Photometry and polarimetry of the largest Earth-approaching asteroid 1036 Ganymed

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While (1036) Ganymed is the largest of the objects that come into the region defined as "near" Earth it never gets very close to Earth. Perihelion is 1.24 AU and the closest distance between the orbit of Ganymed and that of the Earth is 0.34 AU i.e. it never gets closer to the Earth than a distance of 50 million km.

List of close approaches to Earth and to Mars

Date	Δ_E (AU)	α	Date	Δ_A (AU)	Δ_E (AU)
1911-Oct-15	0.381	34 - 51	2050-Dec-07	0.096	0.618
1924-Oct-17	0.496	30 - 53	2176-Dec-16	0.029	-
1998-Oct-14	0.464	12 - 55			
2011-Oct-13	0.359	1 - 53			
2024-Oct-13	0.374	29 - 50			
2037-Oct-15	0.466	31 - 51			
2124-Oct-12	0.376	-			
2137-Oct-12	0.359	-			
2150-Oct-13	0.413	-			

1036 Ganymed belongs to Near Earth Asteroids of Amor group

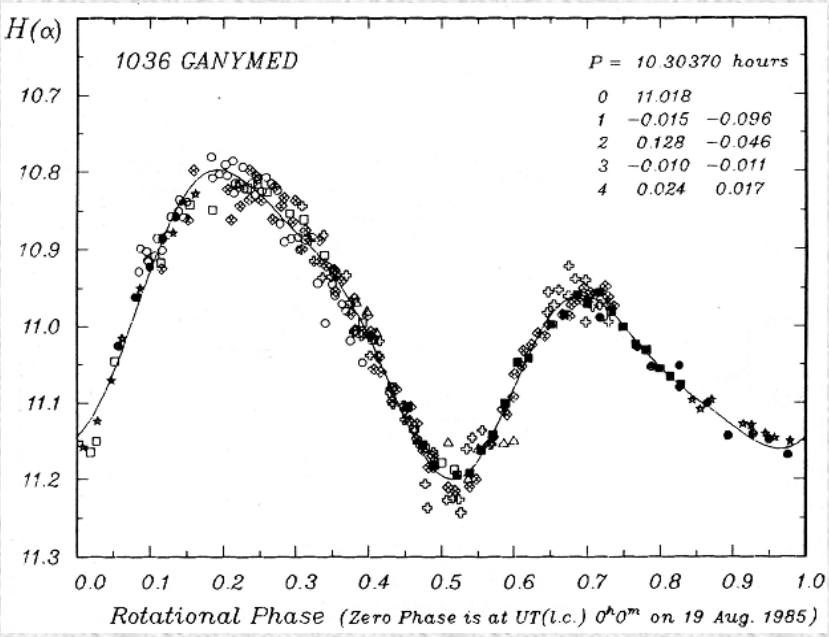
Semi-major axis (AU)	2.66
Inclination (deg)	26.7
Eccentricity	0.53
Diameter (km)	32
Rotation period (hour)	10.31
Lightcurve amplitude (mag)	0.12-0.40
Albedo	0.29
Pole coordinates (deg)	λ_o=214, β_o=-76
	λ_o=130, β_o=-70
Taxonomic type	S (IV)
Mineralogy	orthopyroxenes and (possibly) metals
Radar (1985)	a roughly spherical
Space mission	no plan

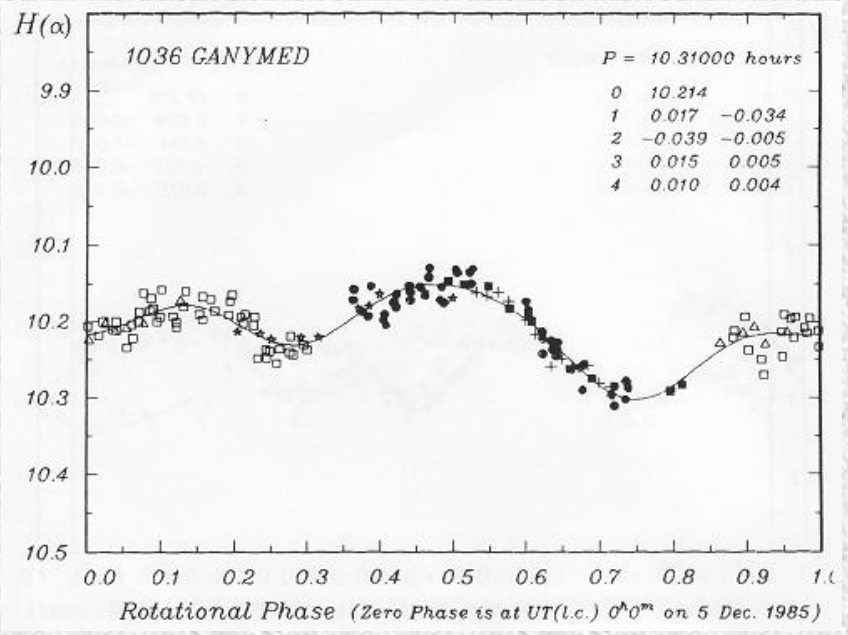
Lightcurve amplitudes, aspect data of asteroid 1036 Ganymed

Date, UT	λ_{2000} (deg)	β_{2000} (deg)	α (deg)	ζ (deg)	Ampl. (mag)	References
1985 Jul. 12	29.8	36.4	53.0	38	0.25	Lupishko, Velichko et al., 1987
1985 Aug. 18	59.9	25.2	54.5	52	0.40	Lupishko, Velichko, Shevchenko, 1988
1985 Sep. 17	74.0	10.3	48.3	70	0.32	Hahn,…, Velichko et al., 1989
1985 Oct. 17	77.0	-9.3	32.8	90	0.22	–" –
1985 Nov. 10	70.2	-23.9	18.8	102	0.12	–" –
1985 Dec. 2	61.3	-30.6	17.3	107	0.15	–" –
1989 May 25	230.9	17.5	9.6	87	0.13	Chernova,…,Velichko et al., 1995
1994 Oct. 7	116.0	-21.7	27.7	111	>0.10	Krugly, Velichko
1998 Nov. 12	53.4	-20.8	13.4	97	≥ 0.13	Nakayama et al., 2000
2002 May 23	228.3	15.3	8.5	89	0.27	Gaftonyuk, 2005
2006 Apr. 20	208.9	-4.5	1.5	110	0.12	Krugly,…, Velichko et al., 2006
2011 May 23	310.2	38.0	36.2	49	0.25	Velichko, Magnusson, 2012
2011 Nov. 18	30.7	-15.4	18.9	120	>0.10	Velichko et al., 2012

Occultation of a star by Ganymed was observed on August 22, 1985.

Lightcurves of the asteroid 1036 Ganymed

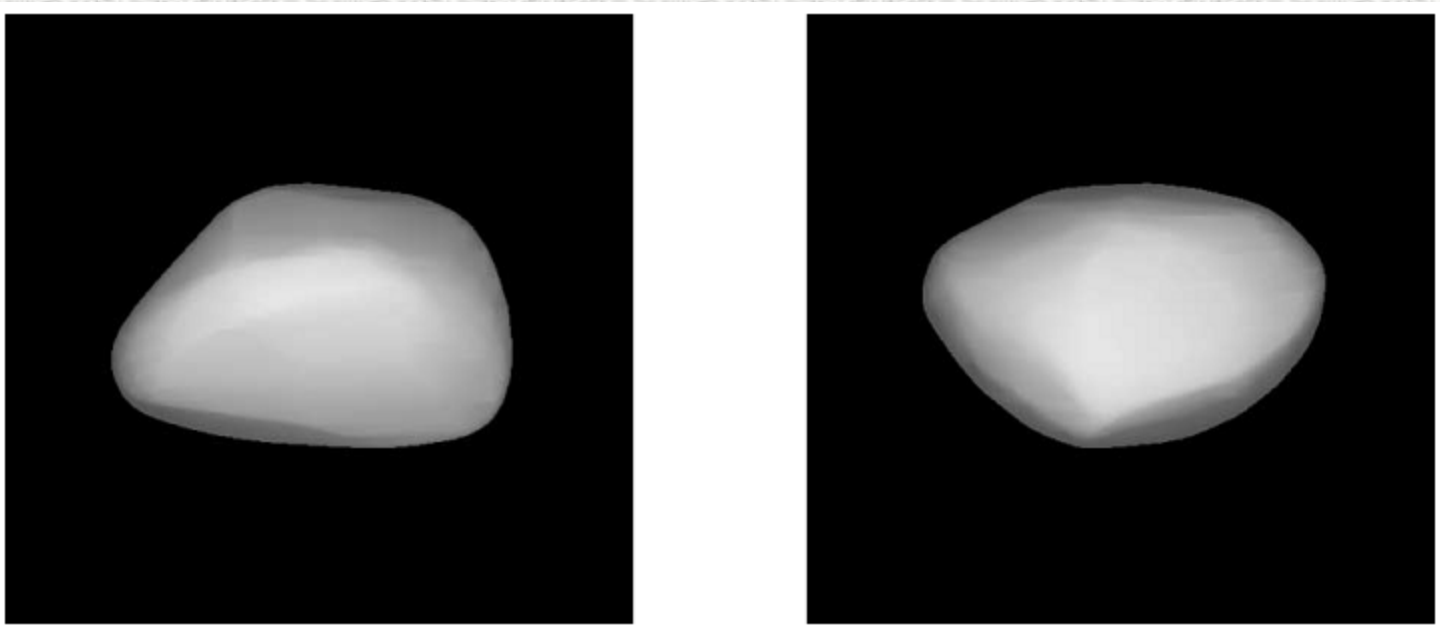




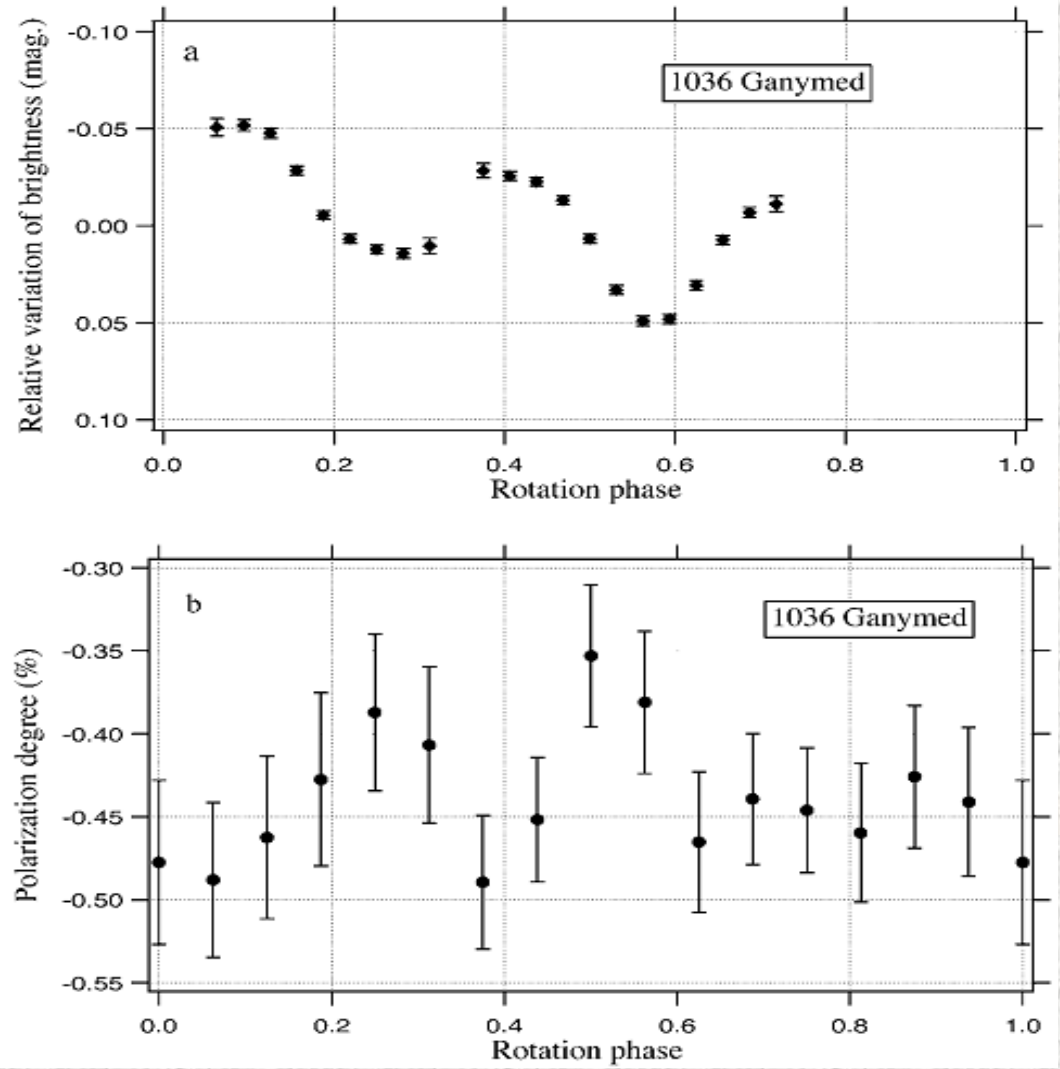
The V-lightcurves of the asteroid 1036 Ganymed on 1985 (Hahn et al.,1989).

Model of the asteroid 1036 Ganymed

By considering photometric data (Lagerkvist et al., 2001) it can be concluded that the asteroid has a large pole flattening. An ellipsoidal model is not useful for modelling of Ganymed (Velichko, Magnusson, 2012), as evidenced by radar results (Ostro et al., 1988) and by anvil-like shape with slight albedo variegation offered by Kaasalainen et al., 2002.

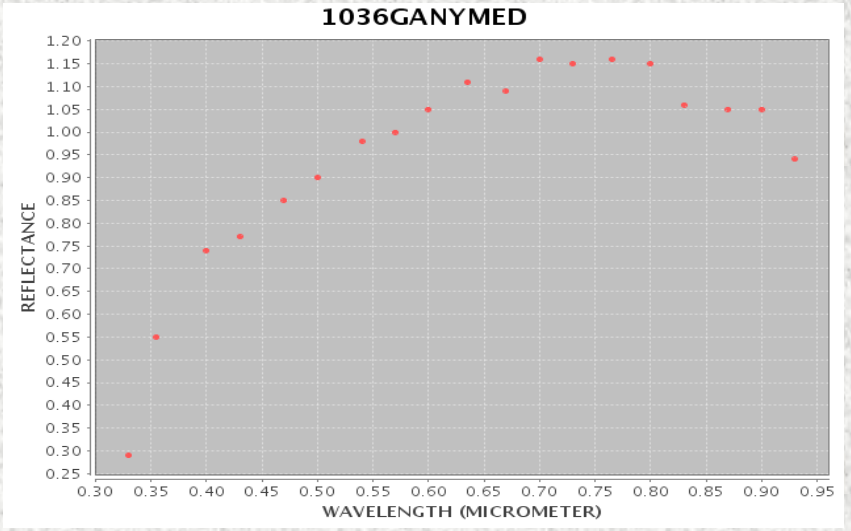


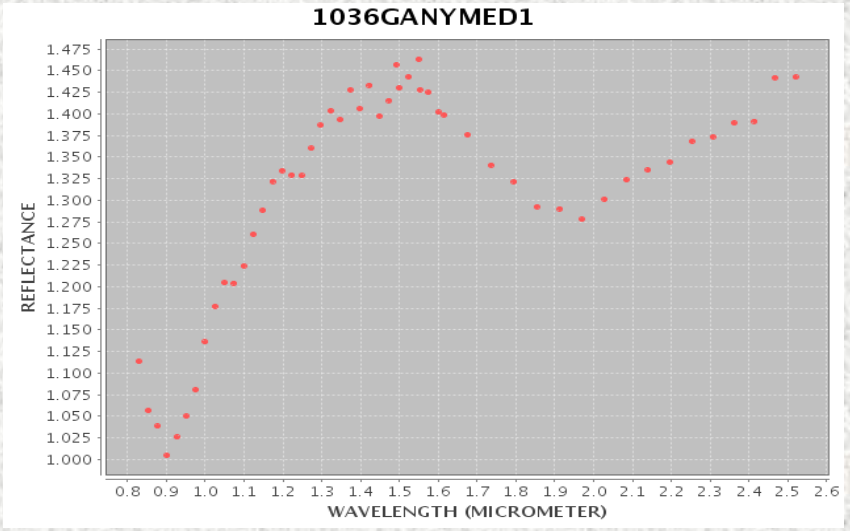
Lightcurve and linear polarization of the asteroid 1036 Ganymed

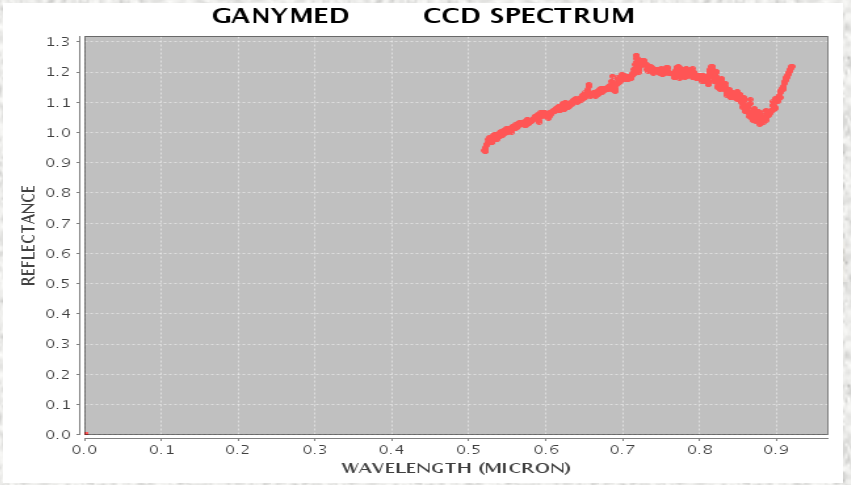


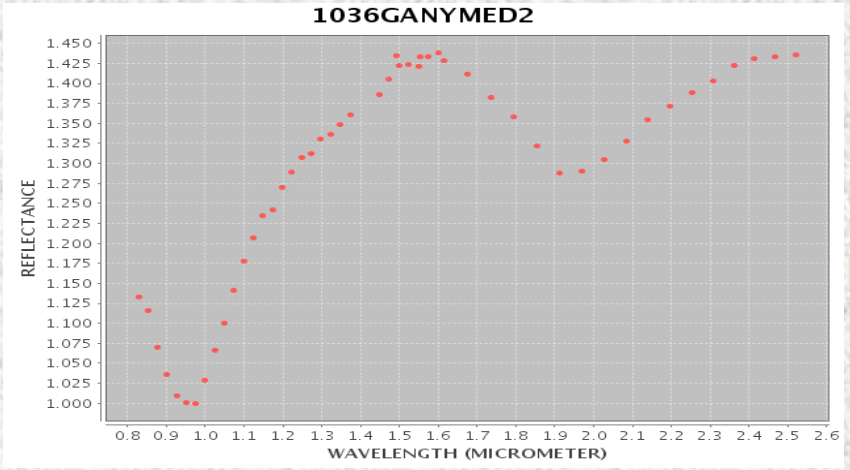
The lightcurve and variation of linear polarization of the asteroid 1038 Ganymed in apparition on 1998 (Nakayama et al., 2000).

Spectra of the asteroid 1036 Ganymed









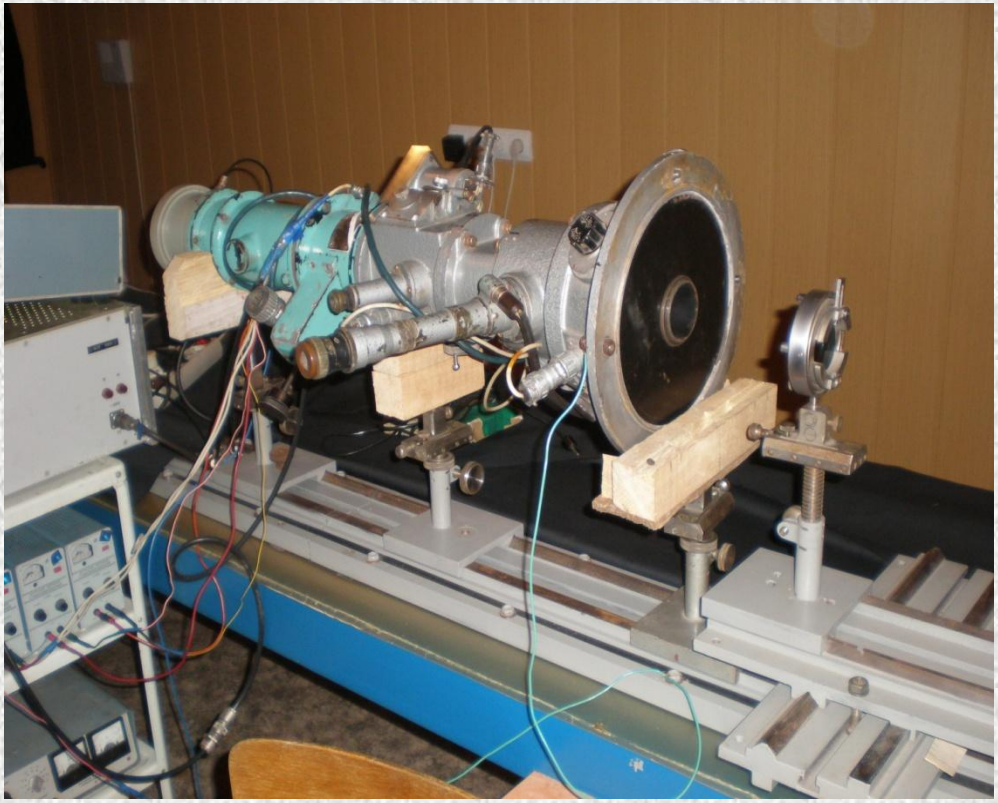
Spectra from NASA Data System EAR_A_DBP_3_RDR_24COLOR_V2_1, EAR_A_RDR_3_52COLOR_V2_1, EAR_A_I0052_8_S3OS2_V1_0, and Fieber-Beyer et al., 2007.

Our new observations of the asteroid 1036 Ganymed

The observations were carried out with 70-cm reflector of Institute of Astronomy of Kharkiv Karazin University (Grakovo), 1.0-m reflector of Simeiz Observatory and 30-cm telescope of International Center for Astronomical, Medical and Ecological Research at peak Terskol (North Caucasus). We used CCD cameras ML47-10 and STL-1001 equipped by standard BVRI filters for photometry and a modernized single channel photoelectric photometer-polarimeter AFM-6 with V filter for polarimetry. In the second mode as analysers the fast rotating achromatic quarter wavelength retarded plate with linear polaroid, and the fast rotating linear polaroid were used.

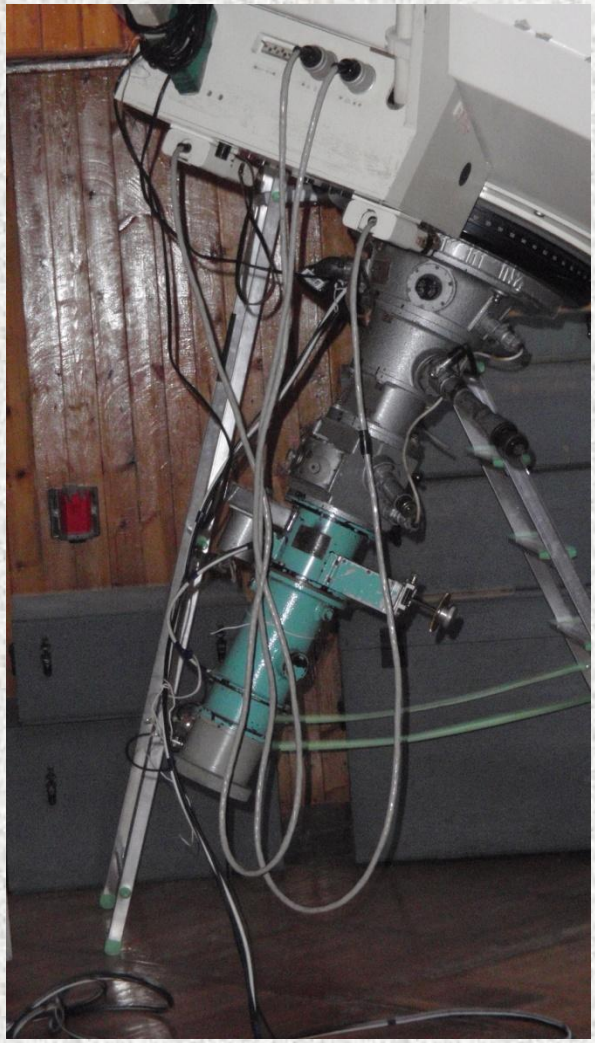
- Up today our photometry of the asteroid was performed during May-June and August-November, polarimetry – August-November 2011.

Photoelectric photometer-polarimeter AFM-6 of IA KhNU



Three mode AFM-6 at a stand of OCPI (Grakovo)

The AFM-6 is attached to RC-1000 (Simeiz Observatory) →



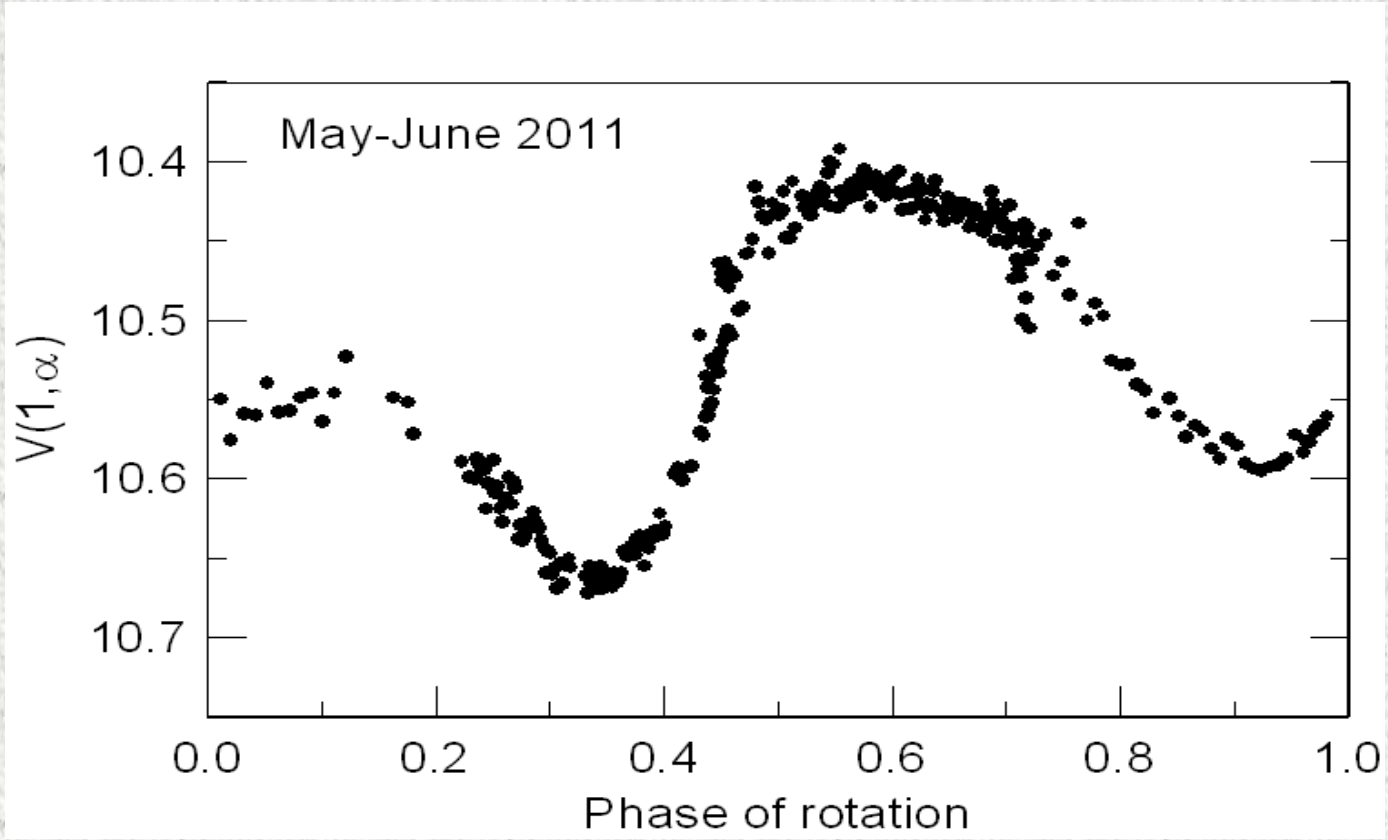
Aspect and photometric data of asteroid 1036 Ganymed

Date 2011, UT	r (a.u.)	Δ (a.u.)	λ_{2000} (deg)	β_{2000} (deg)	α (deg)	$V(1,\alpha)$ (mag)
May 19.9	1.670	1.077	307.6	36.1	35.59	10.42
23.9	1.644	1.037	310.2	38.0	36.15	10.66
30.9	1.600	0.973	315.0	41.3	37.23	10.47
Jun. 2.8	1.582	0.949	317.1	42.7	37.72	10.61
3.9	1.576	0.940	317.9	43.3	37.91	10.55
Aug. 21.0	1.248	0.554	33.8	58.9	52.56	–
30.8	1.241	0.510	39.4	55.9	51.90	–
31.9	1.241	0.505	39.8	55.5	51.74	10.16
Sep. 2.0	1.241	0.500	40.3	55.1	51.55	10.35
11.0	1.245	0.458	42.8	50.9	49.11	10.28
14.8	1.250	0.440	43.4	48.6	47.49	10.02
15.7	1.251	0.436	43.4	48.0	47.05	10.09
16.1	1.251	0.434	43.5	47.8	46.86	–
16.8	1.252	0.431	43.5	47.3	46.50	–
19.0	1.256	0.422	43.6	45.8	45.26	–
26.8	1.272	0.391	43.7	39.4	39.61	–
Oct. 1.9	1.286	0.375	42.7	34.3	34.75	

continuation of Table

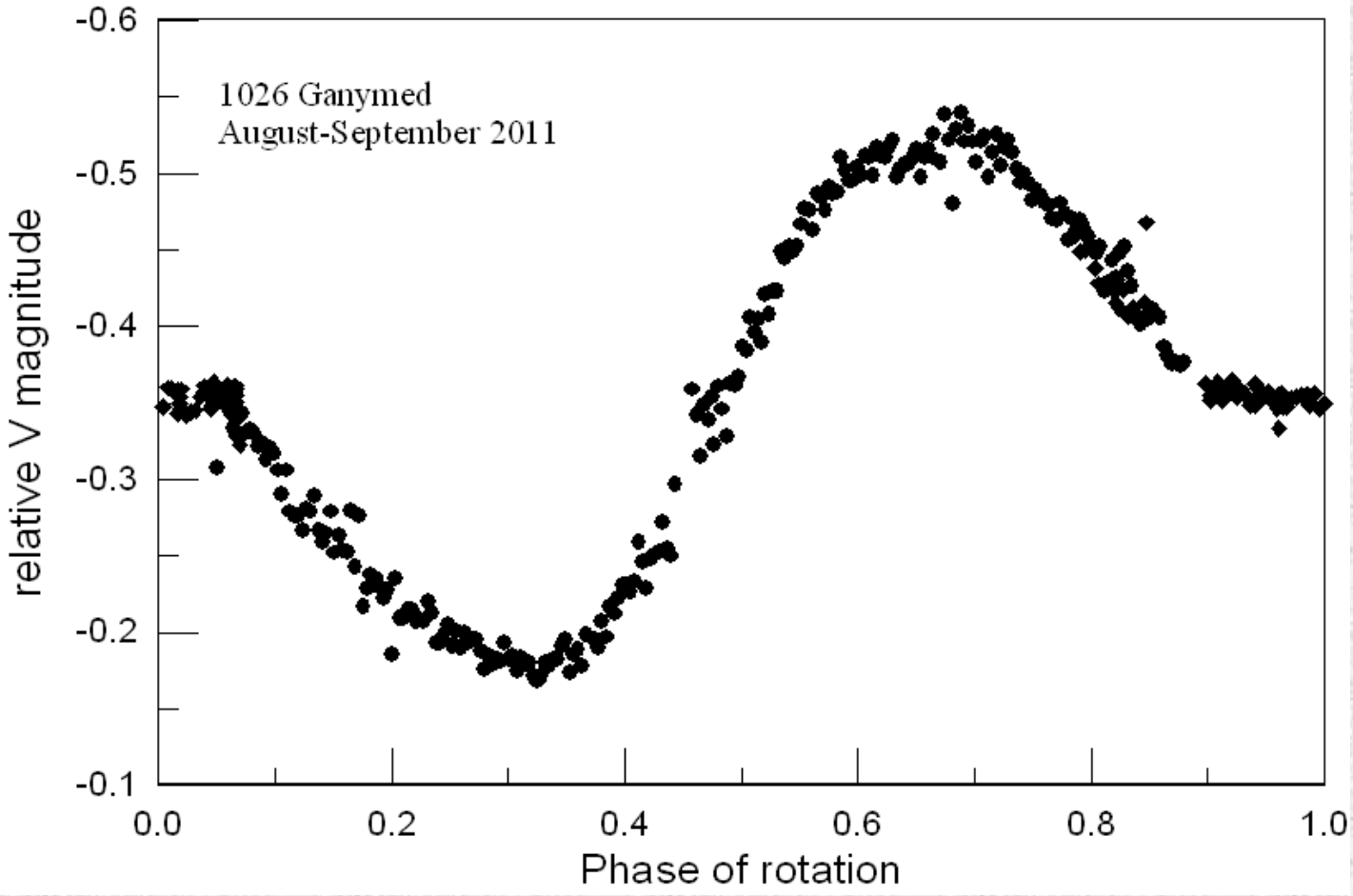
Date 2011, UT	*r (a.u.)*	*Δ (a.u.)*	*λ_{2000} (deg)*	*β_{2000} (deg)*	*α (deg)*	*V(1,α) (mag)*
Oct. 6.9	*1.302*	*0.364*	*41.4*	*28.8*	*29.25*	*9.80*
19.9	*1.351*	*0.366*	*37.2*	*12.3*	*12.10*	-
20.8	*1.355*	*0.369*	*36.9*	*11.1*	*10.89*	-
22.0	*1.360*	*0.372*	*36.5*	*9.6*	*9.30*	-
22.9	*1.364*	*0.374*	*36.2*	*8.5*	*8.10*	-
25.8	*1.377*	*0.384*	*35.3*	*5.0*	*4.37*	-
29.8	*1.397*	*0.404*	*34.0*	*0.3*	*1.34*	-
30.9	*1.402*	*0.409*	*33.8*	*-0.8*	*2.31*	-
31.9	*1.407*	*0.415*	*33.5*	*-1.8*	*3.40*	-
Nov. 1.8	*1.411*	*0.420*	*33.3*	*-2.7*	*4.33*	-
7.7	*1.442*	*0.462*	*31.9*	*-8.1*	*10.33*	-
14.8	*1.481*	*0.523*	*30.8*	*-12.1*	*16.18*	-
18.8	*1.504*	*0.563*	*30.5*	*-15.4*	*18.89*	-
19.9	*1.511*	*0.574*	*30.4*	*-15.9*	*19.55*	-

Lightcurve and colours of the asteroid 1036 Ganymed obtained on May-June 2011

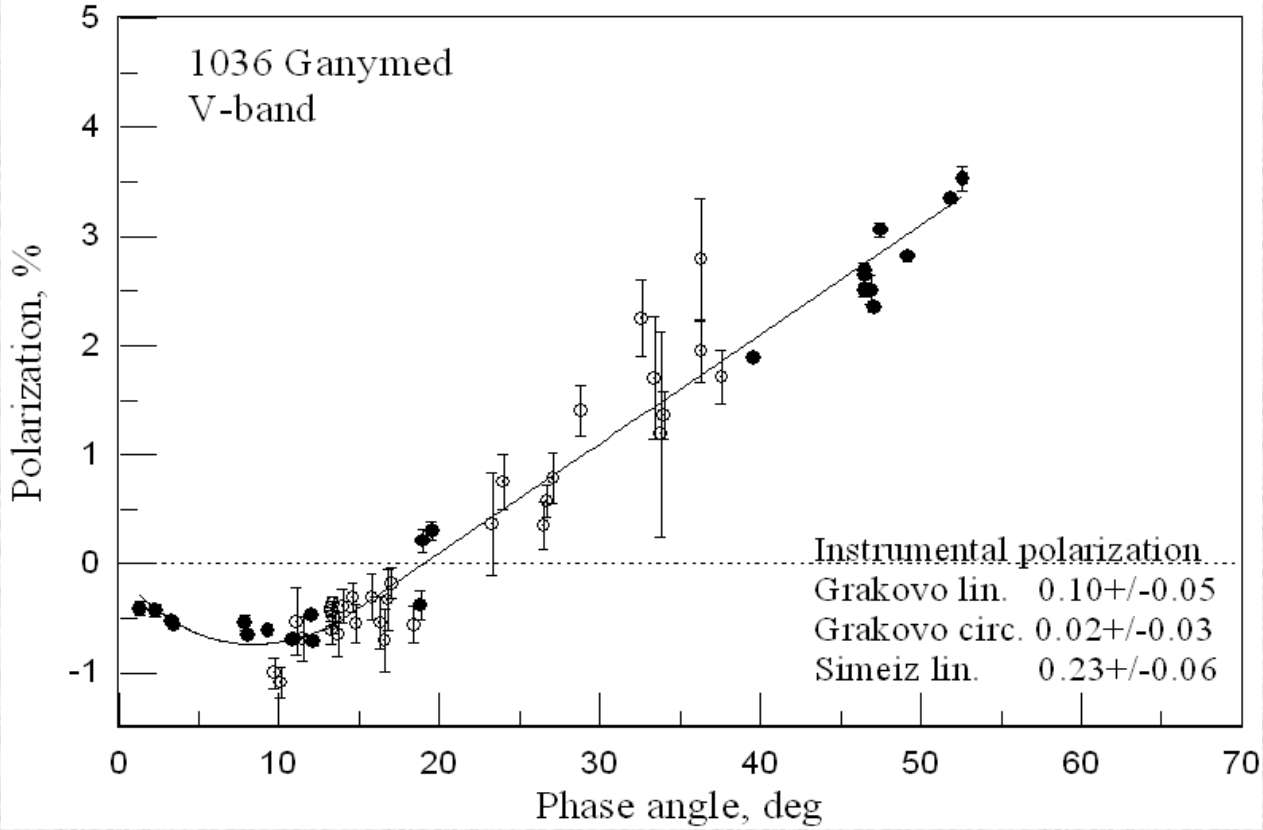


At the lightcurve primary maximum color indexes are the following: B–V=$0^m.85$ ±$0^m.02$, V–R=$0^m.53$±$0^m.01$, and R–I=$0^m.36$±$0^m.01$. The obtained values coincide or are close to earlier observed ones (Hahn et al.,1989; Chernova et al., 1995). The only V–R differs on $0^m.05$ between the presented opposition and 1985.

Lightcurve of the asteroid 1036 Ganymed obtained on August-September 2011



Phase dependence of linear polarization of the asteroid 1036 Ganymed



Results of our observations on August-November, 2011 (•), and data from the previous oppositions (o) obtained by Kiselev et al., 1997; Nakayama et al., 2000. Parameters of phase dependence are the following: h=0.097 *%/deg*; α_o=19 .1; P_{min}= -0.74 *%*; α_{min}=8 .5.

Main results

The asteroid 1036 Ganimed was observed in opposition 2011 by photometry and polarimetry in broad range of the aspect (50°-120°) and phase angle (1.3°-52°).

The lightcurve of the asteroid changes from standard type with two pairs extrema for period of the rotation to strange type with two extrema and plateau of the constant brightness by length about of 2 hours. Variations of colour are noted on surfaces of the asteroid. This points to complex shape of Ganymed and albedo (mineral) spotted to surface.

The phase dependence of linear polarization of Ganymed in negative and positive branches are obtained. It has allowed to elaborate the polarimetrical albedo of asteroid. Its importance turned out to be close to that (≈0.30) that was determined by other methods.

The circular polarization obtained under large phase angle (near 50°) turned out to be different in different part of lightcurve (from 0.2 % to 0%).

The Model of the shape of the asteroid expects the large flattening near pole of the asteroid 1036 Ganymed.

Thank you!