

# PARTICIPATION IN ISON PROJECT: OBSERVATIONS OF NEAR-EARTH ASTEROIDS AND GRB AFTERGLOW

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# Institute of Astronomy of Karazin Kharkiv National University UKRAINE

1804: Kharkiv University was opened

1808: The astronomy lectures were started

1908: The planetary and Moon study was started

1978: Study of asteroids was started

1995: CCD observations of asteroids were **initiated**

2006: **Cooperation with the ISON project was started**



# Chuguev Observation Station

Institute of Astronomy of Karazin Kharkiv National University, UKRAINE

70-cm telescope



25-cm telescope



Kharkiv Asteroids and Comets Group



(15898) *KharAsterTeam*



# ISON - Scientific Optical Network

The Network Aims are:

- **Monitoring** of man-made space debris (primarily high-geostationary orbits, high-elliptical, circular type of GLONASS and GPS).
- Tracking of near-Earth asteroids (NEAs): to search for new objects, to improve orbital parameters and to study their physical properties.
- GRB optical afterglow observations.

*Since 2006 Kharkiv Asteroids and Comets Group cooperates with ISON in photometry of asteroids.*

Several ISON observatories are involved in this work managed from Kharkiv. Several meetings and mutual visits were organized in frame of ISON cooperation in order

- to install photometric observations
- to train observers
- to discuss problems of photometry and discovery of asteroids.

# The Network Telescopes: created in **the** frame of ISON

Several different wide-field telescopes were developed and made in **the** frame of ISON project, **including** 22 and 25 cm, 40 and 50 cm telescopes, and also wide-field camera lens with 195 mm aperture.

D = 19.5 cm



D = 25 cm



D = 40 cm



# ASTEROID HAZARD PROBLEM:

## Contribution from the Optical Observations

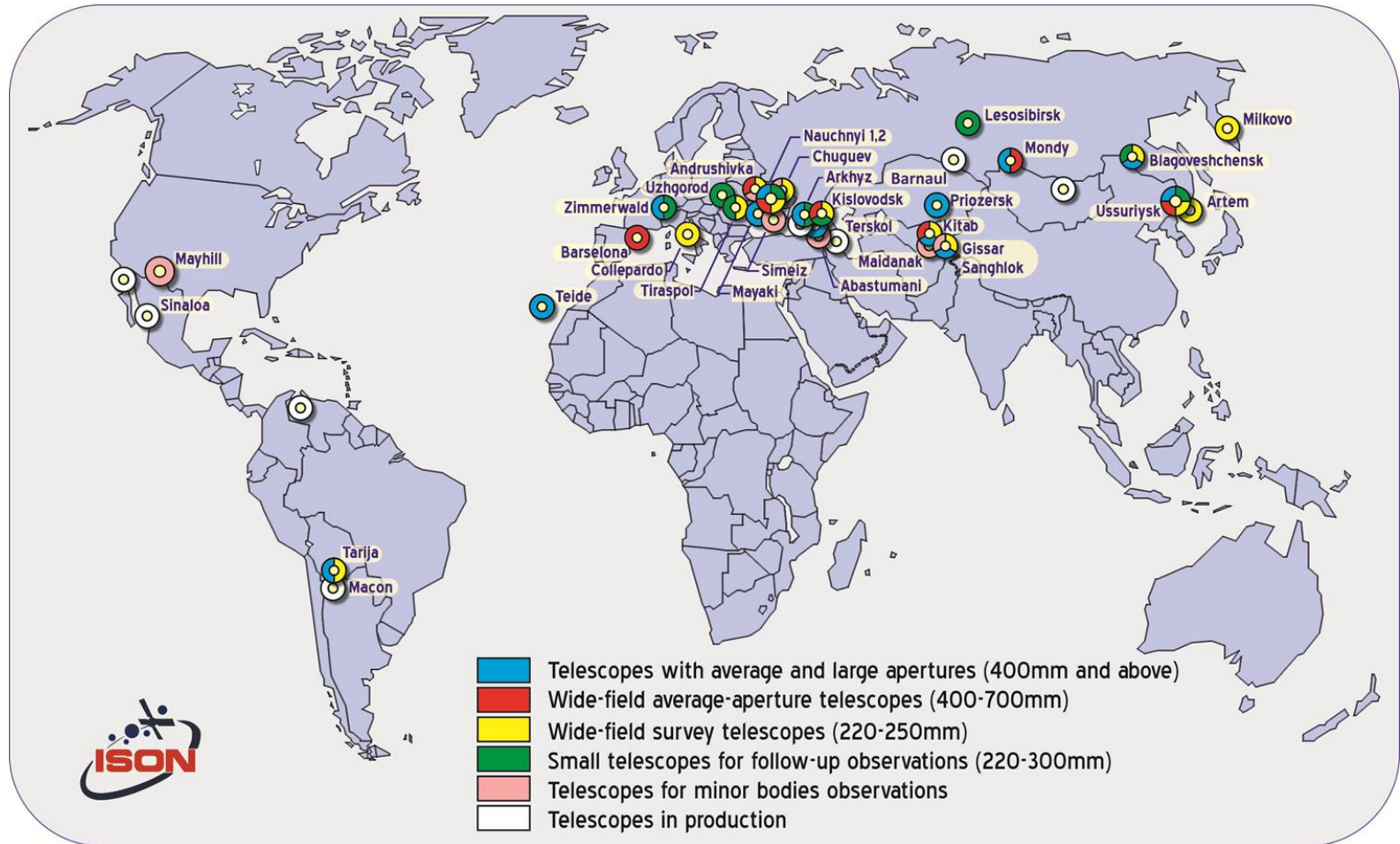
- Discovery of new NEAs. Particularly important discovery of asteroids, which are potentially dangerous for human civilization
- Observations of newly discovered objects in a follow-up mode to determine **their** coordinates and to **estimate sizes** of these bodies
- The study of the physical properties of NEAs (**rotation, composition, shape etc**) needed to prevent any future collisions with Earth.

# The Asteroid Subsets

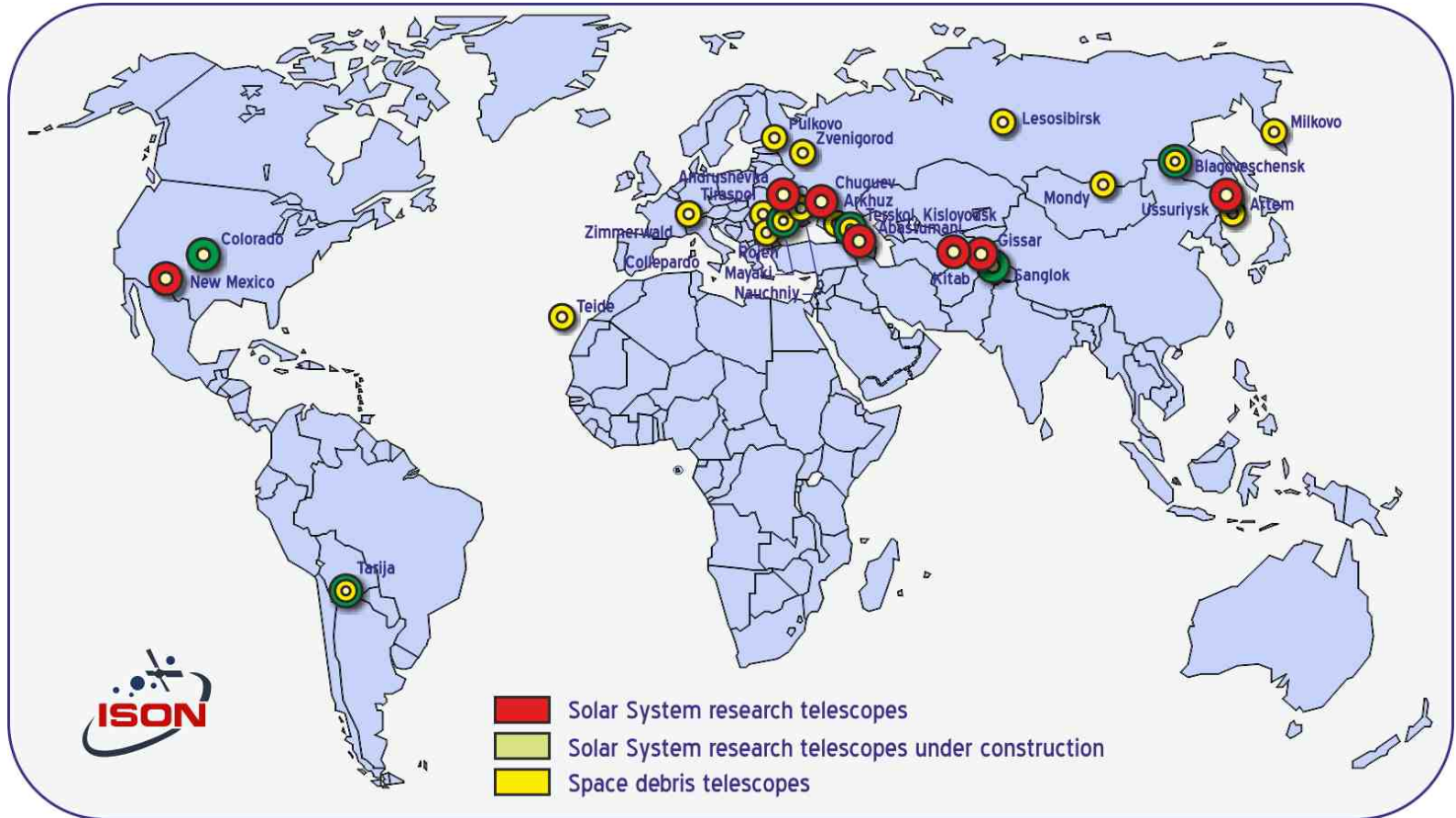
Two subsets were formed in **the** frame of ISON for asteroid's observations during last three years:

- (I) Several telescopes (with apertures more then 40 cm) are involved in carrying out photometry of asteroids. Also they **are used** for observations of GRB afterglow.
- (II) Two wide-field telescopes (46 cm and 60 cm) **are** used for searching asteroids. The main objects of our interest are NEAs.
- (III) We are forming 3<sup>th</sup> subset of ISON for **efficient improvement** of the orbits of newly detected NEA. These telescopes will be able to participate in supporting the alerts of the Gaia mission.

# The Network Observatories



# ISON Observatories Involved in Asteroid Observations

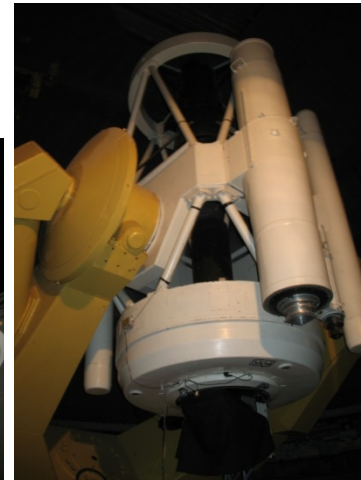
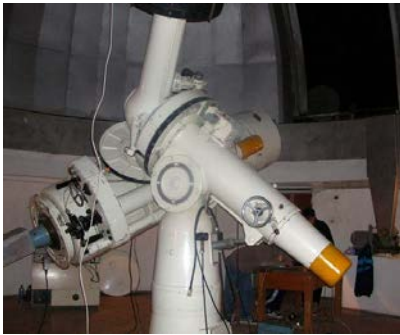


# List of “Photometric” Observatories

- Abastumani Astrophysical Observatory, Ilia University, GEORGIA
- Chuguev Observatory, Karazin Kharkiv National University, UKRAINE
- Crimean Astrophysical Observatory, Crimea, UKRAINE
- Gissar Observatory, TAJIKISTAN
- ISON-NM Observatory, Mayhill, USA (remotely controlled from Moscow)
- Kitab Observatory, UZBEKISTAN
- Lisnyky Observatory, Kiev Shevchenko National University, UKRAINE
- Maidanak Observatory, UZBEKISTAN
- Simeiz Observatory, Crimea, UKRAINE

# Photometric Telescopes in Network

The old telescopes with diameters from 60 cm up to 2.6 m have been modernized to use in the network. Most of these telescopes have been equipped with modern CCD-cameras, mainly manufactured by firm Finger Lakes Instrument (FLI) in USA.

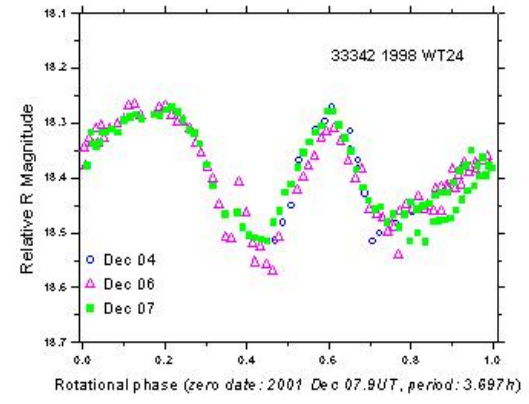
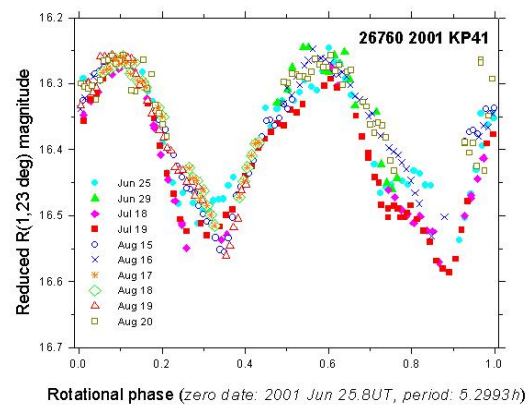
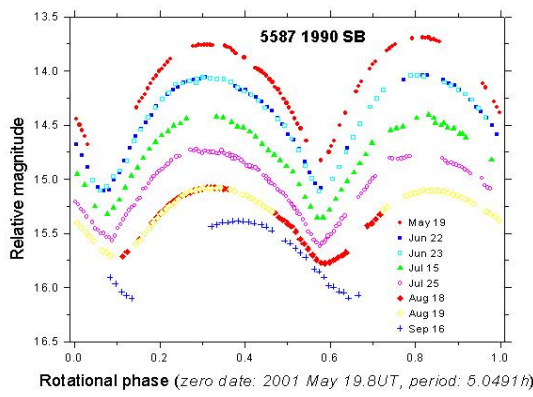
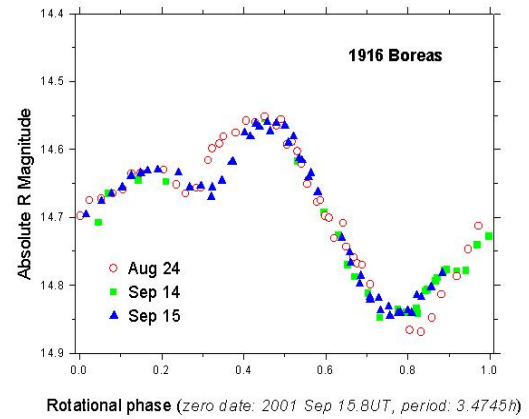
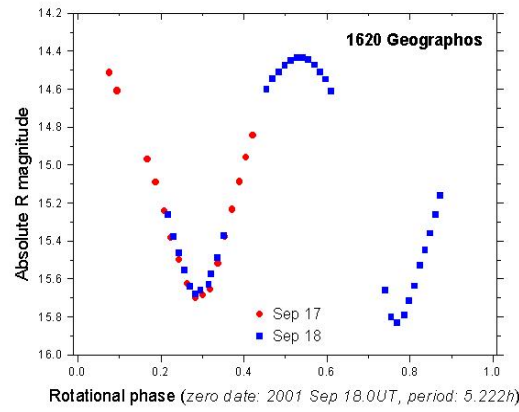
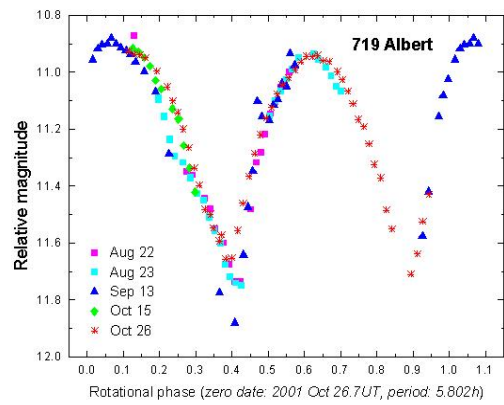


# Asteroid Photometry

## *The main aims of the photometry is:*

- Physical characteristics of the Near-Earth Asteroids that includes determination diameters, shapes, rotation periods, surface properties of the bodies.
- Observations of newly discovered NEAs and **especially** Potentially Hazardous Asteroids (PHAs)
- Searching for binary asteroids and determining parameters of the binary systems
- Investigation of Yarkovsky-O'Keefe-Radzievskii-Paddack effect (YORP-effect) – detection of the influence on asteroid's rotation
- Support in optics of radar observations of NEAs

# NEAR-EARTH ASTEROID LIGHTCURVES



# Main Results of Asteroid Photometry

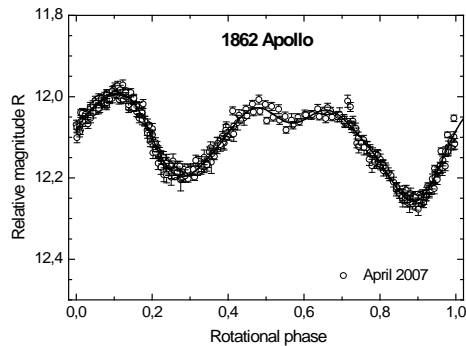
In past 3 years more than 60 NEAs were observed in the frame of ISON and the main results were attained:

- more than 200 lightcurves were obtained;
- 10 asteroids were observed to investigate of the YORP effect, and for 3 of them the YORP was detected;
- 14 new determinations of rotation periods were done;
- 6 from the obtained periods found to be longer 16 hrs;
- 2 super-fast rotators were found: 2001 FE90, 326290 1998 HE3;
- 2 binaries were found: 8373 Stephengould, 3352 McAuliffe; and another 3 NEAs were suspected as binaries;
- absolute magnitudes and BVRI colors were obtained for about 20% for the observed asteroids.

# YORP Investigations

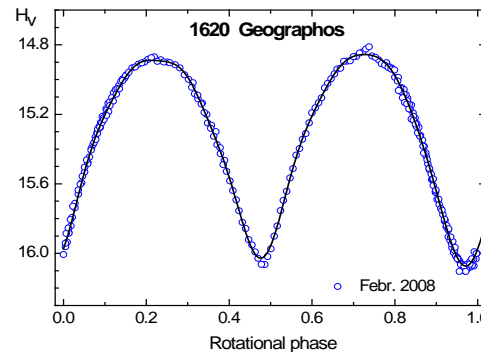
In results of the lightcurve observations an influence of the YORP effect on asteroid rotation was detected/confirmed for 3 NEAs (Apollo, Geographos, Eger). The work are performed in collaboration with David Vokrouhlicky and Josef Durech from Institute of Astronomy of Charles University (Prague, Czech). It is 3 of 4 asteroids with the YORP detected to the date.

Apollo



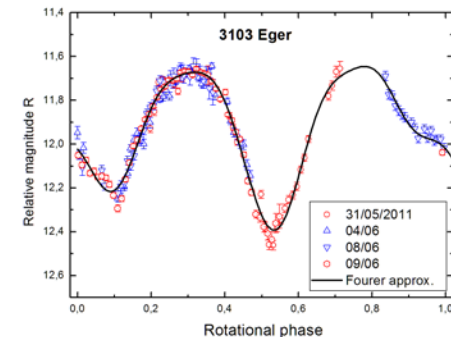
*Kaasalainen et al. 2007;*  
*Durech et al. 2008*

Geographos



*Durech et al. 2008*

Eger



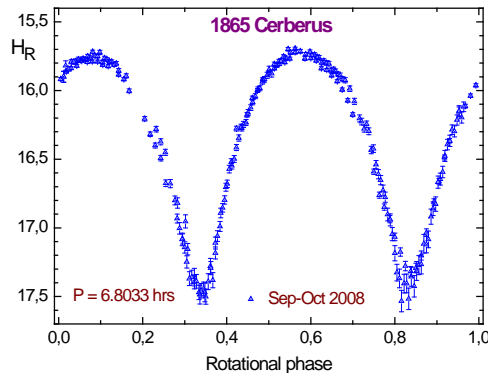
*Durech et al. 2009*

# Detection of YORP effect: 1865 Cerberus

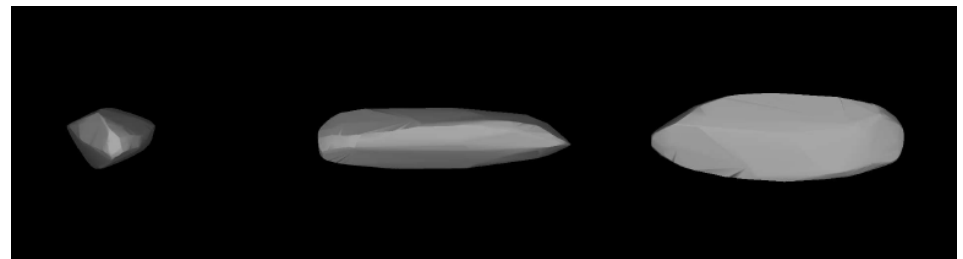


Cerberus was observed during two nights on Sept. 1 and 2, 2008 at Maidanak. The lightcurves are characterized with an unusually large amplitude, up to 1.75 mag. Additional observations were made at Kharkiv and Simeiz in 2008 & 2009.

Analysis of Cerberus' photometry showed that asteroid brightness variations are consistent with a constant-period model and no secular change of the spin rate was detected. We could only constrain maximum values of  $|dw/dt| < 8 \times 10^{-9} \text{ rad } d^{-2}$  for Cerberus. (Durech et al. 2012, sent to Icarus).



Composite lightcurve of Cerberus.



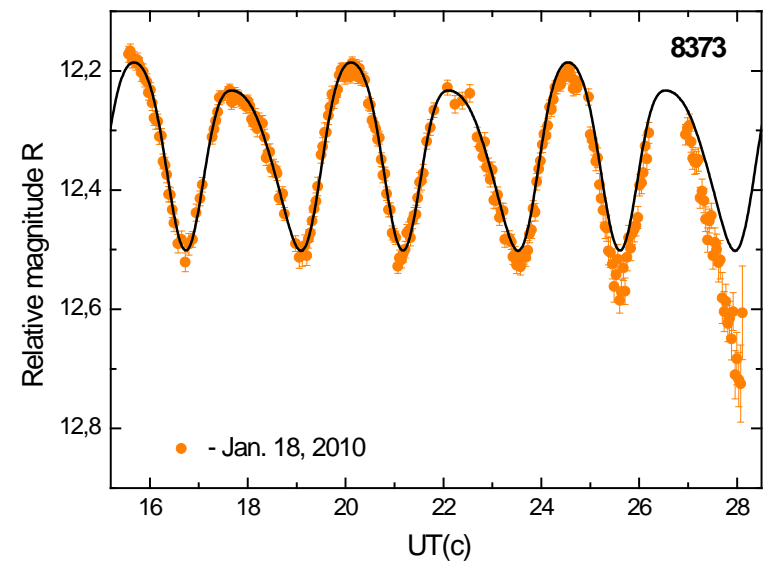
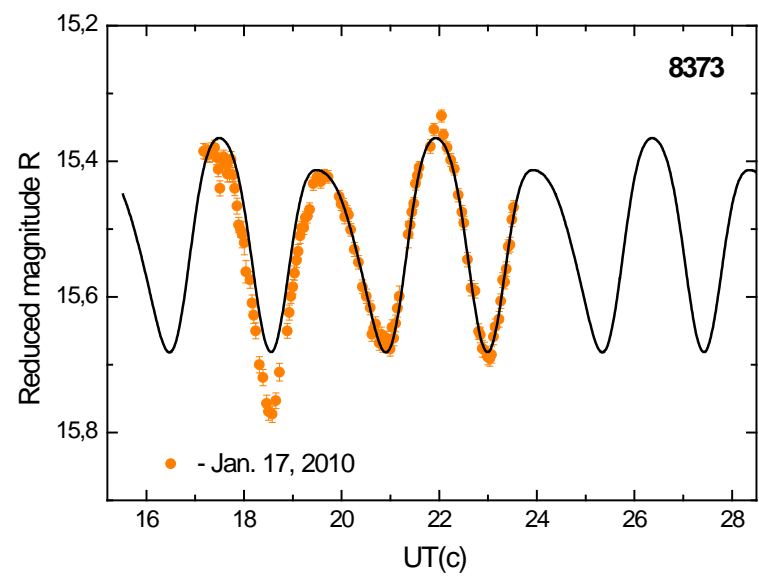
The convex shape model of Cerberus shown at equatorial aspect (left, center) , and pole-on (right).

# Binary Asteroids

1. Searching for binary asteroids and determining parameters of the binary systems is performed in cooperation with Czech astronomers from Ondrejov Astronomical Observatory, Czech Academy of Sciences.
2. To obtain the good results for searching / investigation of binary system we need in regular observations, and as usually as it should be observations during several consecutive nights. The best way to detect and investigate the binary asteroid is to observe the object from several observatories located at different longitudes.

# Binary Asteroids

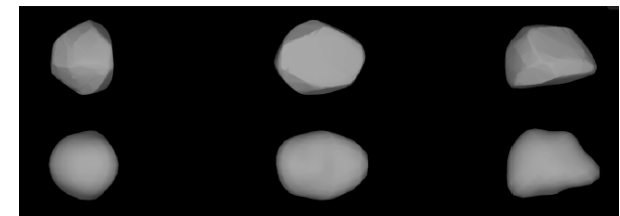
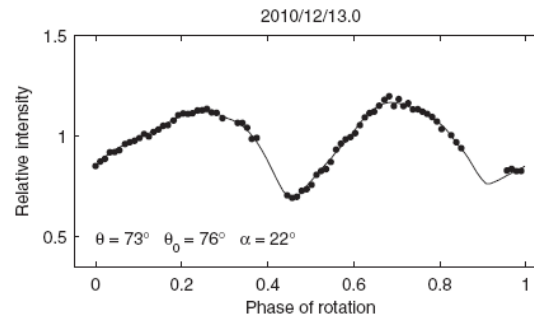
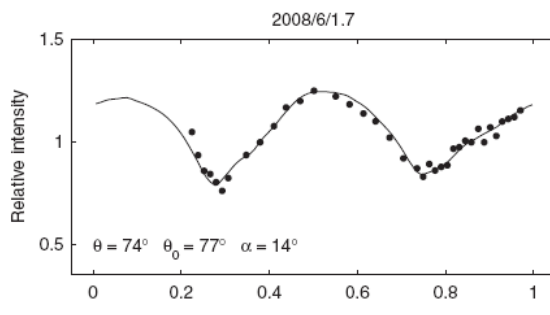
## 8373 Stephengould – discovered as binary in 2010



# Extremely young asteroid groups: 6070 Rheinland



The main belt asteroid (6070) Rheinland with (54827) 2001 NQ8 belong to a small population of couples of bodies that reside in very similar heliocentric orbits: “asteroid pairs” or paired asteroids, which have a common origin within the past tens to hundreds of kyr. Asteroid 6070 Rheinland was observed with 1.5 m telescope at Maidanak in 2008 and 2010/2011. All evaluable photometric observations of this asteroid allowed us to determine its rotation state and shape using the light curve inversion technique. We confirm the retrograde sense of rotation of Rheinland, with obliquity value constrained to be 140 deg. It eliminates some degree of uncertainty in the past propagation of iRheinland’s orbit. The determination of the rotation state of the secondary component, asteroid (54827) 2001 NQ8, is the key element in further constraining the age of the pair and its formation process. The YORP effect has been suggested as the underlying physical mechanism that brought the parent body’s rotation to the fission limit. (*Vokrouhlicky et al. (2011), Astron.J. 142, 159*).



The shape model of Rheinland.

Photometric data from 2008 and 2010/2011 opposition for Rheinland.

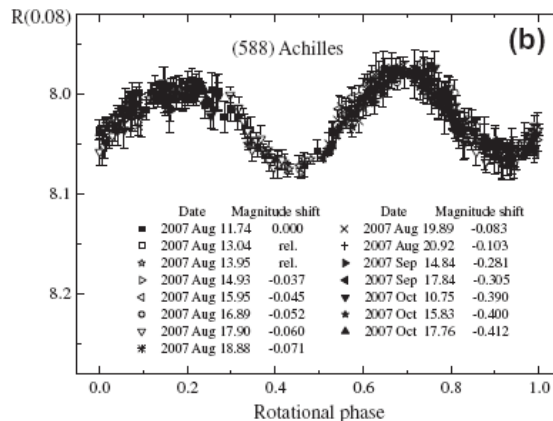
# Absolute Photometry of Trojan asteroids:



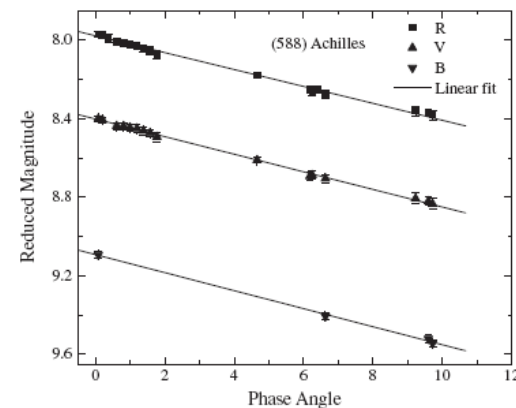
## 588 Achilles

Achilles was observed during 5 nights from 14 to 20 August 2007 with 1.5 m telescope at Maidanak. The asteroid is a very dark object that orbits around the Sun in Jupiter Lagrangian point L4 and was classified as D-type asteroid characterizing by a steep red slope spectrum. Several observatories taken part in a special observation program organized to obtain the phase curve for Achilles. The observations at Maidanak were done in V and R spectral bands at small solar phase angles.

In result the color  $V-R = 0.43 \pm 0.03$  was determined and mean absolute magnitude  $H = 8.47 \pm 0.03$  mag was estimated. The phase dependence of brightness (in phase angle range from 0.08 to 9.7 degrees) can be fit well by a line with the phase coefficients of  $0.045 \pm 0.001$  and  $0.043 \pm 0.001$  mag/deg for the V and R bands, respectively. Any evidence of the opposition surge toward small phase angles has not been found down to the phase angle as low as 0.08 (*Shevchenko et al. 2012, Icarus 217, 202–208*).



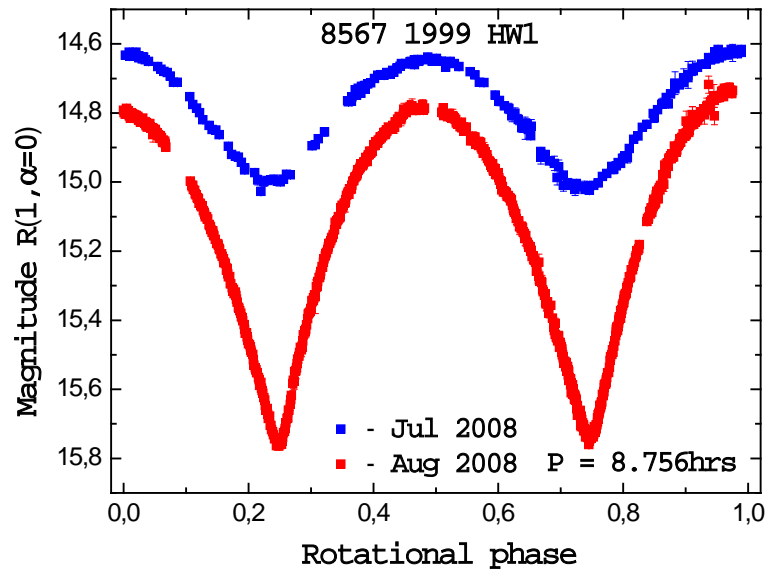
Composite lightcurve of Achilles



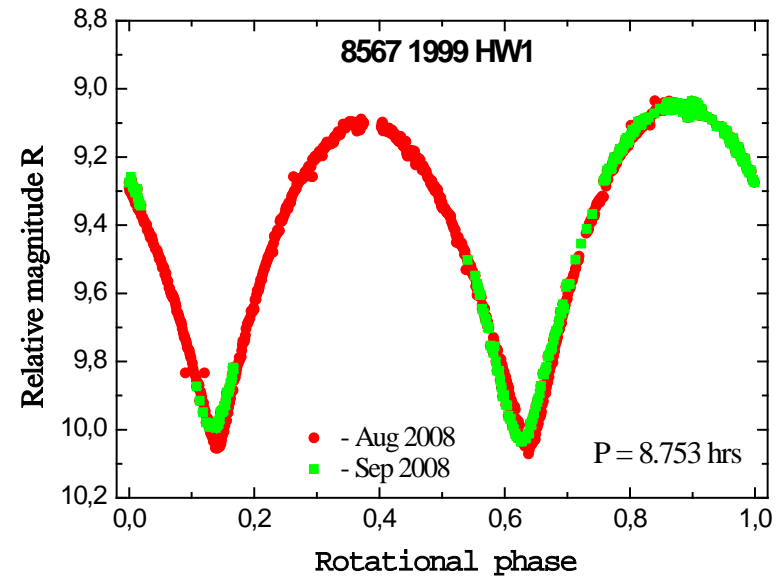
Magnitude phase dependence of Achilles

# Asteroid Radar Shape Models:

## *Lightcurves of NEA 8567 1999 HW1*

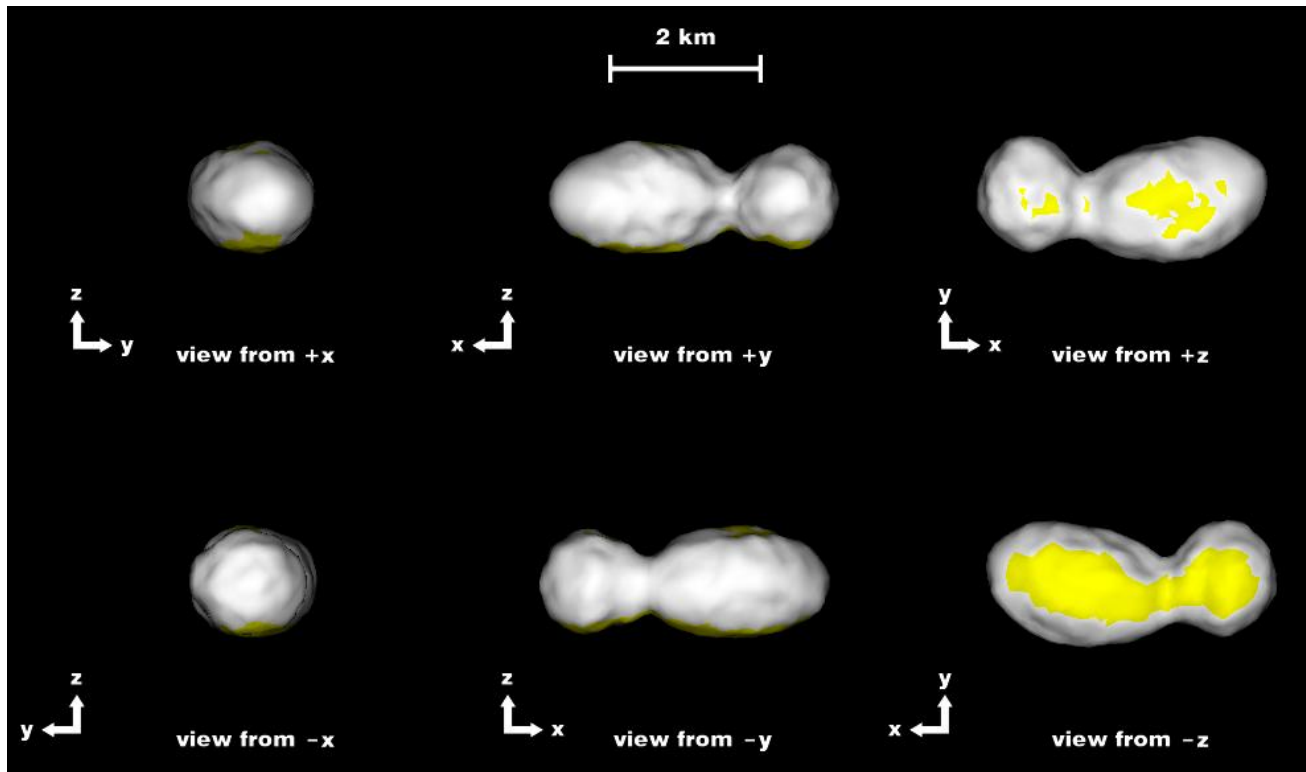


July-August 2008



August-September 2008

# Shape Model of 8567 1999 HW1: *Radar and Photometry*



*Magri et al. (2010), prepared for Icarus submitting*

# NEA Searching in ISON

Two remotely controlled telescopes are involved in asteroid search:

- 45.5 cm telescope Centurion-18 at H15 ISON-NM Observatory, Mayhill, USA;
- 60 cm telescope at A50 Andrushivka Astronomical Observatory, UKRAINE.

Both telescopes have a wide field of view: 100x100 and 51x51 arcmin.

45.5 cm telescope (f/2.8)  
Mayhill, New Mexico



60 cm telescope (f/4)  
Andrushivka, UKRAINE





# Results of surveys in 2011

***H15 ISON-NM Observatory*** started an asteroid searching in July 2010.

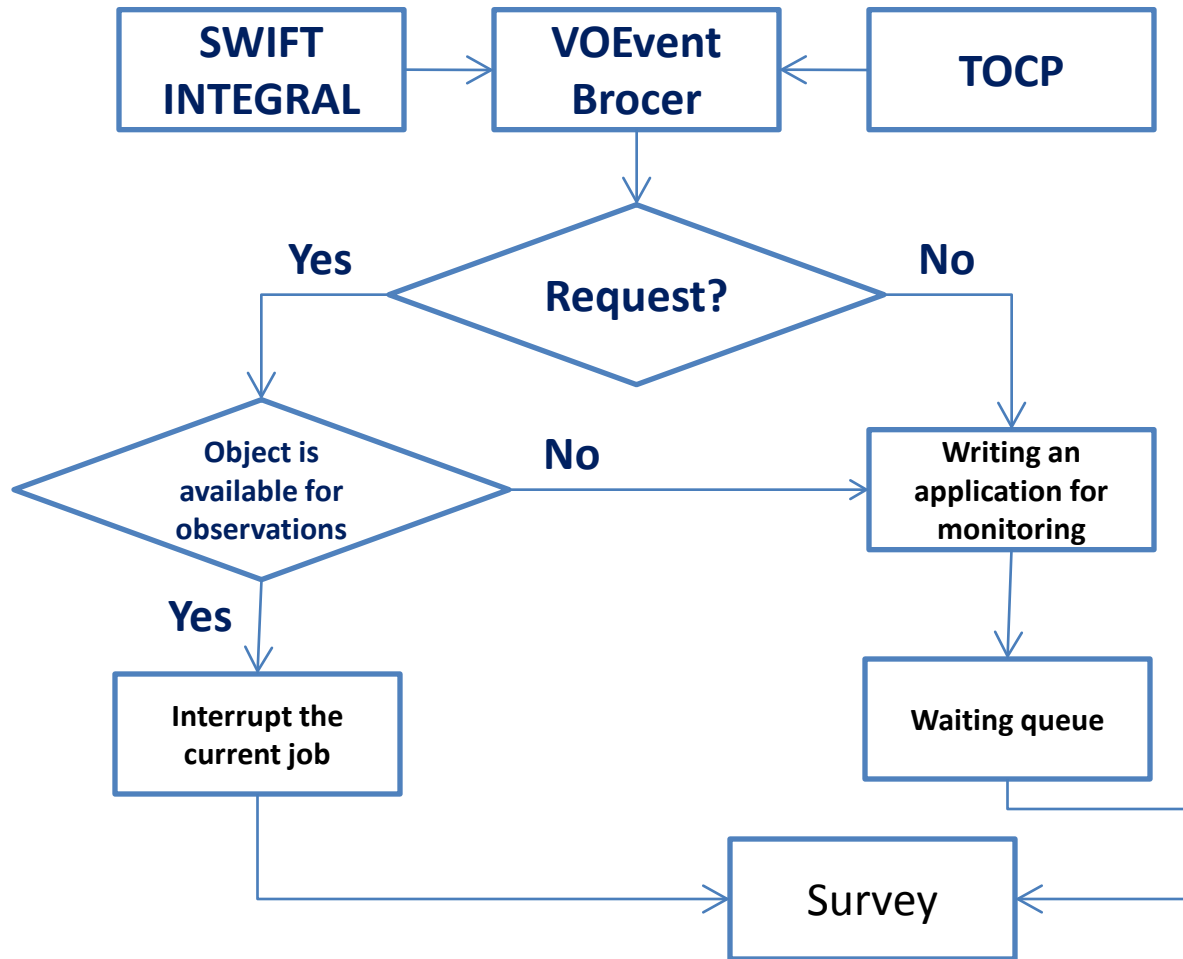
During 2011 the 45.5 cm telescope did **135302** measurements (8<sup>th</sup> between all observatories) of 30818 asteroids and 43 comets, and 768 new asteroids were observed. In total more than 900 asteroids were discovered. Among them there are 2 NEAs (2010 RN80, 2011 QY37), 5 Trojans (2011 QJ9, 2011 QQ47, 2011 YA3, 2012 AF1, 2012 BB27), and 2 comets (C/2010 X1 (Elenin), P/2011 NO1 (Elenin)).

- Obtained more than 185 000 observations
- Discovered more than 1000 MBA (provisional designation)
- Two near-Earth asteroids 2010 RN80 and 2011 QY37 (Amors)
- Long-period comet C/2010 X1 (Elenin)
- Short-period near-Earth ( $q=1.24$ ) comet P/2011 NO1 (Elenin)
- Several Jovian trojans

***A50 Andrushivka Astronomical Observatory*** beginning asteroid survey in 2003. In 2011 there are **33034** (13<sup>th</sup> between all observatories) measurements of 9339 asteroids and 3 comets with 60-cm telescope,

**During 2012-2013 we are planning to install several new 40-65 cm telescopes for asteroid search.**

# VOEvent – work with alerts



First observation of gamma-ray burst GRB 111029A in the alert mode, received October 29, 2011. The telescope began to exhibit in just 77 seconds after receiving the alert.

# Outlooks of ISON

Telescopes which planned to start working in frame of ISON in 2012-2013:

- Kislovodsk Observatory (Russia): 50 cm reflector
- Maidanak Observatori (UZBEKISTAN): 60-cm and 1 m reflector
- Sanglok Observatory (TAJIKISTAN): 60-cm reflector
- Ussurijsk Observatory (Russia): 50 and 65 cm reflector

