19^{\mathrm{h}}20^{\mathrm{m}}47^{\mathrm{s}}$

(9) 1985/7/26: total occultation of J 2 by J 4 from $12^{\mathrm{h}}34^{\mathrm{m}}08^{\mathrm{s}}$ to $12^{\mathrm{h}}35^{\mathrm{m}}47^{\mathrm{s}}$

(10) 1985/9/04: total eclipse of J 2 by J 3 from $21^{\mathrm{h}}44^{\mathrm{m}}08^{\mathrm{s}}$ to $21^{\mathrm{h}}51^{\mathrm{m}}29^{\mathrm{s}}$

(11) 1985/9/12: total occultation of J 2 by J 3 from $0^{\mathrm{h}}03^{\mathrm{m}}31^{\mathrm{s}}$ to $0^{\mathrm{h}}16^{\mathrm{m}}24^{\mathrm{s}}$

(12) 1985/11/04: total occultation of J 2 by J 4 from $2^{\mathrm{h}}52^{\mathrm{m}}21^{\mathrm{s}}$ to $2^{\mathrm{h}}54^{\mathrm{m}}50^{\mathrm{s}}$

(13) 1985/12/25: total occultation of J 1 by J 4 from $2^{\mathrm{h}}38^{\mathrm{m}}36^{\mathrm{s}}$ to $2^{\mathrm{h}}39^{\mathrm{m}}03^{\mathrm{s}}$

(14) 1985/12/29: total occultation of J 2 by J 1 from $13^{\mathrm{h}}45^{\mathrm{m}}08^{\mathrm{s}}$ to $13^{\mathrm{h}}45^{\mathrm{m}}30^{\mathrm{s}}$

(15) 1986/1/04: total occultation of J 1 by J 3 from $19^{\mathrm{h}}36^{\mathrm{m}}14^{\mathrm{s}}$ to $19^{\mathrm{h}}37^{\mathrm{m}}10^{\mathrm{s}}$

(16) 1986/1/11: total occultation of J 2 by J 4 from $9^{\mathrm{h}}56^{\mathrm{m}}00^{\mathrm{s}}$ to $10^{\mathrm{h}}09^{\mathrm{m}}40^{\mathrm{s}}$

(17) 1986/1/26: total occultation of J 2 by J 3 from $12^{\mathrm{h}}07^{\mathrm{m}}16^{\mathrm{s}}$ to $12^{\mathrm{h}}08^{\mathrm{m}}54^{\mathrm{s}}$

(18) 1985/9/12: occultation of J 2 by J 3, the given day is that of the maximum, the beginning of the phenomenon occuring on 1985/9/11, $23^{\mathrm{h}}45^{\mathrm{m}}29^{\mathrm{s}}$

(19) 1986/1/03: occultation of J 4 by J 2, the given day is that of the maximum, the beginning of the phenomenon occuring on 1986/1/2, $23^{\mathrm{h}}58^{\mathrm{m}}08^{\mathrm{s}}$

N.B.: 1) The dates given in the notes are in Ephemeris Time, for G–5 Ephemeris

2) Because the hour of the maximum is the same for the 3 ephemerides (Columns {7}–{9} of Table 1), the minutes may be larger than 60.

velocity between the involved satellites, the greater the precision (generally about 6 s of time).

Since we must use a complete theory to calculate mutual phenomena, much computer time is needed. For the 1979 period we used methods to decrease the computer time (Arlot, 1978). In spite of the technical evolution of the computers, it is always necessary to first determine approximate dates where phenomena are possible. This first determination may cause the omission of some phenomena detectable only with the complete theory.

For the calculations of the dates of the phenomena, we used several ephemerides of the Galilean Satellites: G–5 (Arlot, 1982), E–2 (Lieske, 1980) and SV 2 (Vu, 1977; Sampson, 1921). The calculations differ slightly (cf. Table 1). During the 1979 period of phenomena, comparisons were made between these ephemerides and observations (Arlot et al., 1983). For the present predictions we used the ephemerides of the planets of the JPL DE 102 (Newhall et al., 1983) and the radii of the satellites given by Pioneer 11 (Hollingsworth Smith, 1978). These radii are: for J 1, 1840 km; for J 2, 1552 km; for J 3, 2650 km, and for J 4, 2420 km.

Table 1 gives the dates of the predicted phenomena. These dates are given in the TDB time-scale (temps dynamique barycentrique, cf. Connaissance des Temps for 1984). This time-scale is very close to the Ephemeris Time (ET) or to the International Atomic Time plus 32 s (TAI + 32 s). One obtains the times of the mutual phenomena in the Universal Time scale (UT) by taking off about 55 s of time from the published dates of Table 1.

The first three columns of Table 1 (Columns {1}–{3}) give the year, the month and the day of the instant of maximum of the considered phenomenon. In Column {4} is given the nature of the phenomenon: 102 means J 1 occults J 2; 3E4 means that J 3 eclipses J4; P means partial phenomenon – nothing is indicated when an eclipse is by the penumbra – A means annular and T means total (dates of the beginning of the totality are given in the notes). The next two columns give, for G–5 ephemeris: first Column {5} the entry in the penumbra of the eclipsed satellite for eclipses, and second, Column {6} the entry in the shadow of the eclipsed satellite or the beginning of the occultation. The next columns give: the date of the maximum of the phenomenon for 3 ephemerides G–5 (Column {7}), E–2 (Column {8}) and SV 2 (Column {10}); the duration of the phenomenon for the same 3 ephemerides G–5 (Column {10}), E–2 (Column {11}) and SV2 (Column {12}) – for the eclipses, this duration excludes the penumbra – the amplitude of the phenomenon (for the occultations the calculation is made as for the moon[1]; for the eclipses, the magnitude is the percentage of the eclipsed satellite in the shadow) for G–5 (Column {13}), E–2 (Column {14}), and SV 2 (Column {15}); the impact parameter (the smallest apparent distance in arcsec between the 2 satellites for an occultation and between the eclipsed satellite and the axis of the umbral cone for an eclipse) for G–5 (Column {16}), E–2 (Column {17} and SV 2 (Column {18}); the distance of the occulted or eclipsed satellite to the center of Jupiter in jovian radius (Column {19}) and some notes in Column {20}).

In Table 1, mutual phenomena occurring behind Jupiter or in the shadow of Jupiter are not given as phenomena occurring when the apparent distance Jupiter-Sun is less than 10°. The notes indicates:

(1) The phenomena for which the apparent distance Jupiter-Sun is less than 25°.

(2) The grazing phenomena: their amplitude are less than 0.03 for the occultations and less than 2% for the eclipses. Such events are very difficult to observe. Anyway, it can appear that the real amplitude is larger than the predicted one, so the phenomenon is easily observable. As a matter of fact, note that for the eclipse of J 2 by J 3 on July 23, 1985, the calculated amplitude is 11% using SV 2 ephemeris and 0% using G–5 or E–2. On October 5, 1985, for the occultation of J 2 by J 1, the amplitude is 0.239 using SV 2 and 0. with E–2 or G–5 (no event is found). On the contrary, on April 9, 1986, for the occultation of J 1 by J 2, no event is found using SV 2 when an occultation of amplitude 0.190 is found using G–5 or E–2. For such phenomena, the observation will give valuable information.

(3) The phenomena occurring at a distance to the limb of Jupiter less than 0.3 jovian radius or occurring in front of Jupiter (total occultation of J 2 by J 4 on November 4 in 1985, partial occultation of J 1 by J 3 on November 29, 1985, partial occultation of J 1 by J 2 on April 6, 1986 and partial eclipse of J 1 by J 2 (3%) on April 9, 1986).

(4) A special phenomenon: an occultation of J2 by J3 just followed by an eclipse of J2 by J3.

(5) Very long phenomena: during them the 2 implied satellites have the same apparent speed so that the precision of the calculated dates is not good.

Table 2. Distribution of the different mutual events during the 1985–86 occurrence

	NUMBER OF OCCULTATIONS 1985––––1986								SUMS			NUMBER OF ECLIPSES 1985––––1986							
	feb. jul.	aug.	sept.	oct.	nov.	dec.	jan.	feb. apr.				feb. jul.	aug.	sept.	oct.	nov.	dec.	jan.	feb. apr.
I/II	0	0	7	8	8	8	6	0	37	31	142	0	3	9	10	8	1	0	0
II/I	2	0	0	0	0	1	9	11	23	51		0	0	0	8	8	9	9	17
I/III	3	5	5	0	0	4	4	0	21	18	79	0	3	8	4	1	0	2	0
III/I	10	0	0	0	4	5	3	0	22	18		0	0	2	5	8	2	1	0
I/IV	4	2	2	0	0	2	1	0	11	5	38	0	1	2	2	0	0	0	0
IV/I	7	2	0	0	2	4	0	0	15	7		0	2	0	3	2	0	0	0
II/III	2	0	0	0	0	4	1	3	10	7	64	1	0	0	0	1	0	0	5
III/II	10	4	8	0	0	0	3	1	26	21		3	5	4	0	4	4	1	0
II/IV	2	1	0	0	1	0	1	0	5	5	21	1	0	1	2	1	0	0	0
IV/II	2	0	1	0	2	0	2	0	7	4		0	0	2	1	1	0	0	0
III/IV	2	1	0	0	0	0	1	0	4	4	17	0	0	2	1	0	1	0	0
IV/III	2	1	0	0	0	1	1	0	5	4		0	1	1	1	1	0	0	0
SUMS:	46	16	22	8	17	29	32	15	186	175	361	5	15	31	37	35	17	13	22

The use of the radius deduced from the observations made by Voyager – J 1: 1816 km, J 2: 1563 km, J 3: 2638 km, J 4: 2410 km (Morrison, 1983) – changes very slightly the results (anyway the dates of the maximum remain unchanged). The greatest difference in duration is about 20 s for slow phenomena, and most of the dates of the beginning of the phenomena change only by less than 10 s.

Conditions for the observation of the mutual phenomena in 1985–1986

How are the observable events distributed in 1985–86? It would be nice to have the same number of events for each pair of satellites. However, since the period of each satellite is different, the faster satellites participate in more events than the slower ones. Table 2 gives the number of phenomena for each pair of satellites each month. It is shown that the pair 1–2 participates in many more events than the other pairs, and that the pair 3–4 participates in very few events. The period between maximum events is not the same for each pair because of the small, distinct, inclination of each satellite. Note that the radii of the satellites also determine the number of events.

Table 3 gives the number of events as a function of the duration (the transit of eclipsed satellites in the penumbra is not taken into account in the calculation of the duration). The longest event is about 2 h long and 17 events are about one hour long.

Table 4 gives the number of events (grazing or not) observable in several observatories. We selected phenomena occurring, first, when Jupiter is more than 5° above the horizon and second, when Jupiter is more than 15° above the horizon. In all cases, the Sun is less than 5° below the horizon. It is easy to understand that the best observational conditions are obtained for the observatories whose latitudes are close to the declination of Jupiter (about $-19°$ to

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[1] for the occultations, the amplitude is calculated as follows: let R_T be the radius of the cone of visibility of the total occultation near the Earth, R_p the radius of the cone of visibility of the partial occultation near the Earth and D the distance between the Earth and the common axis of these cones. The amplitude is $\frac{R_p - D}{R_p - R_T}$ (Danjon, 1959, p. 320)

Table 3. Numbers of mutual events as a function of their durations

DURATIONS	NUMBER OF OCCULTATIONS	NUMBER OF ECLIPSES	SUMS
GRAZING EVENTS	32	81	113
< 100^s	0	1	1
100^s TO 299^s	57	46	103
300^s TO 599^s	43	20	63
600^s TO 999^s	26	10	36
1000^s TO 1499^s	9	6	15
1500^s TO 2499^s	8	4	12
2500^s TO 4999^s	11	6	17
5000^s TO 7000^s	1	0	1
SUMS :	186	174	361

–14° during the period of the mutual phenomena). If someone wishes to have the list of phenomena observable in a special observatory, please contact the author.

The instruments to be used for the observation of the mutual phenomena

Since a large number of astronomers made observations of mutual phenomena during the 1973–74 and 1979–80 periods, most of the observers are aware of the main instruments which can be used for these observations. Everyone knows that the magnitude of the galilean satellites allows their observations with telescopes of small apertures. The observation of nongrazing phenomena is possible even with a sky of bad transparency (in cities for example). On the contrary, to catch grazing phenomena, very good conditions are needed.

To be useful, the observation of a mutual phenomenon may give at least a date in UT (precise within half a second of time) of the instant of the maximum drop of light during the phenomenon (which corresponds to a minimum intensity on the light curve). Anyway, other elements of the observation are of great interest: – the entire light-curve will be useful to improve the accuracy of the time of the instant of the drop of light and necessary to calculate the duration of the phenomenon; – an evaluation of the magnitude drop will be necessary to determine the amplitude of the phenomenon. All these data (time of the minimum intensity light, duration and amplitude) are useful to improve the ephemerides.

Since the sky background may vary (mainly during twilight), it is necessary to record it several times during each observation.

For these photometric observations, two possibilities of recording are available. First, the old classical single channel photoelectric photometer with analog or digital output may be used. In that case, except for the eclipses where the eclipsing satellite is far from the eclipsed one, both satellites involved must be put in the diaphragm. Second, two-dimensional photometers (for example Vidicon-tubes) may be used for the observations. In that case, there is no problem of diaphragm since the images are studied numerically after the observations. The large number of data constrain to record the phenomenon analogically and to digitize the images after the observation. This method has been already used successfully for the observation of mutual phenomena (Mosher et al., 1975; Arlot et al., 1982) or for other observations of the same type (Arlot et al., 1984).

Table 4. Numbers of observable phenomena (not grazing) for several observatories

OBSERVATORIES		NUMBER OF OBSERVABLE PHENOMENA (NOT GRAZING)	
NAMES	LATITUDES	JUPITER IS MORE THAN 5 DEG. ABOVE THE HORIZON	JUPITER IS MORE THAN 15 DEG. ABOVE THE HORIZON
LA SILLA (CHILI)	-29°	66	57
SUTHERLAND (SOUTH AFRICA)	-32°	69	56
JOHANNESBURG (SOUTH AFRICA)	-26°	62	56
CAPE TOWN (SOUTH AFRICA)	-34°	67	54
RIO DE JANEIRO (BRASIL)	-23°	60	51
MELBOURNE (AUSTRALIA)	-38°	50	46
MAUNA KEA (HAWAI ISL.)	+20°	54	44
WISE. OBS. (ISRAËL)	+30°	55	45
HELWAN (EGYPT)	+30°	51	44
GRANADA (SPAIN)	+37°	54	43
MADRID (SPAIN)	+40°	52	43
KODAIKANAL (INDIA)	+10°	51	43
MC DONALD (USA)	+31°	48	42
HYDERABAD (INDIA)	+17°	49	40
CATANIA (ITALY)	+37°	49	41
PIC-DU-MIDI (FRANCE)	+43°	48	41
BARCELONA (SPAIN)	+41°	44	41
MOUNT PALOMAR (USA)	+33°	50	39
LYON (FRANCE)	+46°	47	40
BORDEAUX (FRANCE)	+45°	47	40
CERGA/NICE (FRANCE)	+44°	45	40
MC CORMICK (USA)	+38°	48	38
FLAGSTAFF (USA)	+35°	47	38
OBS. HTE PROVENCE (FRANCE)	+44°	45	39
SHANGHAÏ (CHINA)	+31°	42	38
DODAIRA (JAPAN)	+36°	51	37
ROMA (ITALY)	+42°	47	38
PURPLE MOUNTAIN (CHINA)	+32°	42	37
USNO (USA)	+39°	47	36
MITAKA (JAPAN)	+36°	46	34
PARIS-MEUDON (FRANCE)	+48°	45	35
NAINITAL (INDIA)	+29°	44	34
PEKING (CHINA)	+40°	41	34
DRESDEN (GERMANY)	+51°	52	30
PULKOVO (URSS)	+60°	32	0
OULU (FINLAND)	+65°	20	0

Another method of observation is the visual one. With this method, it is not possible to measure accurately the magnitude drop. Anyway, the time of the instant of maximum of the phenomena may be determined by reference to a nearby satellite not affected by the phenomenon. Trained observers (especially amateur astronomers) are able to provide useful data: this has been demonstrated during the 1979–80 period (Arlot et al., 1982).

The significance of the observations of mutual phenomena

These observations should be made in order to improve our knowledge of the Galilean Satellites. The former campaigns of observations produced a large set of data which has been used for several purposes: for the improvement of the ephemerides (mid-times of the events for the longitude corrections and magnitude drops for the latitude corrections), for the determination of the radius (duration of the phenomena) and for the evaluation of the albedos (magnitude drops and shapes of the light-curves).

A large number of publications were made after the last two periods of occurrence of mutual phenomena which increased our knowledge on the subject. But now, is it always worthwhile to make such observations? Spacecrafts Pioneer and Voyager gave valuable information about the Galilean Satellites. As a matter of fact, some quantities which were not known have been determined with a high accuracy by these spacecrafts: for instance radius and surface features. On the other hand, the albedos are not yet well know and the asymmetry of some light-curves of mutual phenomena still remains unexplained. About the ephemerides, more observations are necessary. Let us notice that ephemerides may be improved using observations of eclipses by Jupiter or photographic observations. Moreover the observations of mutual phenomena are more precise than other types of observations. Photographic observations, however, may be made at anytime whereas mutual phenomena are fairly rare. But the observations of mutual phenomena are very different from the other types of observations. They provide information not otherwise available. Moreover, it is easier to eliminate the systematic observational errors when several types of observations are available. It is valuable to mix different types of observations of Galilean Satellites, when calculating the constants of their motions.

Conclusion

Observations of the mutual phenomena of the Galilean Satellites are always of great interest and we encourage observers to make them; note that they do not occur each year (if someone needs more information about those observations, please contact the author). In the past, everyone making such observations provided interesting results, but much more may be done and we look forward to much observational data in 1985 and 1986.

References

Arlot, J.-E.: 1978, *Astron. Astrophys. Suppl.* **34**, 195

Arlot, J.-E.: 1982, *Astron. Astrophys.* **107**, 305

Arlot, J.-E., Bernard, A., Bouchet, P., Daguillon, J., Dourneau, G., Figer, A., Helmer, G., Lecacheux, J., Merlin, Ph., Meyer, C., Mianes, P., Morando, B., Naves, D., Rousseau, J., Soulié, G., Terzan, A., Thuillot, W., Vapillon, L., Wlérick, G.: 1982, *Astron. Astrophys.* **111**, 151

Arlot, J.-E., Lecacheux, J., Richardson, Ch., Thuillot, W.: 1984, *Icarus* (submitted)

Connaissance des Temps for 1984, ed. by Bureau des Longitudes, Paris 1983

Danjon, A.: 1959, Astronomie Générale (new edition in 1980 by A. Blanchard, Paris)

Hollingsworth Smith, P.: 1978, *Icarus* **35**, 167

Lieske, J.H.: 1980, *Astron. Astrophys.* **82**, 340

Mosher, J., Johnson, T., Matson, D.: 1975, in *Imaging in Astronomy*, Cambridge, Mass., June 18–21

Morrison, D.: 1983, *Mercury* **12**, 118

Newhall, X.X., Standish Jr, E.M., Williams, J.G.: 1983, *Astron. Astrophys.* **125**, 150

Sampson, R.A.: 1921, *Roy. Astron. Soc.* **63**

Vu, D.T.: 1977, *Astron. Astrophys. Suppl.* **30**, 361