Non-gravitational parameters in motion of asteroid

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For 36 selected asteroids we compared published values of the Yarkovsky parameter da/dt with our computed values of the non-gravitational parameter $A2$ taking into account observations directly. We used a new version of the OrbFit software v.5.0 suitable for orbital elements computation.

1 Introduction

Non-gravitational parameters $A2$ and da/dt are used in studying motion of asteroids and comets with influence of the Yarkovsky effect. Especially in searching of possible impacts with the Earth when the orbit of asteroid or comet is accurate enough and the observational arc is long enough. Values of parameter da/dt for 36 selected asteroids in Tab. 1 are taken from Tab. 1 of Vokrouhlický et al. (2015).

2 The computation of A2 parameter

Both values of $A2$ and da/dt can be determinated during process of orbit determination as a seventh parameter together with other six orbital parameters, i.e. Keplerian elements. We can compare both of those non-gravitational parameters.

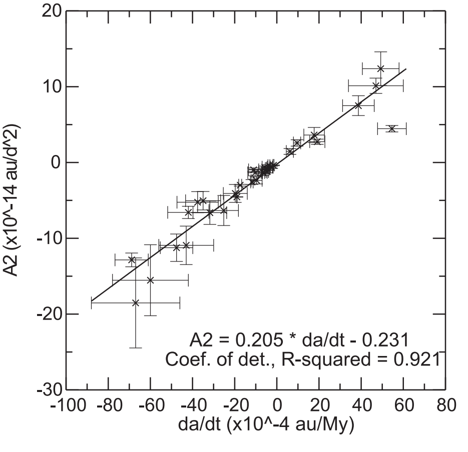

Fig. 1: Non-gravitational parameters: da/dt vs. $A2$ as computed in Tab. 1.

We computed the non-gravitational parameter $A2$ and da/dt according to Farnocchia et al. (2013) and the implemented file *yark_pert.f90* in the OrbFit software v.5.0.

Table 1: LIST OF THE YARKOVSKY EFFECT DETECTIONS UNTIL OCT. 2016.

Object		Type	q	H	da/dt	A2	Optical arc	Radar year	NR	RMS
			(au)	(mag)	(10^{-4} au Myr^{-1})	(10^{-14} au d^{-2})				(arcsec)
101955	Bennu	APO	0.897	20.623±0.523	-18.95±0.10	-4.546±0.023	1999-2013	1999, 2005 2011	29	0.4263
2340	Hathor	ATE	0.464	20.225±0.458	-17.38±0.70	-2.994±0.118	1976-2014	2014	7	0.5370
152563	1992 BF	ATE	0.661	19.655±0.475	-11.82±0.56	-2.577±0.318	1953-2011	—	0	0.6114
	2009 BD	APO	0.967	28.236±0.567	-489±35	-92.507±2.421	2009-2011	—	0	0.5095
	2005 ES70	ATE	0.468	23.729±0.473	-68.9±7.9	-12.856±0.907	2005-2015	—	0	0.7046
4179	Toutatis	APO	0.939	15.141±0.645	-3.75±0.45	-0.4102±0.1219	1934-2016	1992, 1996 2000, 2004 2012	57	0.4074
2062	Aten	ATE	0.790	17.121±0.370	-6.60±0.80	-1.325±0.153	1955-2016	1995, 2012 2013, 2014 2015	7	0.5222
437844	1999 MN	ATE	0.226	21.200±0.561	+54.6±6.8	+4.455±0.426	1999-2015	—	0	0.6913
6489	Golevka	APO	0.993	18.979±0.814	-4.52±0.60	-1.203±0.167	1991-2015	1991, 1995 2003	40	0.6335
1862	Apollo	APO	0.647	16.067±0.445	-1.58±0.24	-0.3832±0.0428	1930-2016	1980, 2005	17	0.5962
	2006 CT	APO	0.844	22.280±0.417	-47.6±7.7	-11.245±1.809	1991-2014	2013	4	0.5552
3908	Nyx	AMO	1.042	17.290±0.505	+9.6±1.7	+2.577±0.422	1980-2016	1988, 2004	16	0.5507
	2000 PN8	APO	0.980	22.061±0.534	+49.3±8.7	+12.375±2.226	2000-2014	—	0	0.5004
162004	1991 VE	ATE	0.299	18.063±0.570	+19.2±3.6	+2.740±0.343	1954-2015	2015	2	0.5974
10302	1989 ML	AMO	1.099	19.370±0.564	+38.7±7.5	+7.497±1.309	1989-2016	—	0	0.4996
2100	Ra-Shalom	ATE	0.469	16.151±0.550	-5.8±1.2	-0.6183±0.1452	1975-2016	1981, 1984 2000, 2003	6	0.5354
29075	1950 DA	APO	0.837	17.052±0.513	-2.70±0.57	-0.6018±0.125	1950-2016	2001, 2012	12	0.5238
85953	1999 FK21	ATE	0.219	18.076±0.613	-11.0±2.4	-0.9703±0.2493	1971-2016	—	0	0.5861
363505	2003 UC20	ATE	0.518	18.257±0.821	-4.5±1.0	-0.8253±0.1467	1954-2015	2003	5	0.4092
468468	2004 KH17	ATE	0.357	21.880±0.531	-42.0±9.8	-6.588±0.808	2004-2016	2013	1	0.6166
66400	1999 LT7	ATE	0.366	19.313±0.657	-35.0±8.3	-5.047±1.216	1987-2014	—	0	0.6389
	1995 CR	ATE	0.119	21.703±0.389	-314±76	-20.8571±3.088	1995-2014	—	0	0.7261
4034	Vishnu	APO	0.589	18.316±0.5183	-31.8±8.0	-6.624±1.548	1986-2015	1989	1	0.5183
85774	1998 UT18	APO	0.942	19.119±0.687	-2.45±0.63	-0.6274±0.156	1989-2014	2003, 2008 2013	8	0.6260
	1994XL1	ATE	0.318	20.838±0.448	-37.6±9.8	-5.244±1.396	1994-2011	—	0	0.7655
3361	Orpheus	APO	0.819	19.167±0.5182	+6.2±1.7	+1.455±0.382	1982-2014	—	0	0.5591
377097	2002 WO4	APO	0.872	19.519±0.525	-9.6±2.6	-2.366±0.461	1950-2014	—	0	0.6541
138852	2000 WN10	APO	0.702	20.142±0.495	+17.7±4.9	+3.625±1.00	2000-2015	—	0	0.5435
399308	1999 GD	APO	0.840	20.640±0.424	+47±13	+10.123±1.012	1993-2015	—	0	0.6180
4581	Asclepius	APO	0.657	20.738±0.349	-19.7±5.7	-4.085±1.177	1989-2016	2012	4	0.5113
	2007 TF68	AMO	1.033	22.682±0.556	-60±18	-15.536±4.683	2002-2012	—	0	0.7601
	1999 FA	APO	0.935	20.645±0.490	-43±13	-10.933±2.541	1978-2016	—	0	0.5047
2063	Bacchus	APO	0.701	17.250±0.574	-6.6±2.0	-1.320±0.417	1977-2016	1996	8	0.6062
350462	1998 KG3	AMO	1.023	22.066±0.448	-25.2±7	-6.341±1.983	1998-2013	—	0	0.5683
256004	2006 UP	AMO	1.108	23.031±0.587	-67±21	-18.529±5.939	2002-2014	—	0	0.6200
37655	Illapa	APO	0.366	17.788±0.462	-10.3±3.5	-1.342±0.426	1994-2015	2003, 2012	2	0.4581
3757	Anagolay	AMO	1.017	19.070±0.319		-0.3759±1.2338	1982-2014	1987	2	0.8223
247517	2002 QY6	ATE	0.246	19.581±0.573		+0.5408±1.5297	2002-2016	—	0	0.6936
5797	Bivoj	AMO	1.053	18.662±0.449		-0.4119±0.9391	1953-2014	—	0	0.6473
152742	1998 XE12	ATE	0.229	19.024±0.561		+0.4332±1.4552	1995-2014	—	0	0.6380
1221	Amor	AMO	1.083	17.178±1.035		0.0292±0.3206	1932-2015	—	0	0.7437
225312	1996 XB27	AMO	1.120	21.816±0.491		-1.410±2.599	1996-2014	—	0	0.6988

3 Correlation between da/dt and A2

Farnocchia et al. (2013) have studied motion of the potentially dangerous asteroid Apophis with the use of the non-gravitational parameters. According to their Eq. 6

$$\frac{da}{dt} = \frac{2A_2(1-e^2)}{np^2}, \tag{1}$$

where a is semimajor axis, t – time, e – eccentricity, n – orbital mean motion, and p is orbital period.

Fig. 1 presents results of our computations of non-gravitational parameter $A2$, vs. non-gravitational parameter da/dt from Tab. 1 of Vokrouhlický et al. (2015). The results of $A2$ for two extreme large da/dt i.e. -489 and -314×10^{-4} au Myr^{-1} for asteroids 2009 BD and 1995 CR are not presented. The best fit of the linear function gives the following relation

$$A2 = 0.205 * da/dt - 0.231 \tag{2}$$

with the coefficient of determination, R-squared = 0.921, where $A2$ is in 10^{-14} $\mathrm{au\,d^{-2}}$, and da/dt in 10^{-4} $\mathrm{au\,Myr^{-1}}$.

Using the new version of the OrbFit software 5.0.5, we can compute the non-gravitational parameters: $A1$, $A2$, $A3$, da/dt and follow propagation of clones of interesting asteroids and comets in the past and/or in the future. We can also predict possible impact solutions of many potentially dangerous asteroids like Apophis, Bennu and others.

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References

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