Institute of Astronomy of Kharkiv University – National Institute for Astrophysics, Italy
March 22-23, 2018

OPTICAL ASTRONOMY

Yurij Krugly

Institute of Astronomy of V.N. Karazin Kharkiv National University
Kharkiv, UKRAINE

Astronomical Map of Ukraine

Astronomical Observatories in Ukraine

In Ukraine there are Astronomical Observatories of Universities and Astronomical Institutes of National Academy of Science of Ukraine

Variable stars: Odesa, Kiev, Uzhgorod

Galaxies and deep-space objects: Kiev, Kharkiv, Lviv

Planetary research: Kharkiv, Kiev, Odesa

Institute of Astronomy
V.N. Karazin Kharkiv National University

1804: Kharkiv University was opened

1808: The astronomy lectures were started

1882: The Astronomical Observatory was stated

1908: The planetary and Moon study was started

1978: Physical study of asteroids was started

1995: CCD observations of asteroids were initiated

Chuguev Observation Station

Institute of Astronomy of Karazin Kharkiv National University, UKRAINE

70-cm telescope

Kharkiv Asteroids and Comets Group

(15898) *KharAsterTeam*

25-cm telescope

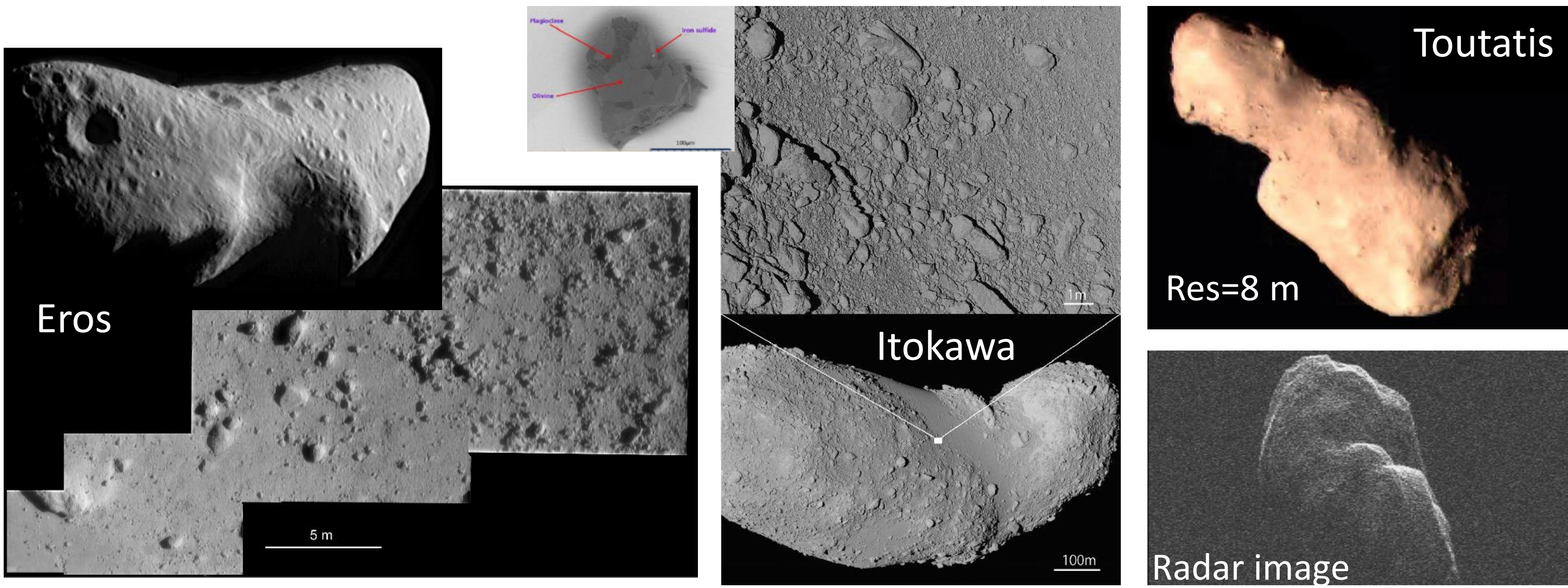
The home telescopes are useful for planning alert observations

Simeiz Observatory, Crimea

1-m Zeiss telescope

NEAR-EARTH OBJECTS

- Intensive discovery (~3 objects/day);
- Evidences of a very heterogeneous population;
- First detections of YORP effect (spin-up was detected for 6 NEAs thanks to long-term observations by *Lowry et al., 2007; Kaasalainen, Krugly et al. 2007*);
- Establishments of direct links between NEAs and meteoroids (2008 TC3 =Almahata Sita);
- Study of Eros (33x13 km), Itokawa (0.5x0.3 km) and Toutatis (4.75x1.95 km). by space missions.



✓ Exploration of small NEAs (D<300 m);
✓ Search for organics, water, metals; better understanding weathering processes.

PHOTOMETRY OF NEAR-EARTH ASTEROIDS IN THE FRAME OF ISON NETWORK

- Since 2006 we are cooperated with ISON network
- Coordination of the asteroid research in the frame of ISON network
- It is possible to use the telescopes in the ISON network in alert regime for follow-up newly discovered NEAs during its close approaching with the Earth

ISON – INTERNATIONAL SCIENTIFIC OPTICAL NETWORK

ISON is non-government project established in 2004 to carry out regular monitoring of space debris: primarily high-geostationary orbits, high-elliptical, circular type of GLONASS and GPS. The Project joins 38 organizations in 16 countries with about 80 telescopes of different classes with diameters from 0.2 m up to 2.6 m which are modernized and using in the network.

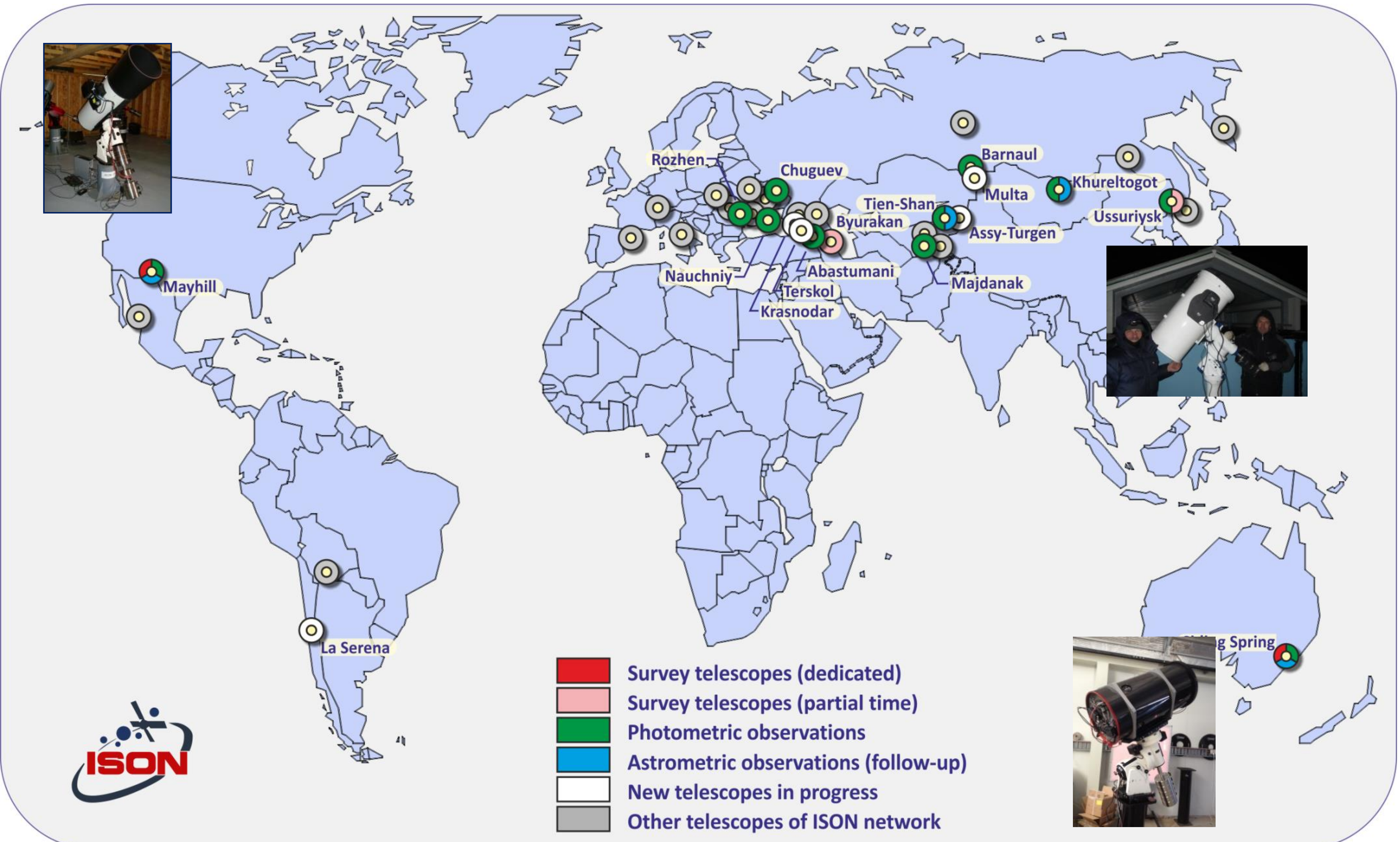






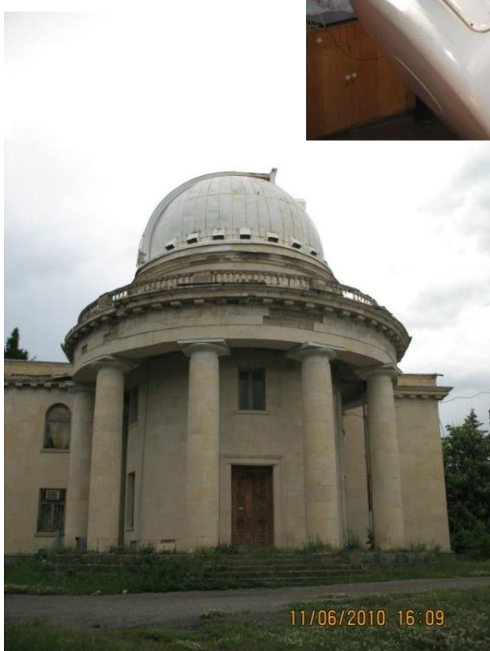


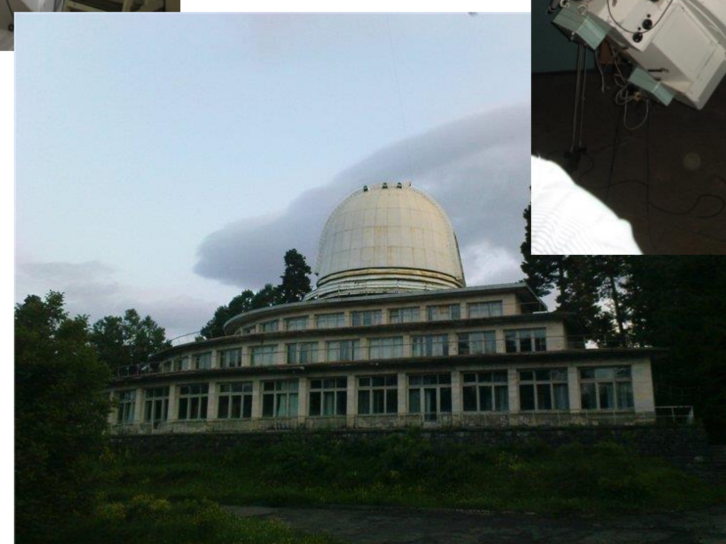
ISON Observatories Involved in Asteroid Observations (green)



Abastumani Observatory, Georgia

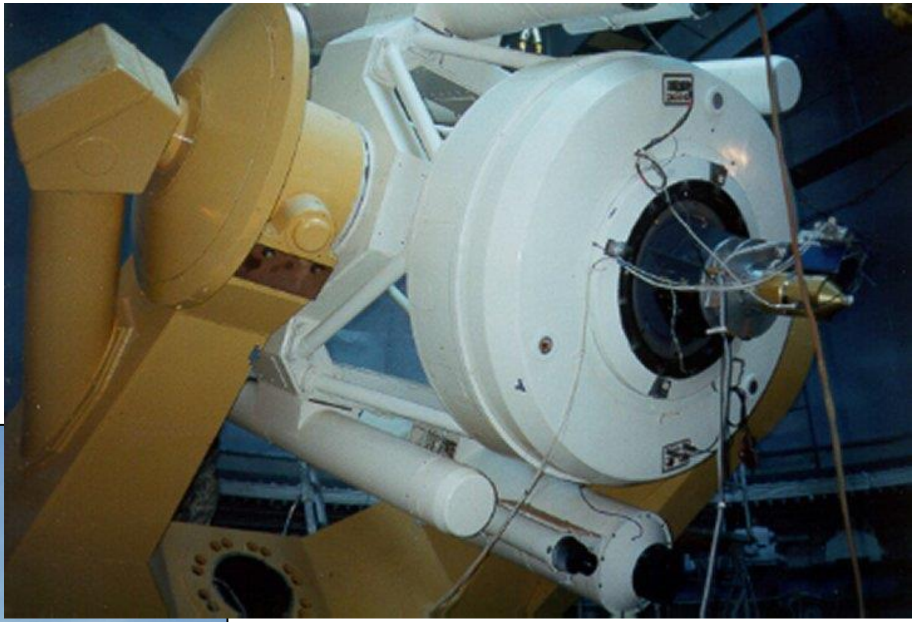
70-cm and 1.25-m telescopes

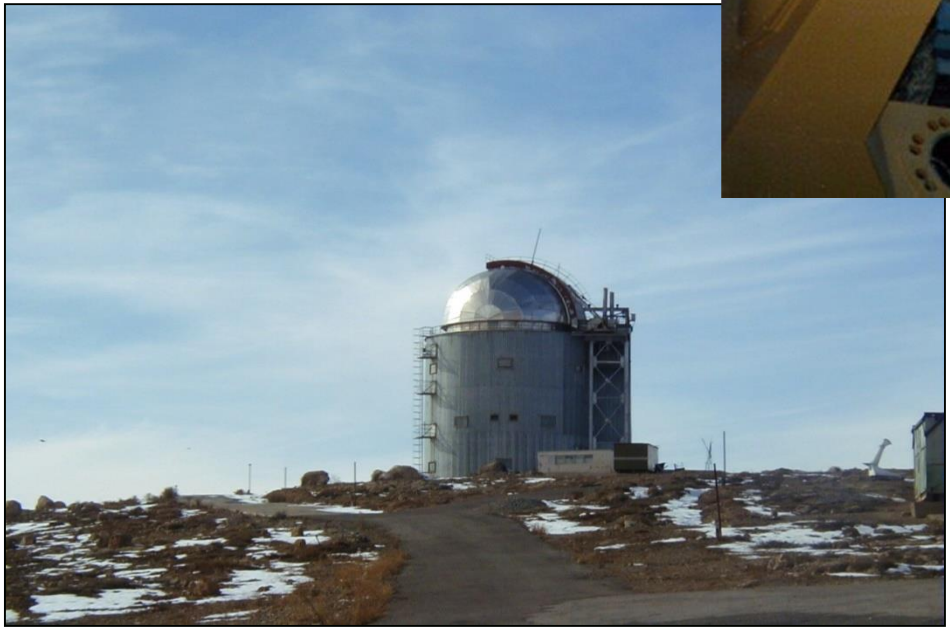


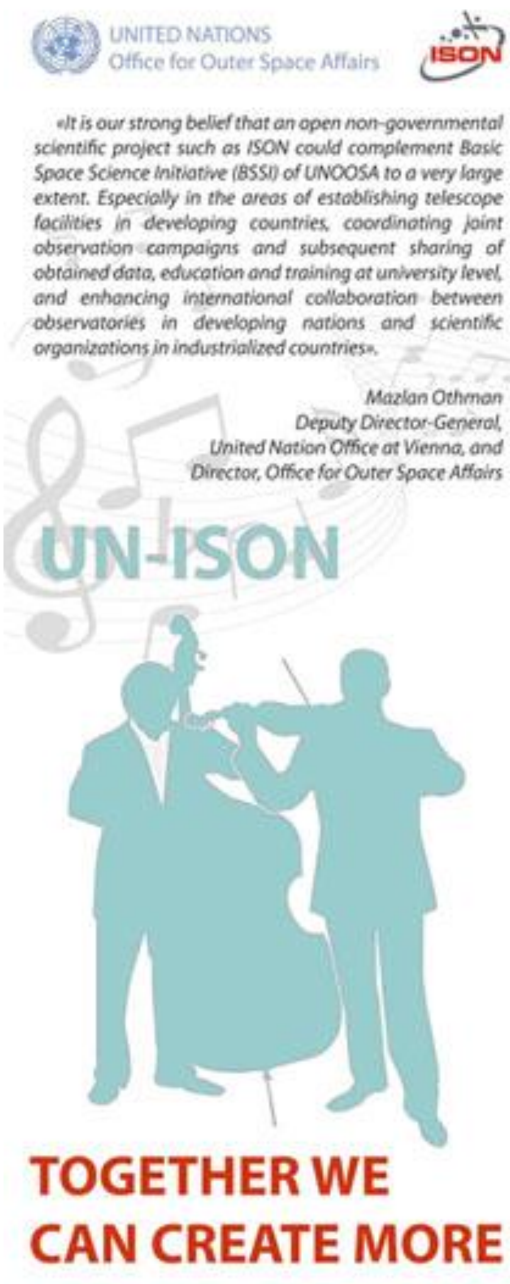


Maidanak Observatory, Uzbekistan

60-cm and 1.5-m telescopes







Monday, 11 June 2012
12:00 – 15:00, Room M0E100

Outreach seminar on BSSI-ISON cooperation

Basic Space Science Initiative (BSSI) of UNOOSA is a long-term effort in the development of astronomy and space science through regional and international cooperation on a worldwide basis, mainly for the benefit of developing nations. Through a series of annual workshops and subsequent follow-up projects, particularly the establishment of astronomical telescope facilities in developing countries for research and education programmes at university level, development of materials for teaching and observing programmes for small optical telescopes and facilitation of deployment and operation of global arrays of instruments for studying the Earth-Sun relationship, this initiative contributes significantly to building capacity of developing nations in space science.

International Scientific Optical Network (ISON), which has been initiated in 2001 and is coordinated by the Keldysh Institute of Applied Mathematics (KIAM) of the Russian Academy of Sciences, now includes more than 40 telescopes in 23 observatories of 14 countries and with ongoing work on enlarging the number of participating countries, mostly developing ones. It represents a positive example of cooperative research that provides reliable scientific outputs on asteroids, GRB afterglows and space debris.

The outreach seminar, organized as a side event of 55th session of COPUOS, will discuss opportunities in BSSI-ISON cooperation in the areas of establishing telescope facilities in developing countries, coordinating joint observation campaigns, subsequent sharing and join analysis of obtained data, education and training at university level, and enhancing international collaboration between observatories in developing nations and scientific organizations in industrialized countries.

Open remarks: ***M. Othman (UNOOSA)***

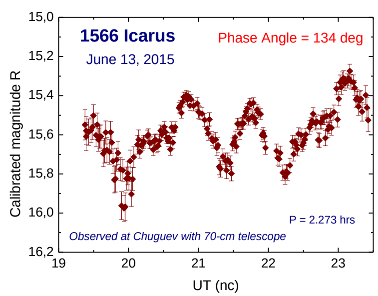
Expected speakers (in alphabetic order):

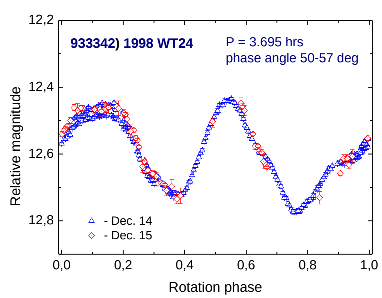
- ***A. A. Abiodun (Nigeria)***
- ***V. Agapov (Russia)***
- ***N. Archinard (Switzerland)***
- ***S. Camacho (Mexico)***
- ***H. Haubold (UNOOSA)***
- ***Yu. Krugly (Ukraine)***
- ***P. Martinez (South Africa)***
- ***F. Menicocci (Argentina)***
- ***T. Namkhai (Mongolia)***

Open discussion at the end of the meeting

Monitoring of potentially hazardous asteroids

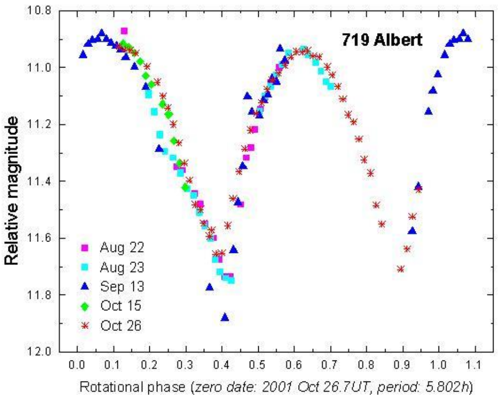
- ~ 50 newly discovered and hazardous near-Earth asteroids are observed each year (> 200 observational nights)
- the network includes telescopes of the 0.6-2.6 m diameters in Ukraine, Georgia, Kazakhstan, Uzbekistan, Bulgaria.

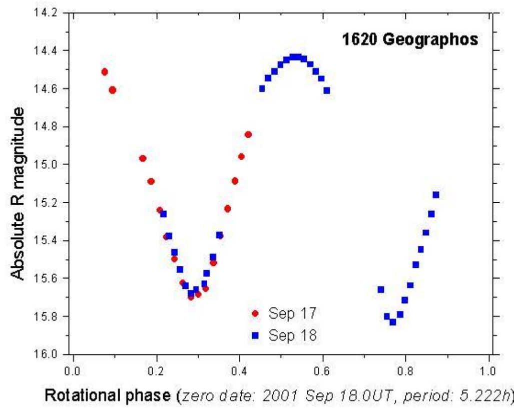


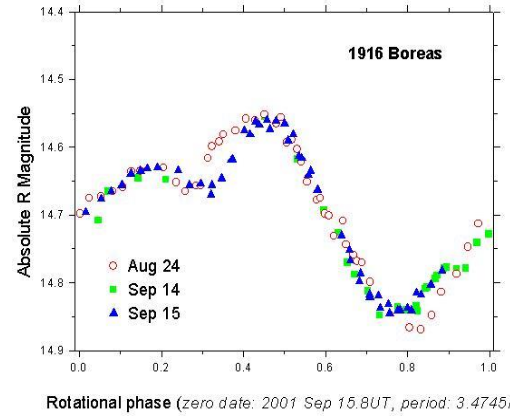


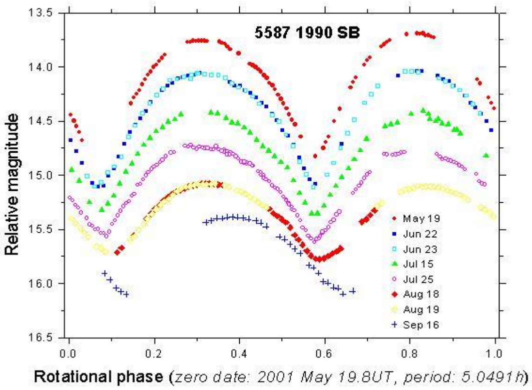
- observational confirmation of theoretically predicted YORP effect;
- discovery of super-fast rotators with rotation periods of several minutes;
- determinations of sizes and composition of potentially hazardous asteroids.

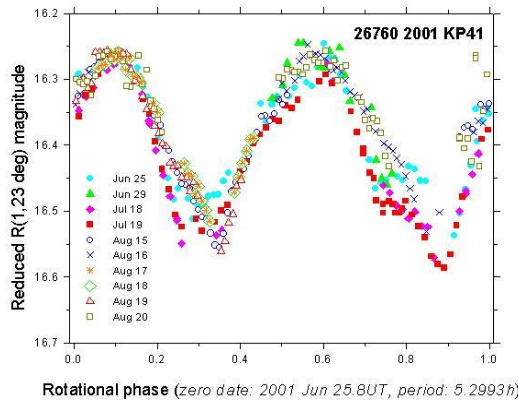
NEAR-EARTH ASTEROID LIGHTCURVES

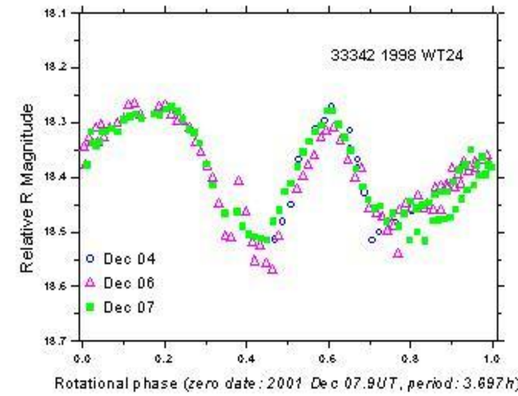












OBJECTS OF PHOTOMETRY

In 2015 observations were carried out during 220 nights for 67 NEAs:

PHA (23)

- 1566 Icarus H=16.9
- 1620 Geographos H=15.60
- 3200 Phaethon H=14.6
- 4183 Cuno H=14.4
- 6239 Minos H=18.5
- 7822)1991 CS H=17.4
- 23187 2000 PN9 H=16.1
- 33342 1998 WT24 H=17.9
- 66391 1999 KW4 H=16.5
- 85989 1999 JD6 H=17.1
- 85990 1999 JV6 H=20.2
- 138127 2000 EE14 H=17.1
- 140288 2001 SN289 H=16.7
- 141527 2002 FG7 H=18.9
- 163899 2003 SD220 H=17.3
- 206378 2003 RB H=18.7
- 235756 2004 VC H=18.7
- 2014 YB35 H=19.0
- 2015 DD54 H=25.4 (Virtual Impactor)
- 2015 FL H=20.8
- 2015 FS332 H=18.4
- 2015 NK13 H=21.0
- 2015 TB145 H=20.0
- 2015 VE1 H=21.0

Radar targets (18)

2015 SV2
33342 1998 WT24
163899 2003 SD220
1864 Daedalus
2015 TB145
2006 UY64
86666 2000 FL10
206378 2003 RB
385186 1994 AW1
85989 1999 JD6
436724 2011 UW158
1566 Icarus
2012 LC1
235756 2004 VC
2015 FL
189008 1996 FR3
357439 2004 BL86
85990 1999 JV6

Binary NEAs

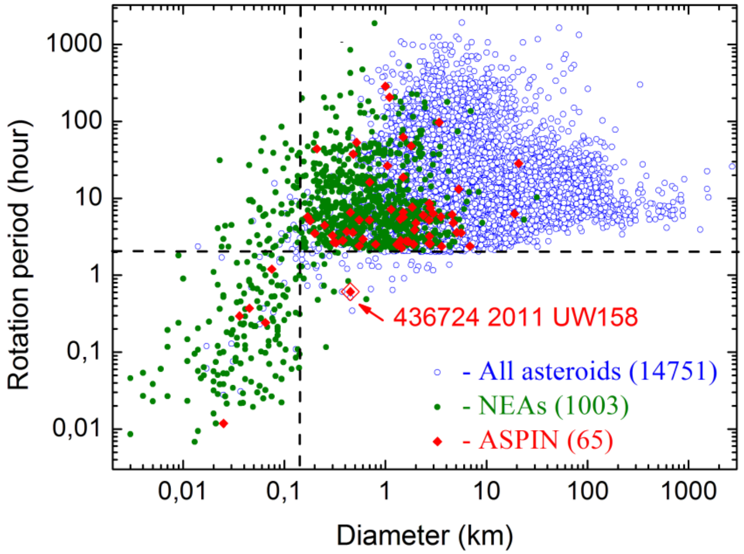
1866 Sisyphus
66391 1999 KW4
137170 1999 HF1
357439 2004 BL86

Tested for Binary

7889 1994 LX
152679 1998 KU2

YORP and BYORP effects

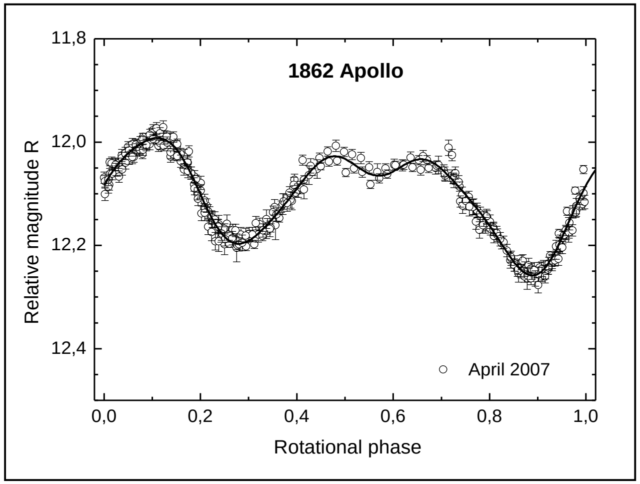
1864 Deadalus
4055 Magellan
66391 1999 KW4
85990 1999 JV6
137170 1999 HF1
1620 Geographos



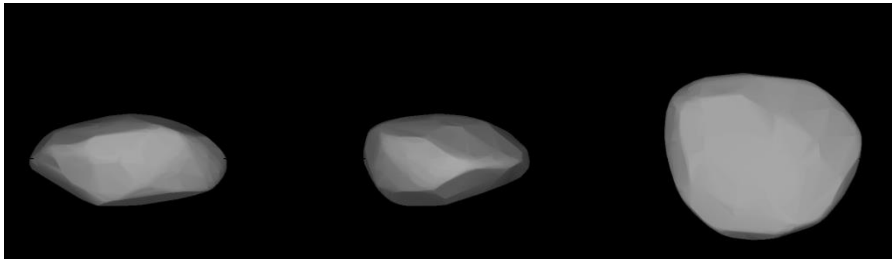
Detection of YORP effect: 1862 Apollo

Our observations on the NEA 1862 Apollo have been done at Simeiz Observatory (Crimea, Ukraine) in 2005. It was found a linear increase of the sidereal rotation period *P* in time *t as* $dP/dt = -4.5 \times 10^{-3}$ min/year. It was the first detection of YORP on an asteroid rotation (*Kaasalainen , Krugly et al. 2007, Nature 446, 420*).

Our new observations of Apollo in April 2007 have confirmed an influence of the YORP effect on Apollo's rotation period (*Durech , Krugly et al. 2008, A&A 488, 345–350*).



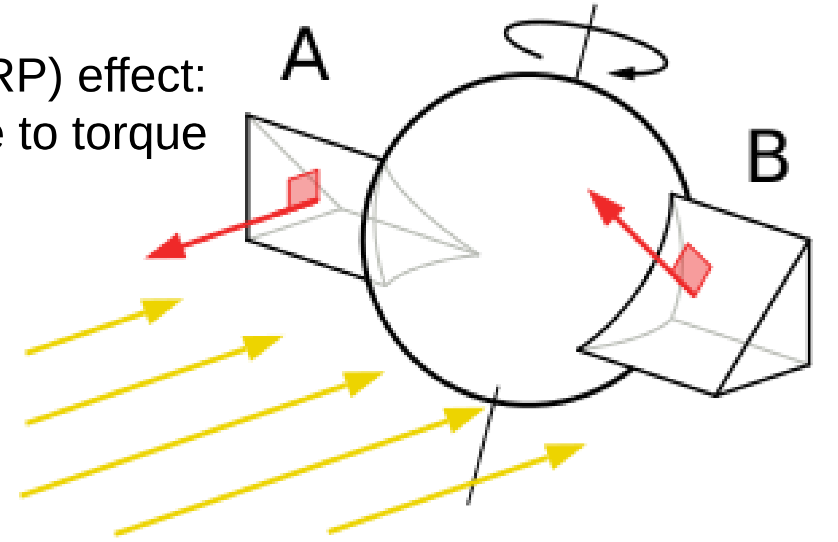
Composite lightcurve of Apollo.

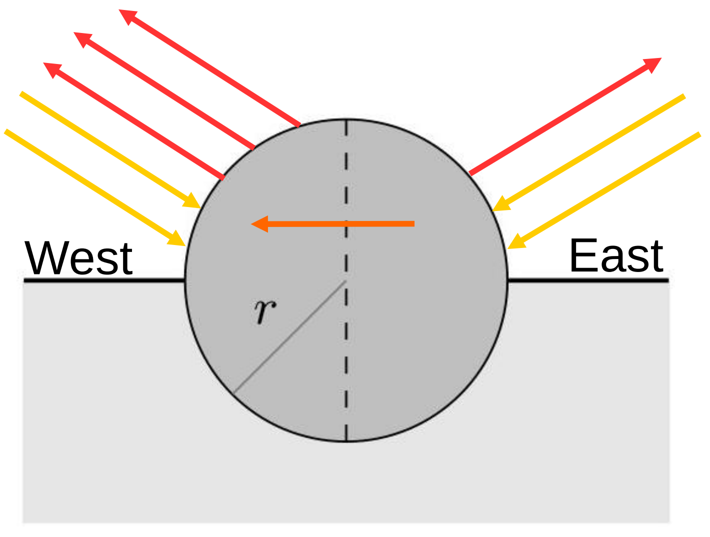


The shape model of Apollo shown at equatorial aspect (*left and centre, 90˚ apart), and at pole-on (right).*

YORP effect

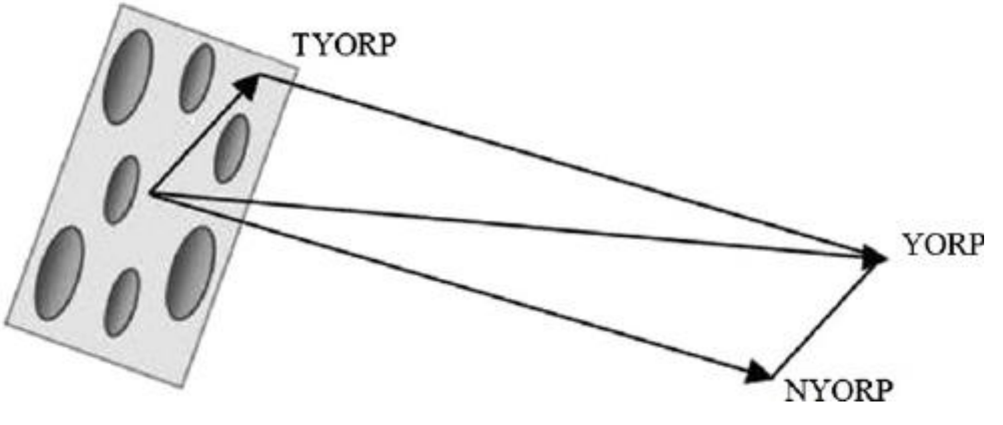
Yarkovsky–O'Keefe–Radzievskii–Paddack (YORP) effect: an asymmetric asteroid can alter its rotation due to torque of the radiation forces (Rubincam 2000)





Tangential YORP (Golubov and Krugly 2012): even a symmetric asteroid can alter its rotation rate due East-West asymmetry in the infrared light emission by the boulders

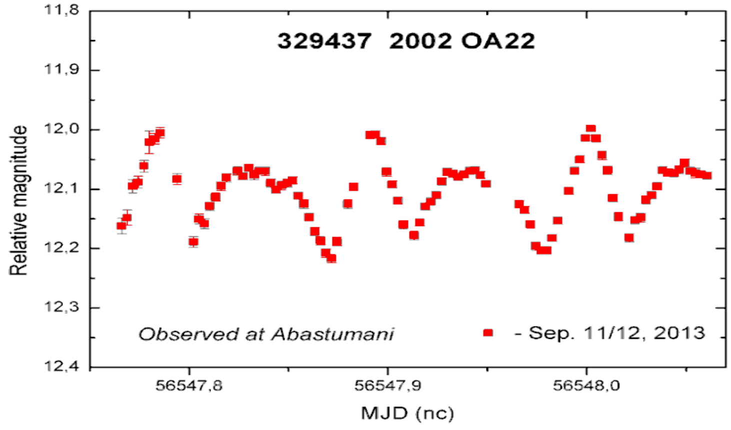
Both effects act in concert and have the same order of magnitude.



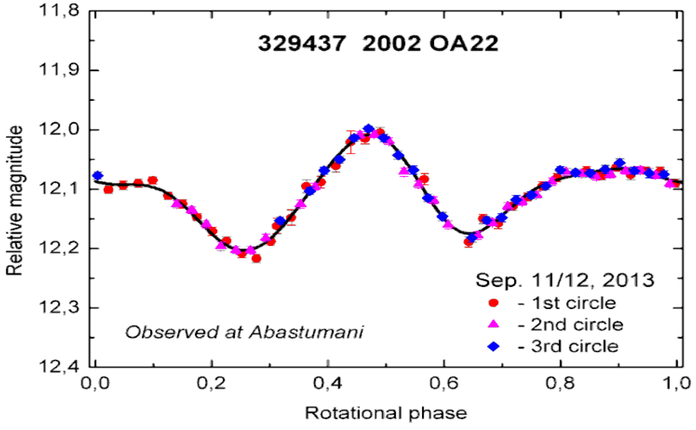
Search for Binary Asteroids

We search for binary asteroids and determine parameters of the binary systems.

NEA (329437) 2002 OA22 was observed during Sep 11 & 12, 2013 at Abastumani (Georgia) and binary sings were not registered.
The rotation period is found to be 2.621 hrs.



Lightcurve on Sept. 11, 2013

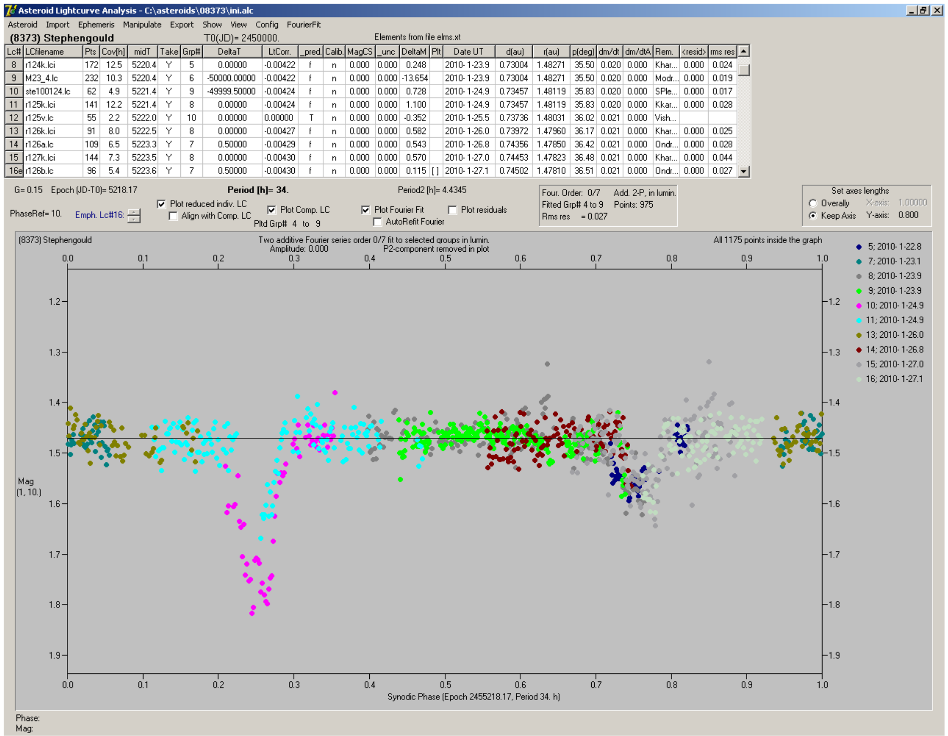


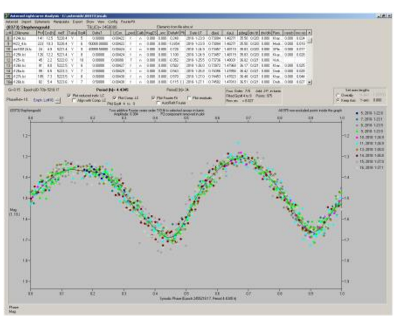
Composite lightcurve, P = 2.621 hrs

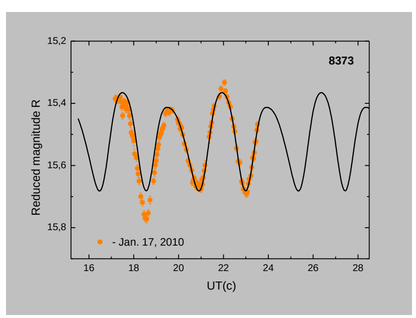
Search for binary asteroids

- ~15% small asteroids are found to be binary systems

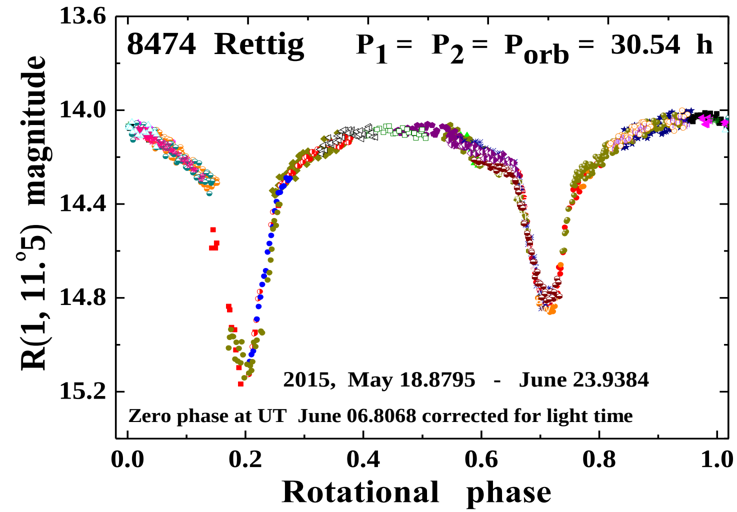
Asynchronous binary's lightcurves

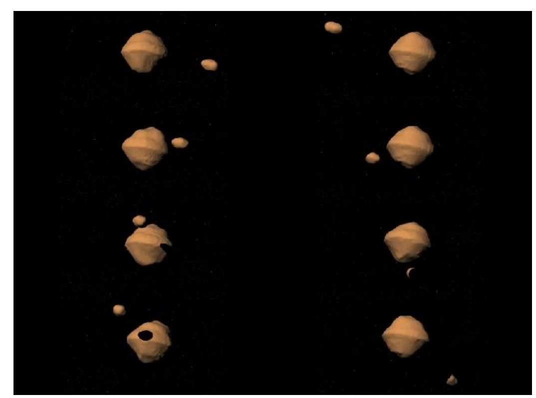






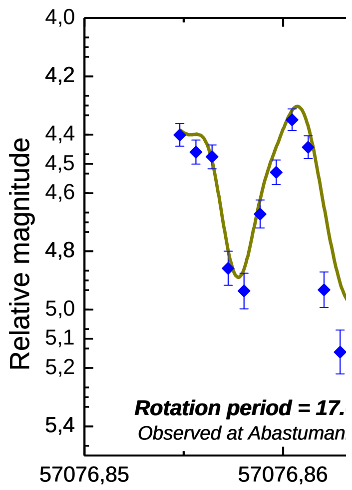
Synchronous binary's lightcurve

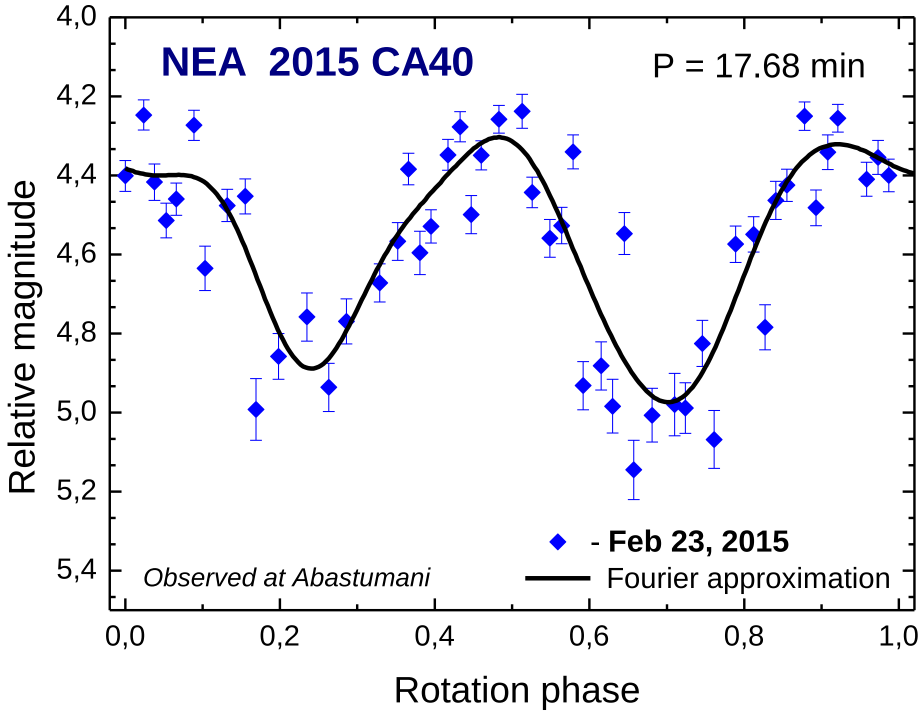




NEWLY DISCOVERED NEAs

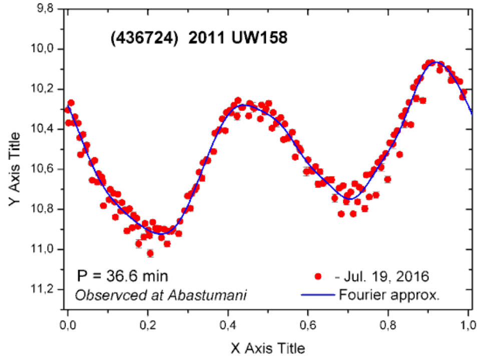
- 2015 CA40 with H = 24.5 (pv=0.18) D = 38 m

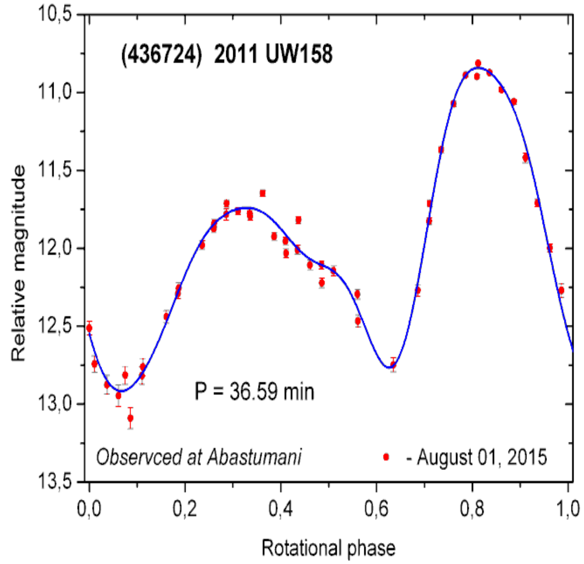


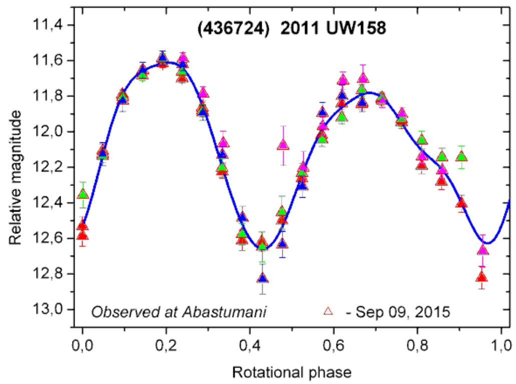


LARGE SUPER FAST ROTATOR

- (436724) 2011 UW158 with H = 19.5 (pv=0.18) D = 350 m



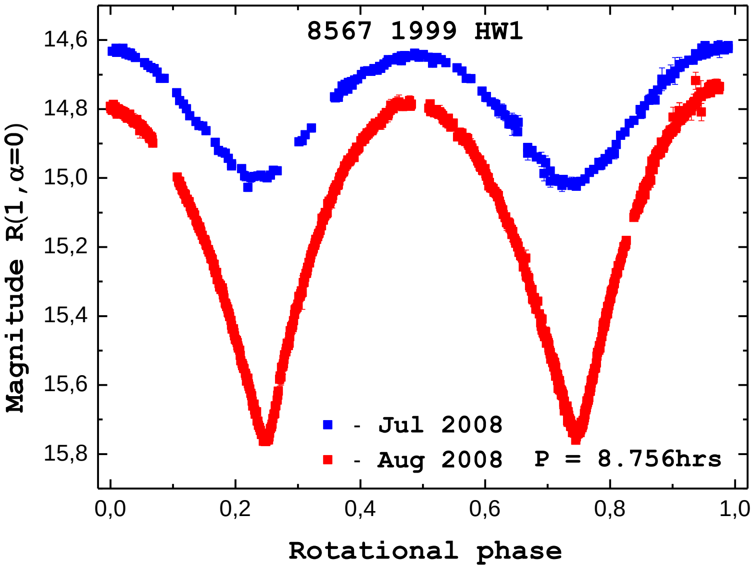




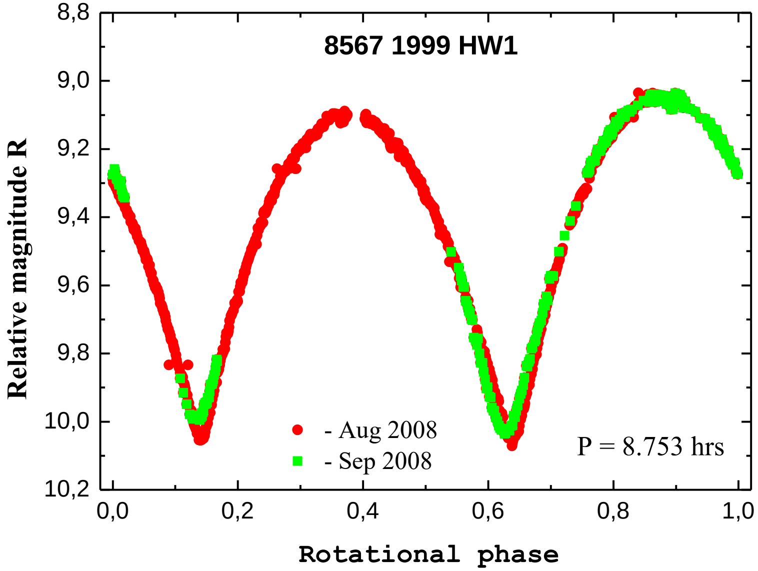
Arecibo radar image of 2011 UW158

Asteroid Radar Shape Models:

Lightcurves of NEA 8567 1999 HW1



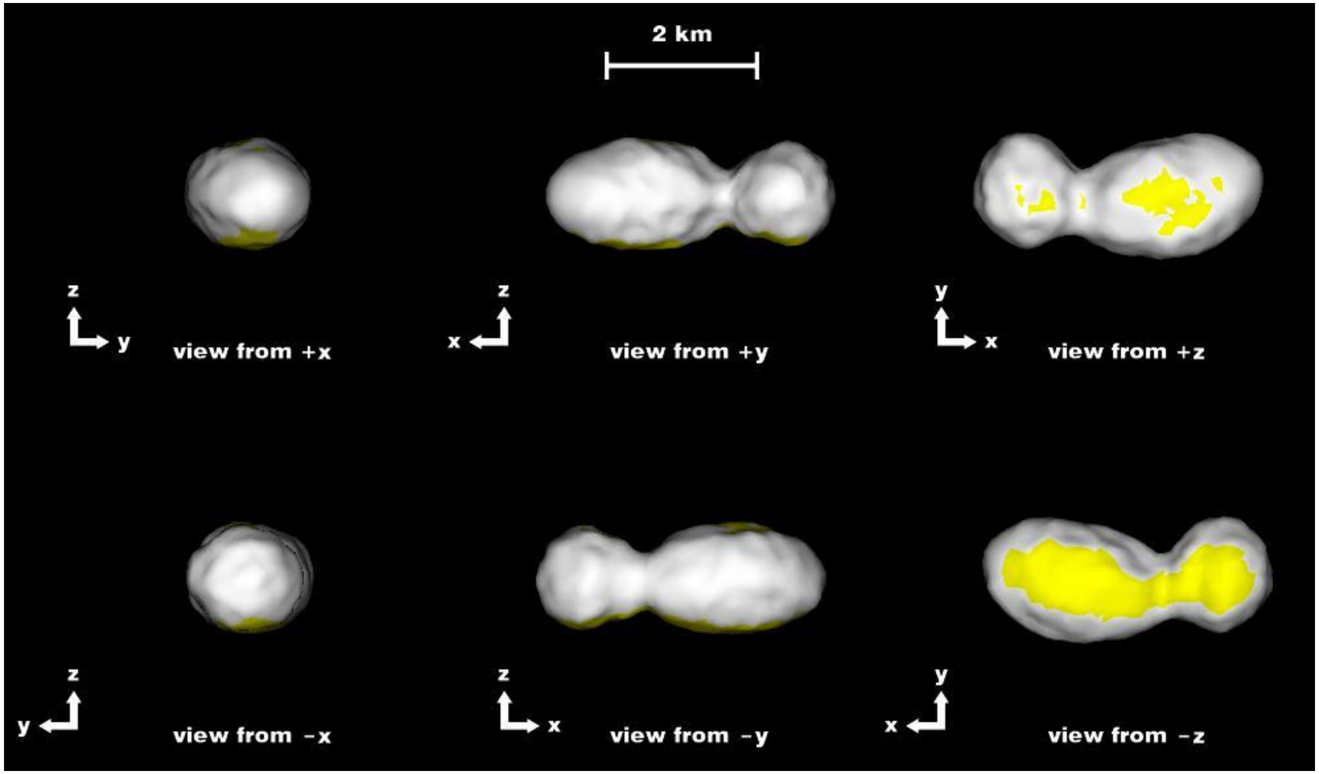
July-August 2008



August-September 2008

Shape Model of *8567 1999 HW1:*

Radar and Photometry



Magri, Krugly et al. 2011. Icarus 2014, 210-227.

MAIN–BELT ASTEROID: (21) LUTETIA

- Validation of interpretive methodologies by spacecraft missions

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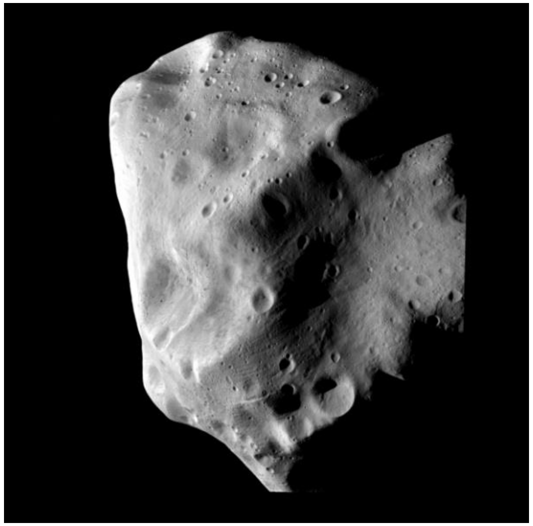
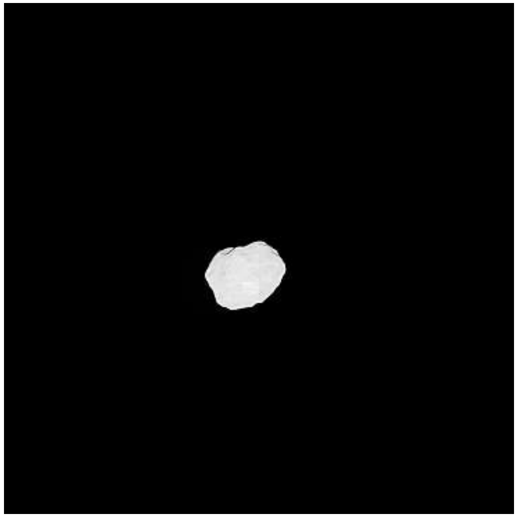
Highlight: Puzzling asteroid 21 Lutetia: our knowledge prior to the Rosetta fly-by (vol. 515)

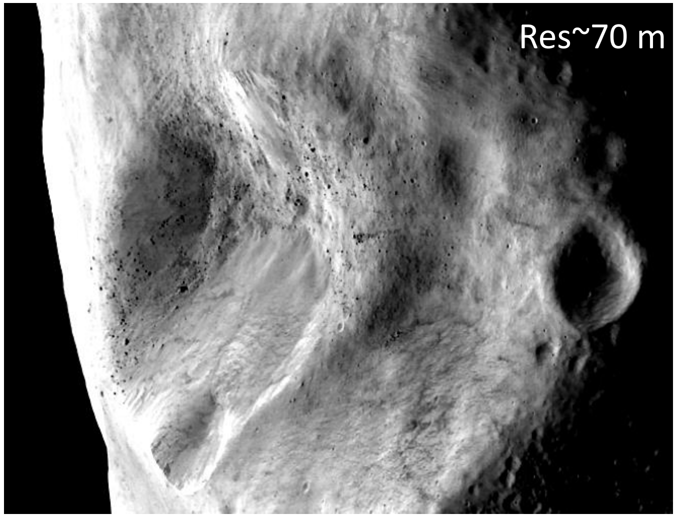
Vol. 515 In section 10. Planets and planetary systems by I. N. Belskaya, S. Fornasier, Yu. N. Krugly, V. G. Shevchenko, N. M. Gaftonyuk, M. A. Barucci, M. Fulchignoni, and R. Gil-Hutton, A&A 515, A29

Asteroid 21 Lutetia will be visited by the Rosetta spacecraft on July 10, 2010. Belskaya et al. analyze photometric and polarimetric measurements over a wide range of phase angles. They make predictions that should be directly tested by the fly-by observations: (i) Lutetia has a non-convex shape, probably caused by a large crater, and heterogeneous surface properties probably related to surface morphology; (ii) at least part of the surface is covered by a fine-grained regolith with a particle size less than 20 microns; (iii) the surface composition is similar to that of CO, CV, and/or CH carbonaceous chondrites.

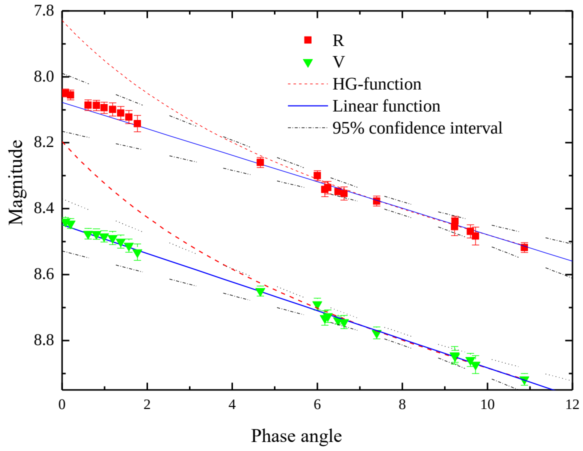
126 x 103 x 95 km

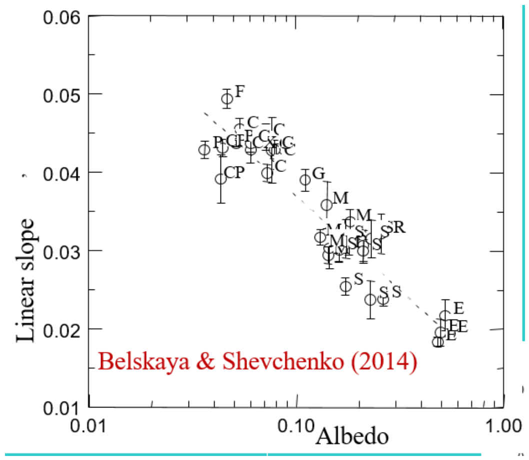




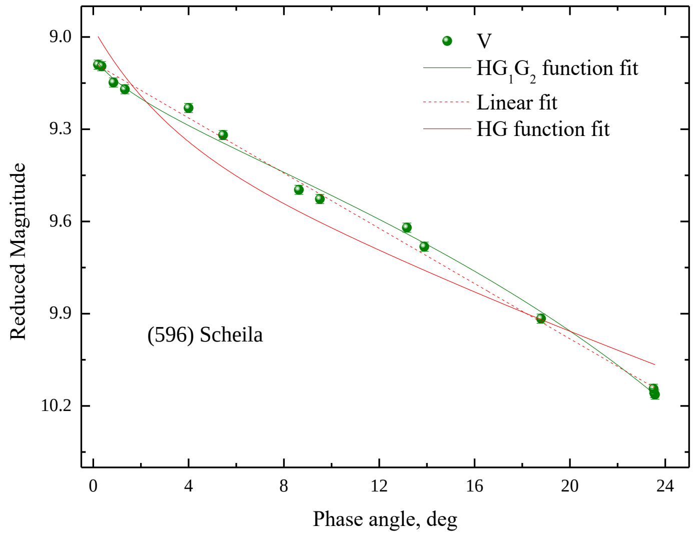


Absolute Magnitudes of Asteroids





• Our observation data on phase-magnitude relations have been served to establish a new magnitude system of asteroids **HG1G2,** which was accepted by IAU



Kharkiv Asteroid Magnitude-Phase Relations

A database of asteroid magnitude-phase relations compiled at the Institute of Astronomy of Kharkiv Kharazin University by Shevchenko et al., including observations from 1978 through 2008. Mainly the observations were performed at the Institute of Astronomy (Kharkiv, Ukraine) and at the Astrophysics Institute (Dushanbe, Tadjikistan). For most asteroids the magnitude-phase relations were obtained down to phase angles less than 1 deg. For some asteroids the magnitudes are presented in three (UBV) or four (BVRI) standard spectral bands.

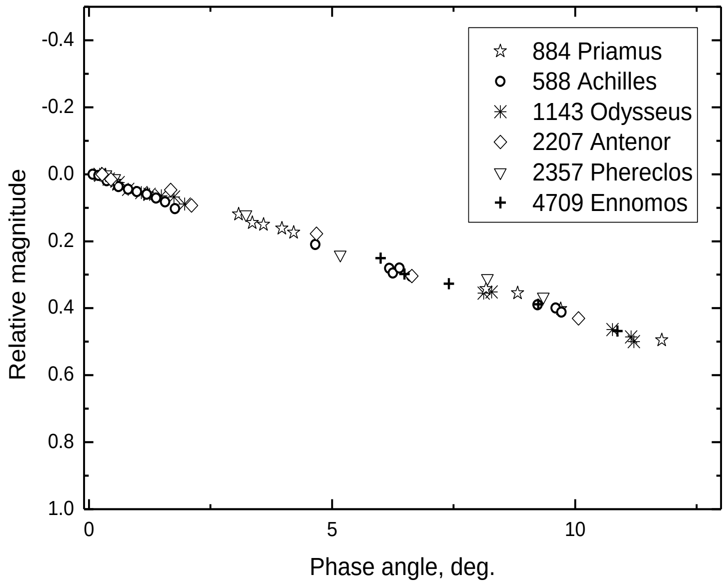
EAR-A-COMPIL-3-MAGPHASE-V1.0	Browse	Download (34 kb)

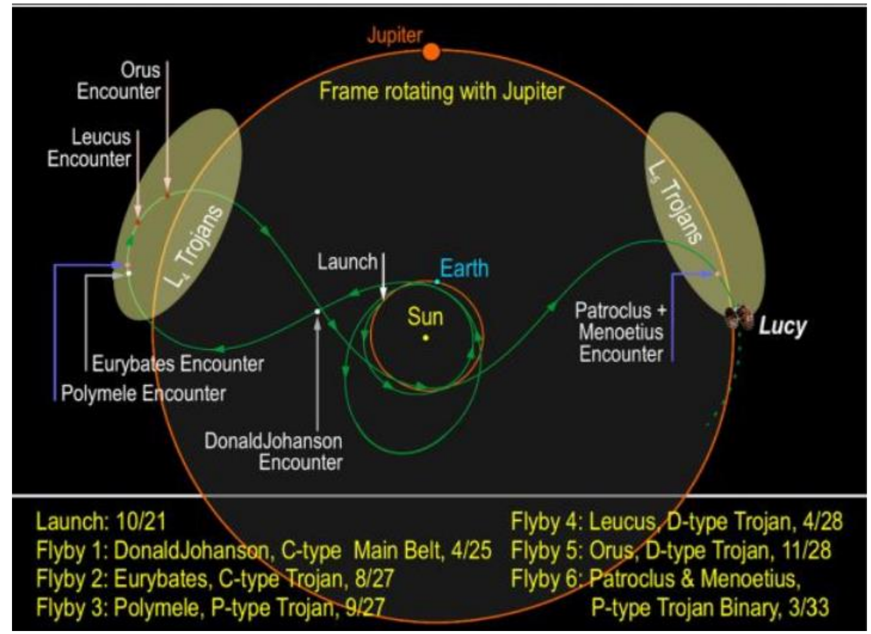
Use the following citation to reference this data set:

"Shevchenko, V.G., Belskaya, I.N., Lupishko, D.F., Krugly, Yu.N., Chiorny, V.G., and Velichko, F.P., Eds., Kharkiv Asteroid Magnitude-Phase Relations V1.0. EAR-A-COMPIL-3-MAGPHASE-V1.0. NASA Planetary Data System, 2010."

Photometry of Jupiter Trojans

Kharkiv observations of Trojans.
(*Shevchenko et al. 2013*)





Lucy mission will be launched in 2021.
We need physical properties of 5 targets.

- Absence of the opposition effect.
- Phase slope correlates with albedo – method to determine the albedo.
- Searching differences in physical and dynamical properties between L4 and L5 swarms of Jupiter Trojans.

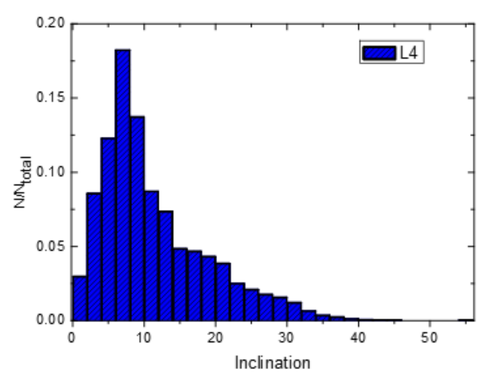


Figure 4: Distribution of the orbital inclinations of Trojans in the L4 swarm.

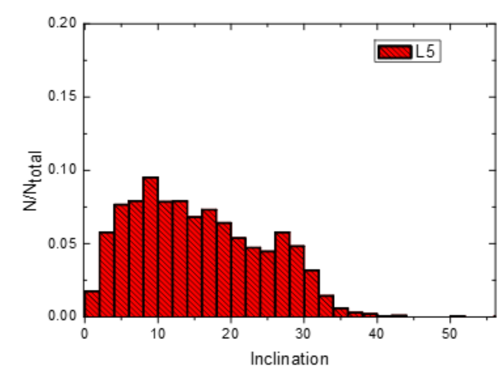
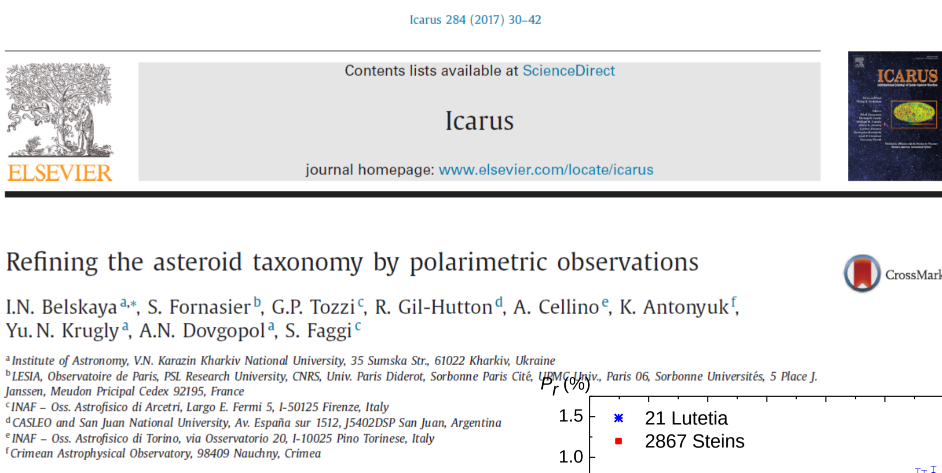


Figure 5: Distribution of the orbital inclinations of Trojans in the L5 swarm.

Polarimetry of Asteroids and Transneptunian Objects

- ~ 150 objects
- telescopes of the 1.25-8.2 m diameters in Ukraine, Italy (1.8 m Asiago obs., 1.5 m Loiano station), Argentine, Bulgaria, ESO-Chile.
- long-term cooperation with Italian scientists



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Refining the asteroid taxonomy by polarimetric observations

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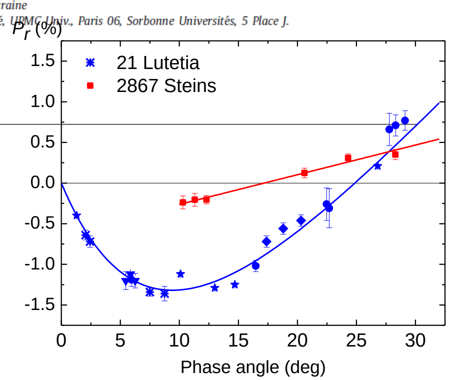
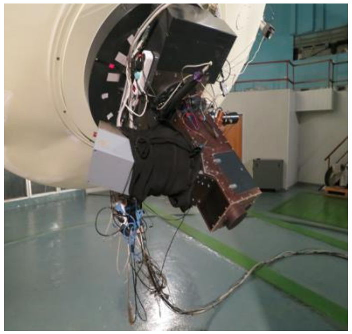


- discovery of asteroids with peculiar polarimetric properties,
- first determination of albedos of targets of space missions and hazardous asteroids;
- diversity in polarization behavious of transneptunian objects and centaurs.

Spectral Observations of Comets

Multi-mode Cassegrain Spectrometer on the 2-m telescope at Terskol Observatory



Modes	Echelle	Quasi Echelle	Classic, 8° grating	Classic, 4° grating	Classic, prism
Max. Resolution	13500	3200	1200	600	100
Limiting Mag., S/N~10	~12.5	~14.5	~15	~16	~18

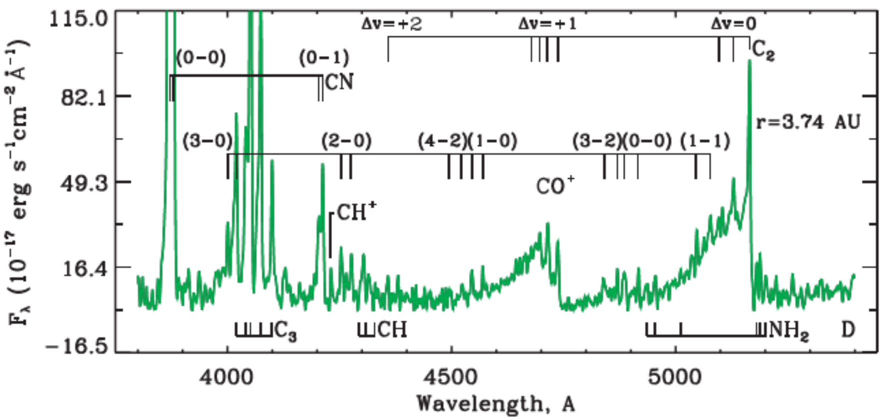
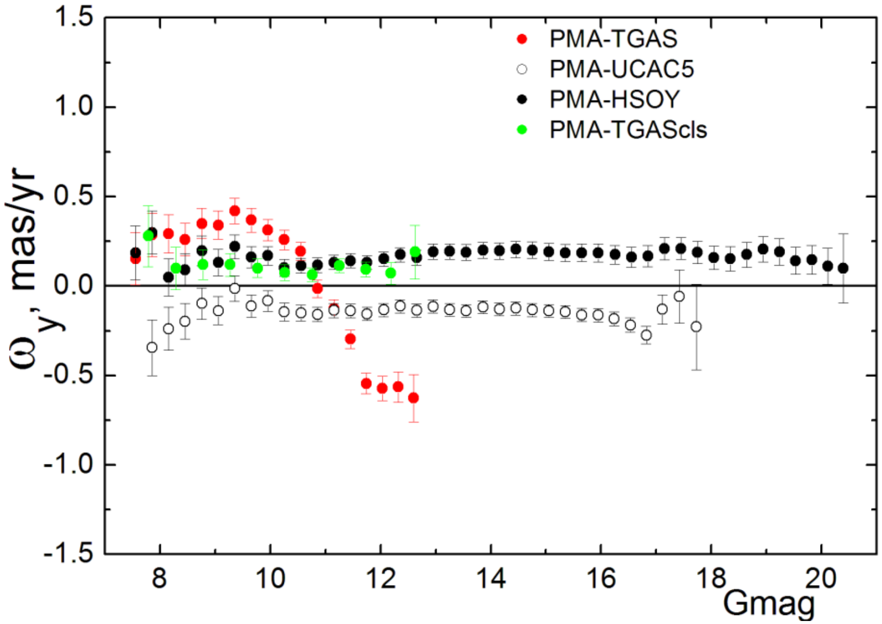


Fig. 1. The observed spectrum – fitted continuum of comet C/2006 W3 (Christensen). Emissions are identified in the spectra, when the comet was at a heliocentric distance of 3.74 au on December 3, 2008 with a spectral resolution of 2.5 Å in the wavelength range of 3800–5400 Å.

Spectral observations of comets allow one to investigate the physical characteristics of dust and gas in cometary atmospheres and their temporal changes (outbursts of activity, disintegration).

Creating catalogue of proper motion stars: **PMA** (Akhmetov et al. 2017)

•PMA - 421 million absolute proper motions of stars from the combination **Gaia DR1** and **2MASS**. The absolute calibration procedure was carried out using about 1.6 million of extragalactic sources.
•The mean formal error is less than 0.3 mas/yr.
•PMA catalogue was used to indicate a magnitude error in proper motions of stars in TGAS catalogue.



V.S. Akhmetov, P. N. Fedorov, A. B. Velichko, V. M. Shulga (2017).
The PMA Catalogue: 420 million positions and absolute proper motions // MNRAS. Vol. 469, Issue 1, 763-773.

New Catalogue of Extragalactic Objects: AllWISE × Pan-STARRS1

We have got 37 million extragalactic objects up to g=22 mag!

In base: WISE in IR + PS1 in optics = 36 colors for ~200 million sources

Catalogue construction includes analysis of SDSS-DR14 using Neural Network.

1. Training with SDSS-DR14 spectroscopically confirmed objects.
2. Creating 5-dimensional Feature Space by transformation of original 36 colors.
3. Classification data from AllWISE x PS1 catalogues.

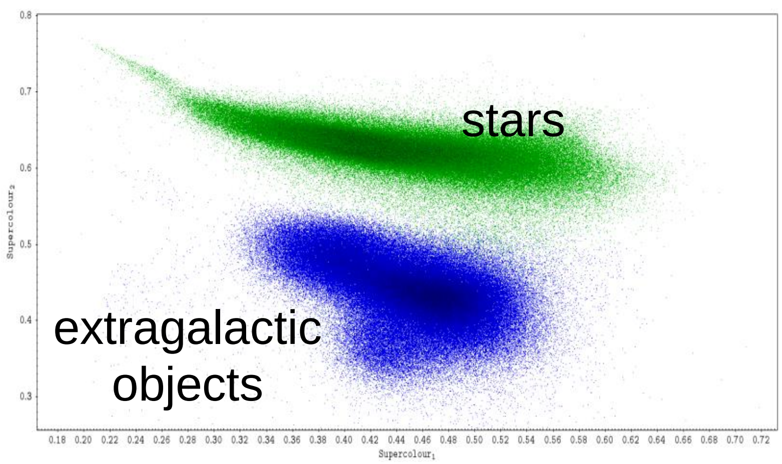


Fig.1. Two-“colors” diagrams calculated by NN

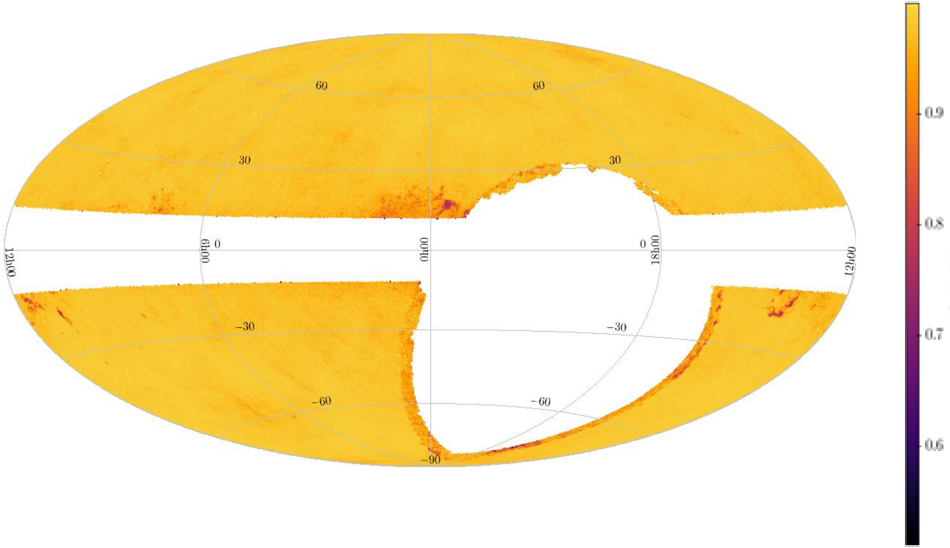


Fig.2. Distribution of probabilities for 37 millions extragalactic objects on the sky

Kinematic parameters of the Galaxy from stellar proper motions of modern catalogues: TGAS, PMA, UCAC5 and HSOY

We use both the **Ogorodnikov-Milne** model and decomposition of the stellar velocity field onto a set of **Vector Spherical harmonics**.

The rotation speed Sun neighborhood around Galaxy center for distance R=8.5 kpc