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Forthcoming Occultations of Astrometric Radio Sources by Planets

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Abstract

Astrometric observations of radio source occultations by solar system bodies may be of large interest for testing gravity theories, dynamical astronomy, and planetary physics. In this paper, we present an updated list of the occultations of astrometric radio sources by planets expected in the coming years. Such events, like solar eclipses, generally speaking can only be observed in a limited region. A map of the shadow path is provided for the events that will occurr in regions with several VLBI stations and hence will be the most interesting for radio astronomy experiments.

1. Introduction

Observations of occultations of compact radio sources by Solar System planets may be interesting for several astronomical and physical applications, such as testing GR [1], improvement of planet orbits and their tie to ICRF [2], and planetary research [3, 4].

Our previous computations of occultations of astrometric radio sources by planets and their close approaches were published in [1]. In this paper we present the updated list of the forthcoming occultations that may be of interest for radio astronomy observations. The main differences with respect to the previous work are the use of an extended astrometric source list and the computation of event maps for a better planning of observations.

2. Forthcoming Occultations

Most computations of occultation events of geodetic radio sources by planets were performed using the codes APPROACH and OCCULT, which utilize the Ephemeride Package for Objects of the Solar System (EPOS) data and environment[1]. Source coordinates were taken from the catalog of astrometric radio source positions of Leonid Petrov, version 2009c[2].

The list of occultations is presented in Table 1 with their basic features. One can see that most of the events are visible in regions with radio astronomy observatories, and several of them can be observed by many antennas. The nearest most interesting event is the occultation of the source 1946–200 by Mars in February 2011 visible in North America with VLBA, VLA, GBT, and other radio astronomy facilities.

Figure 1 and Table 2 present more detailed information about several of the nearest events that can be observed in regions with several geodetic VLBI antennas. The shadow path maps are shown in Figure 1. Table 2 lists the detailed parameters of several of the nearest events, such as

[1] http://neopage.pochta.ru/ENG/ESUPP/main.htm
[2] http://astrogeo.org/vlbi/solutions/2009c_astro/

Table 1. Occultations of radio sources by planets in 2011–2030 (d is the angular distance from the Sun, and the letter indicates east or west elongation).

Planet	Date			Source	d, deg	Region of visibility
	Y	M	D			
Venus	2011	02	26	1946–200	42W	Antarctic, S. America
Mars	2011	05	03	0127+084	19W	N. America
Venus	2012	12	24	1631–208	23W	S. America, Antarctic, Africa
Venus	2015	08	06	0947+064	15E	America
Jupiter	2016	04	10	1101+077	144E	Australia, SE Asia
Venus	2020	01	16	2220–119	38E	S. America, Europe, Africa
Venus	2020	07	17	0446+178	42W	N. America
Mercury	2022	11	14	1529–195	4E	S. America
Jupiter	2025	09	18	0725+219	65W	America
Mercury	2027	03	21	2220–119	27W	N. America
Saturn	2028	10	24	0223+113	173W	by ring; Asia, Europe, N. Africa
Mercury	2029	01	14	1958–179	5E	Australia, Antarctic, S. Africa
Venus	2029	02	28	2221–116	6W	Africa, SE Asia, Australia
Mercury	2029	04	16	0243+181	19E	Asia, N. America
Mercury	2029	12	27	1858–212	8E	S. America, Australia
Mercury	2030	02	27	2208–137	9W	S. America, Africa

the elevation, azimuth, and position angle on the planetary limb at the beginning and the end of the occultation. Detailed parameters for other events are available on request.

3. Conclusion

Observations of the occultations of radio sources by planets are attractive for several interesting applications in physics and planetary science. They can effectively supplement the observations of radio source occultations by the Moon and spacecraft radio occultations by planets. The list of occultations presented in this paper can be used for scheduling observations in different modes such as VLBI, connected-element interferometer, or single-dish mode, depending on the scientific task. The list of occultations as well as an updated list of close approaches of planets to radio sources is available at `http://www.gao.spb.ru/english/as/ac_vlbi/`.

References

[1] Malkin, Z.M., L'vov, V.N., Tsekmeister S.D. (2009) Forthcoming Close Angular Approaches of Planets to Radio Sources and Possibilities to Use Them as GR Tests. Solar System Research, v. 43, No. 4, p. 313.

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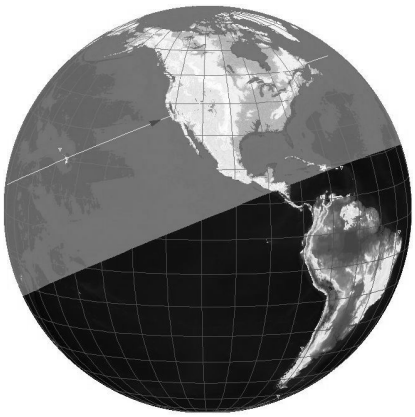
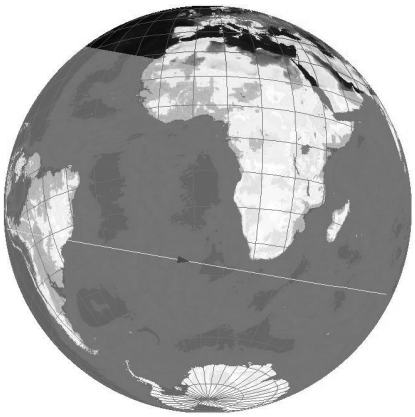
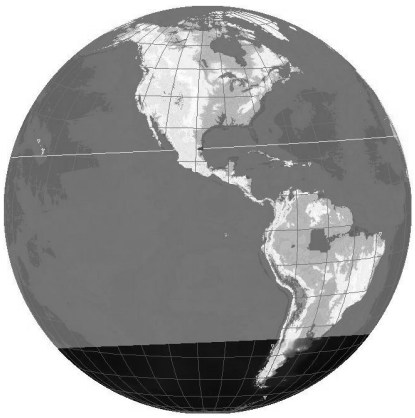
[4] Black, G., Campbell, D., Nicholson, P., Sault, R. (2000) New Long-Wavelength Radio Source Occultations by Saturn's Rings. Bulletin of the American Astronomical Society, v. 32, p. 1086.



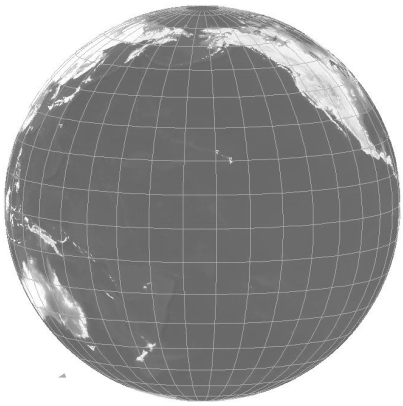
0127+084, Mars, May 03, 2011



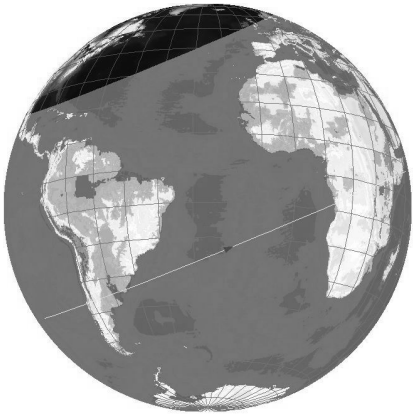
1631–208, Venus, Dec 24, 2012



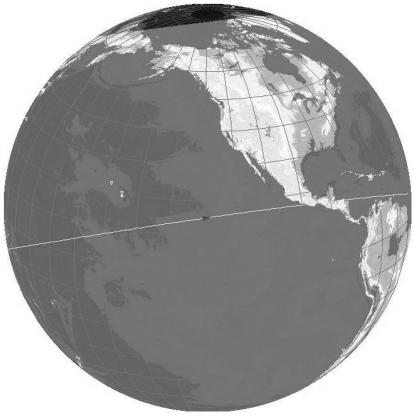
0947+064, Venus, Aug 06, 2015



1101+077, Jupiter, Apr 10, 2016



2220–119, Venus, Jan 16, 2020



0446+178, Venus, Jul 17, 2020

Figure 1. Visibility of selected nearest occultations of radio sources by planets. The visibility regions of the occultations are shown in light (for the 2016 event, the region covers the whole depicted hemisphere).

Table 2. Detailed features of the nearest occultations of radio sources by planets: B — at the beginning, E — at the end.

Planet	Date	Station	Time, TT		El., deg		Az., deg		Pos. angle	
			B	E	B	E	B	E	B	E
Venus	Feb 26, 2011	OHIGGINS	14:18:18	14:22:03	46	45	20	21	35	309
		SYOWA	14:18:20	14:23:11	11	11	118	119	55	290
Mars	May 03, 2011	KOKEE	18:10:19	18:12:26	41	42	278	278	60	256
		MK-VLBA	18:10:19	18:12:28	46	46	278	278	66	250
		OV-VLBA	18:11:31	18:13:40	61	61	345	347	65	251
		DSS13	18:11:32	18:13:41	63	63	348	349	69	247
		KP-VLBA	18:11:38	18:13:45	67	67	359	360	77	239
		BR-VLBA	18:11:43	18:13:45	50	50	347	348	49	266
		PIETOWN	18:11:46	18:13:53	64	64	7	8	75	240
		LA-VLBA	18:11:50	18:13:57	63	63	11	12	74	241
		FD-VLBA	18:11:52	18:13:55	67	67	19	20	84	232
		GILCREEK	18:11:59	18:13:20	28	29	318	319	17	298
		GGAO7108	18:12:37	18:14:41	47	46	55	56	84	232
		HN-VLBA	18:12:42	18:14:48	42	41	57	58	78	237
		WESTFORD	18:12:43	18:14:49	41	41	58	58	79	237
Venus	Dec 24, 2012	FORTLEZA	10:06:07	10:09:25	45	46	244	244	80	300
		OHIGGINS	10:07:13	10:10:03	31	32	286	287	136	244
		HARTRAO	10:08:02	10:11:28	68	67	83	83	87	293
		SYOWA	10:08:11	10:11:16	37	37	43	44	129	252
Venus	Aug 06, 2015	YEBES40M	18:41:27	19:23:00	9	1	91	98	284	68
		FORTLEZA	18:44:31	19:20:16	39	31	79	81	236	117
		SC-VLBA	18:49:35	19:29:43	63	54	68	76	260	94
		WESTFORD	18:53:34	19:32:45	50	46	30	43	284	70
		HN-VLBA	18:53:44	19:32:53	50	46	29	42	284	69
		GGAO7108	18:54:33	19:34:07	55	51	24	39	281	73
		FD-VLBA	19:02:27	19:42:29	63	66	334	357	274	80
		LA-VLBA	19:03:07	19:42:45	58	60	334	353	279	75
		PIETOWN	19:03:41	19:43:28	59	62	330	349	278	76
		KP-VLBA	19:04:48	19:44:46	59	63	322	341	276	78
		DSS13	19:06:13	19:45:56	54	59	318	334	279	75
		OV-VLBA	19:06:34	19:46:03	52	56	318	333	281	73
		BR-VLBA	19 06:39	19:44:22	43	46	324	336	291	63
		GILCREEK	19:10:09	19:43:42	21	23	302	311	305	49
		MK-VLBA	19:17:05	19:58:37	31	41	275	279	269	86
		KOKEE	19:17:31	19:59:12	27	37	274	279	271	83

Table 2. (continued)

Planet	Date	Station	Time, TT		El., deg		Az., deg		Pos. angle	
			B	E	B	E	B	E	B	E
Jupiter	Apr 10, 2016	TIGOCONC	07:02:05	10:07:53	15	-21	68	97	268	133
		LA-VLBA	07:05:34	10:15:00	49	13	54	90	274	128
		KP-VLBA	07:06:09	10:14:31	55	17	52	88	273	128
		DSS13	07:06:55	10:15:16	56	21	42	84	273	128
		OV-VLBA	07:07:09	10:15:37	55	22	38	83	273	128
		BR-VLBA	07:07:37	10:17:21	46	21	29	78	274	128
		GILCREEK	07:10:03	10:20:51	32	26	351	45	274	127
		MK-VLBA	07:12:22	10:16:11	71	58	308	72	271	130
		KOKEE	07:12:53	10:16:52	67	60	306	65	271	130
		USSURISK	07:15:37	10:25:14	7	40	267	305	273	130
		HOBART26	07:16:01	10:15:13	9	34	288	328	265	137
		VERAMZSW	07:16:13	10:24:24	15	48	272	311	272	130
		TSUKUB32	07:16:27	10:24:25	14	50	271	308	272	131
		KASHIM34	07:16:28	10:24:21	14	50	271	308	272	131
		GIFU11	07:16:31	10:24:39	11	48	269	303	272	131
		SESHAN25	07:16:34	10:25:38	-2	38	260	286	272	131
		TIDBIN64	07:16:41	10:16:04	12	41	288	327	266	136
		AIRA	07:16:48	10:24:57	6	45	265	294	271	131
		VERAIRIK	07:16:48	10:24:59	6	45	265	294	271	131
		PARKES	07:16:56	10:16:27	12	43	287	325	266	136
		VERAISGK	07:17:13	10:25:02	0	42	262	283	271	132
		CHICHI10	07:17:14	10:23:43	16	56	270	300	271	131
		VERAOGSW	07:17:14	10:23:44	16	56	270	300	271	131
Venus	Jan 16, 2020		: :	: :						
Venus	Jul 17, 2020		: :	: :						