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PHOTOMETRIC OBSERVATIONS OF ASTEROIDS IN FRAME OF ISON PROJECT

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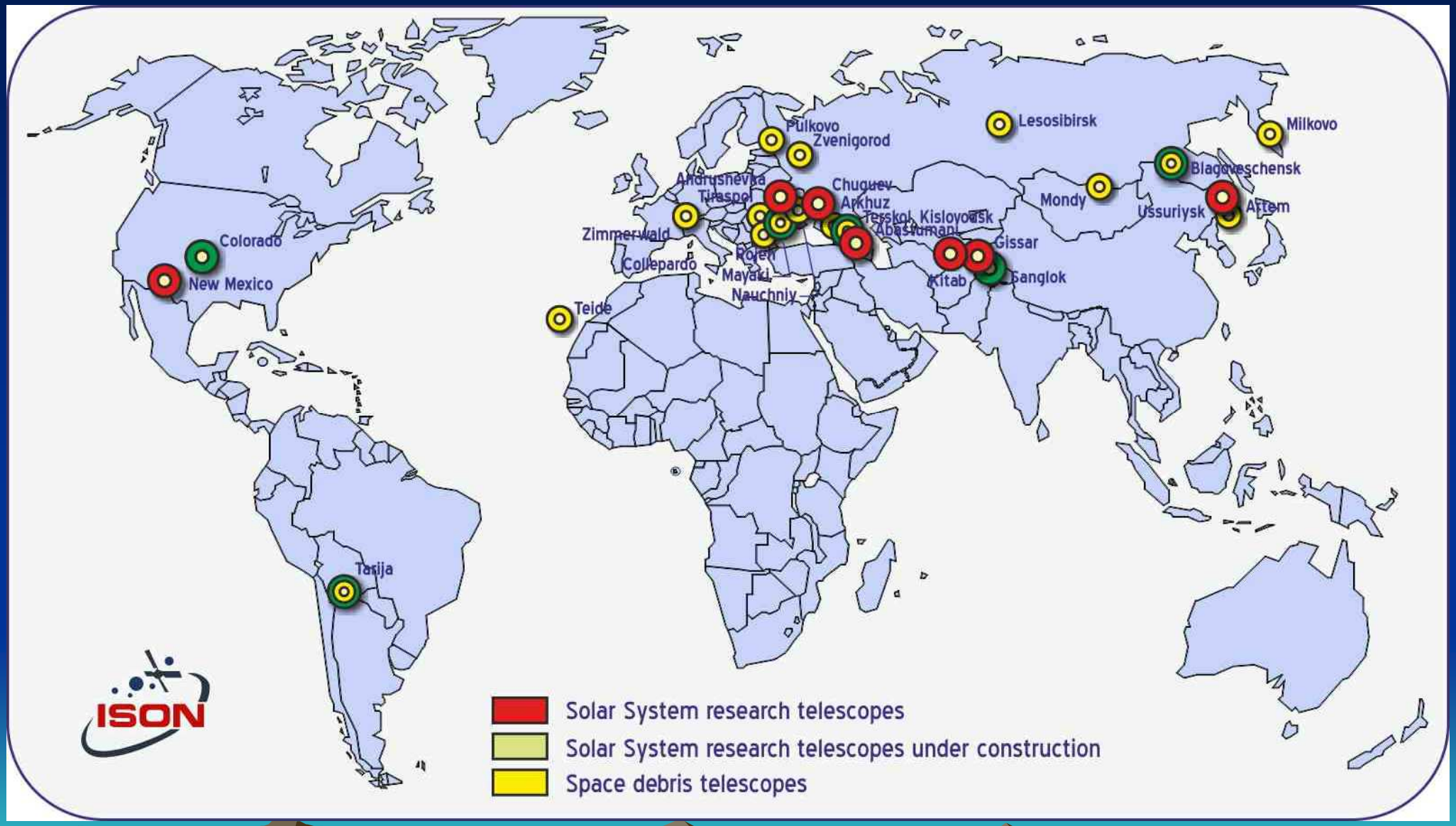
ISON - International Scientific Optical Network

- Started in 2004, currently, the project involves more than 20 observatories and scientific institutions in 10 countries (Russia, Ukraine, Moldova, Georgia, Uzbekistan, Tajikistan, Italy, Bolivia, Switzerland, Spain). The works are part of long-term agreements on scientific-technical cooperation between the Keldysh Institute *of Applied Mathematics* (KIAM, Moscow) and related scientific or scientific-educational organizations, using both their own instruments (telescopes) in the possession of the organization, as well as instruments that, under agreements places the KIAM (or those and other tools are used together). The project presented at the UN and the results obtained are highly appreciated as colleagues from various scientific organizations, and at the level of a number of foreign space agencies (ESA, NASA, JAXA).

The aims of the ISON project

- Monitoring of man-made space debris (primarily high-geostationary orbits, high-elliptical, circular type of GLONASS and GPS) by means of carrying out astrometric and photometric observations of orbiting objects (i.e. the study of their orbital and physical properties), prediction long-term evolution of this state, taking into account various factors, identify the sources of formation of small debris, identifying objects of potential sources of risk to the functioning for operational spacecrafts. This is the main task.
- Tracking of near-Earth asteroids (NEAs), to do the discovery and to study their physical properties and refinement of orbital parameters. This is an additional task

Map of observatories in the network



Telescopes in the network

- More then 20 wide-field telescopes were made and installed at different observatories of the network. The diameters are from 12.5 up to 50 cm, with filed of view on several degrees.

Telescopes in the network

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

INSTITUTE of ASTRONOMY of

KHARKIV KARAZIN NATIONAL UNIVERSITY, UKRAINE

http://www.univer.kharkov.ua/

PHYSICS of ASTEROIDS and COMETS DEPARTMENT

INSTITUTE of ASTRONOMY

(15898) KharAsterTeam

Chuguev Observation Station, Kharkiv
70-cm telescope

Kharkiv Program: CCD Observations of Near-Earth Asteroids (NEA)

Started in 1995 joined with:

DLR PLANETARY INSTITUTE, BERLIN

Participants in Kharkiv Observatory:

- *Yurij Krugly*
- *Irina Belskaya*
- *Vasilij Chiorny*
- *Vasilij Shevchenko*
- *Feodor Velichko*

Since 1996 the program is carried out jointly with:

CRIMEAN ASTROPHYSICAL OBSERVATORY

Simeiz Observatory, Crimea
1-m telescope

Main Aims of the Program

- **PHYSICAL PARAMETERS OF NEAR-EARTH ASTEROIDS BY PHOTOMETRY** TO OBTAIN:
  - *ROTATION PROPERTIES*
  - *SURFACE PROPERTIES*
  - *DIAMETERS*
  - *SHAPE MODELS*

- **FOLLOW-UP ASTROMETRY AND PHOTOMETRY OF NEWLY DISCOVERED NEAs** IN FRAME OF EUROPEAN ASTEROID HAZARD PROGRAM

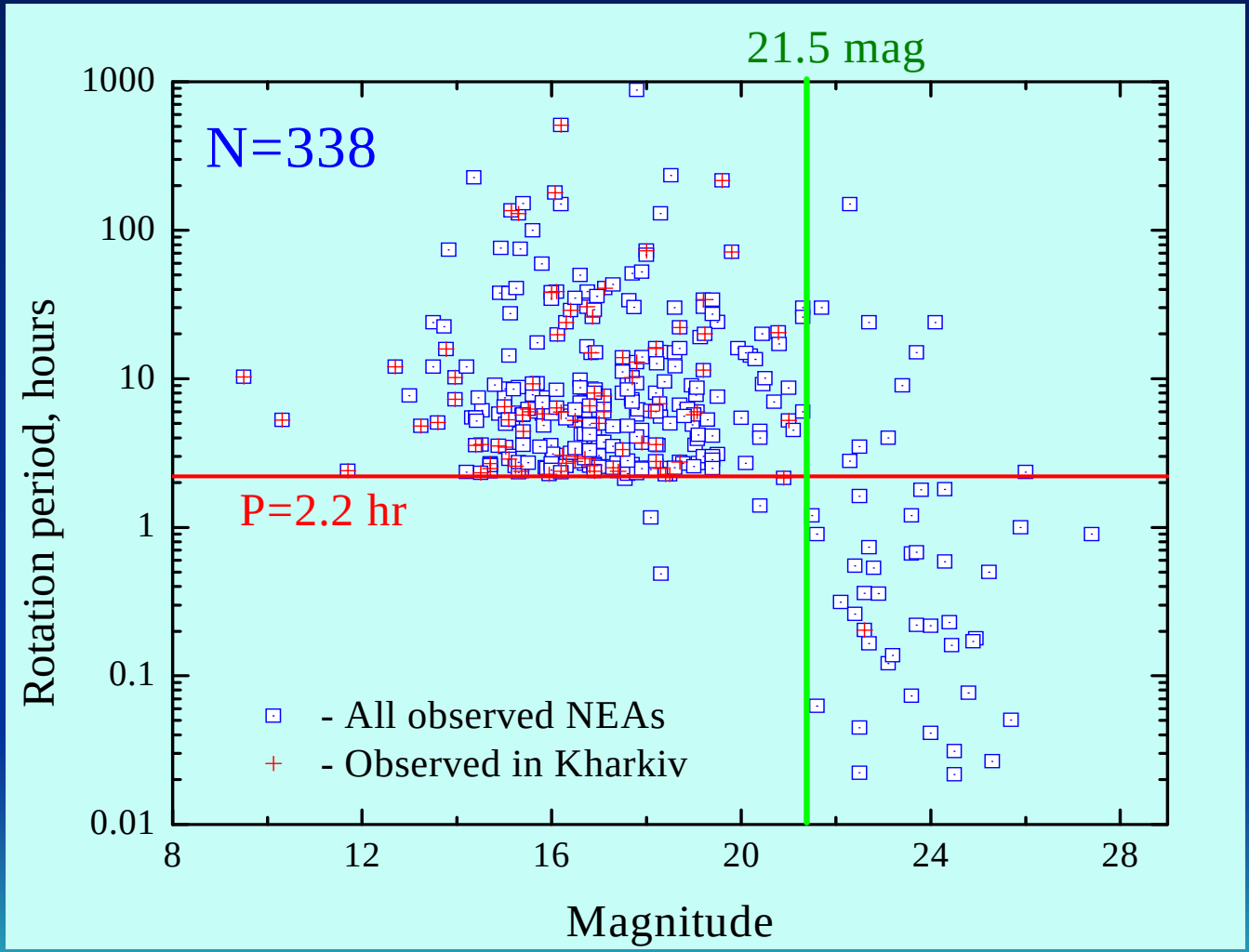
MAIN RESULTS OF THE NEAs PROGRAM

Up to 2005 it has been observed more than 100 NEAs and obtained in result:

- more than 500 lightcurves
- rotational periods: 60 (45 for the first time)
- absolute magnitudes: 60
- binary asteroids: 6
- photometric models: 6

ROTATION PERIOD – ABSOLUTE MAGNITUDE

Obtained up to 2005



Asteroid Observations in frame of ISON

Since 2006 Kharkiv Asteroid Group cooperates with ISON

Several ISON observatories are involved in photometry of asteroids.

THE MAIN DIRECTIONS OF OUR RESEARCHES:

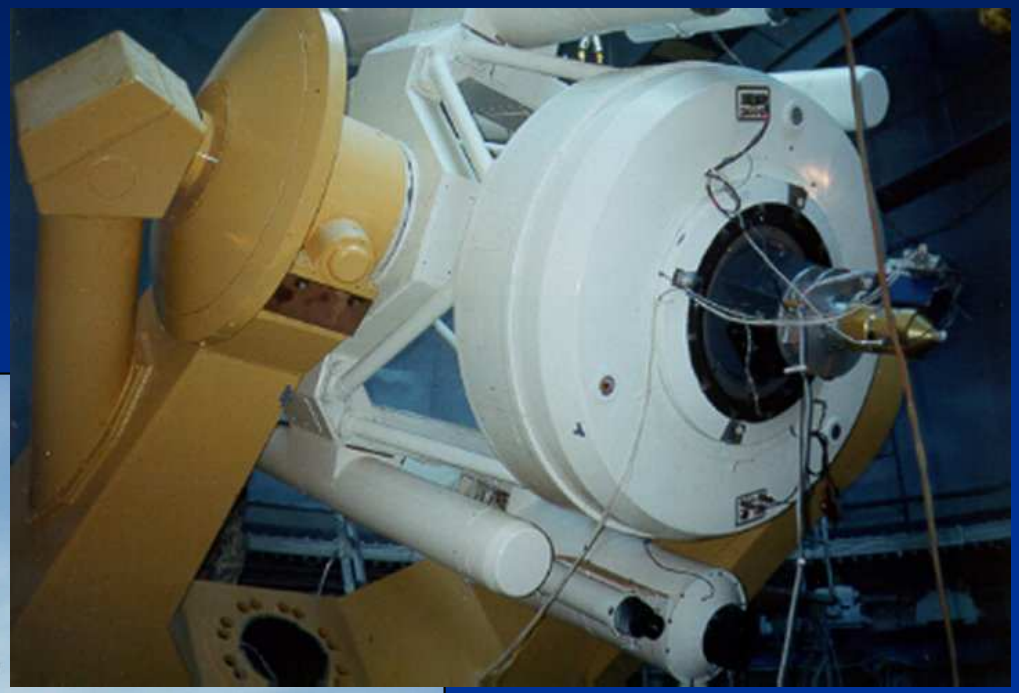
- Physical properties of the Near-Earth Asteroids
- Observations of newly discovered NEAs and Potentially Hazardous Asteroids (PHAs) firstly
- Searching for binary asteroids and determining parameters of the binary systems
- Support in optics of asteroid's radar observations
- Investigation of Yarkovsky-O'Keeffe-Radzievskii-Paddack effect (YORP-effect) – the influence on asteroid's rotation

Crimean Astrophysical Observatory, Nauchnyi
2.6-m telescope

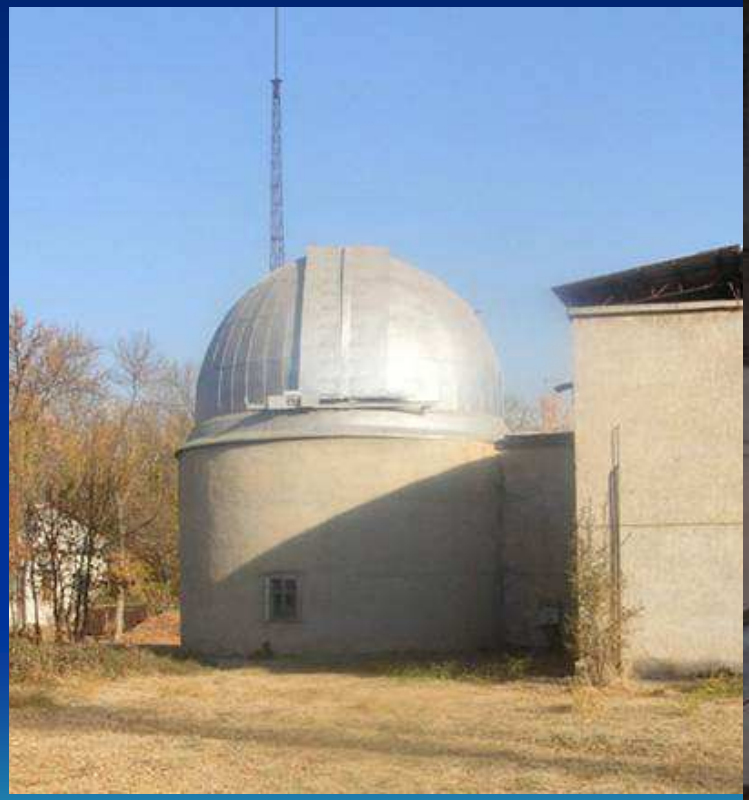
Rozhen Observatory, Bulgaria

2-m telescope

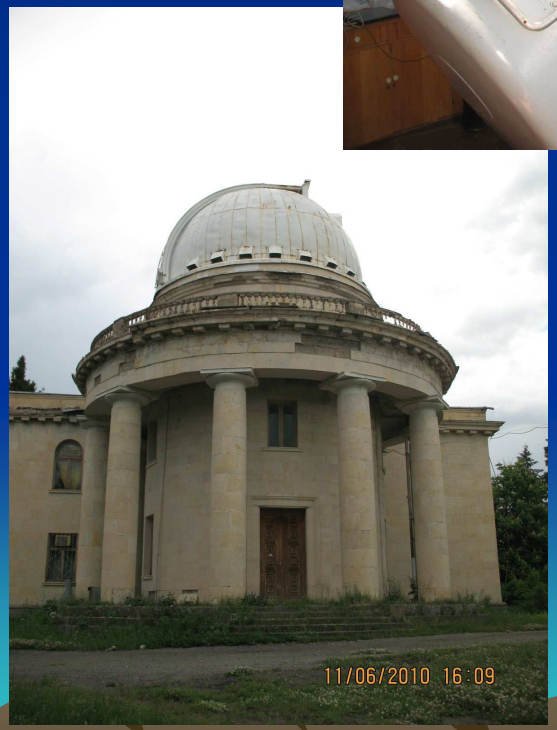
Maidanak Observatory, Uzbekistan
60-cm and 1.5-m telescopes



Gissar Observatory, Tajikistan
70-cm telescope



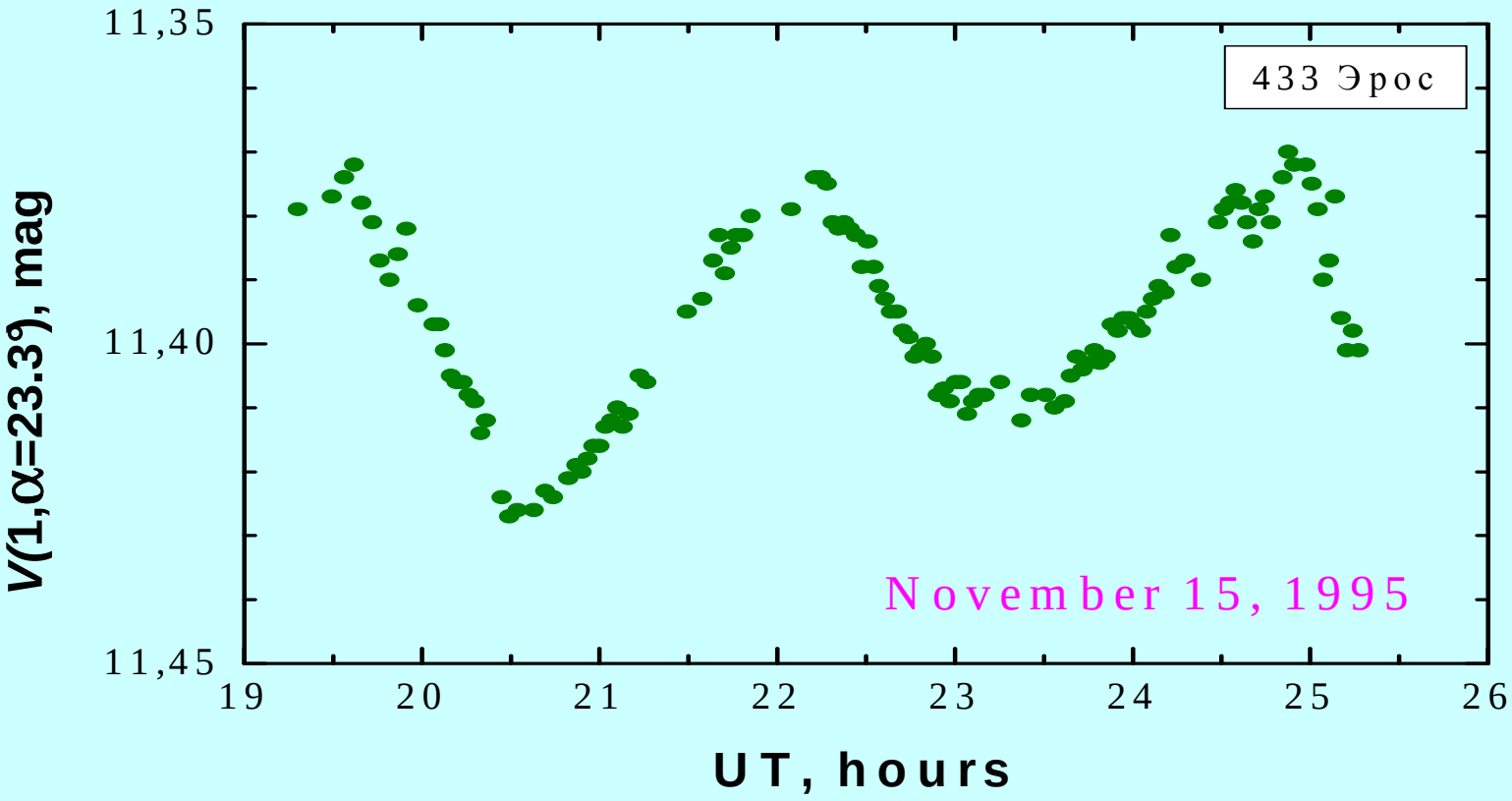
Abastumani Observatory, Georgia
70-cm and 1.25-m telescopes



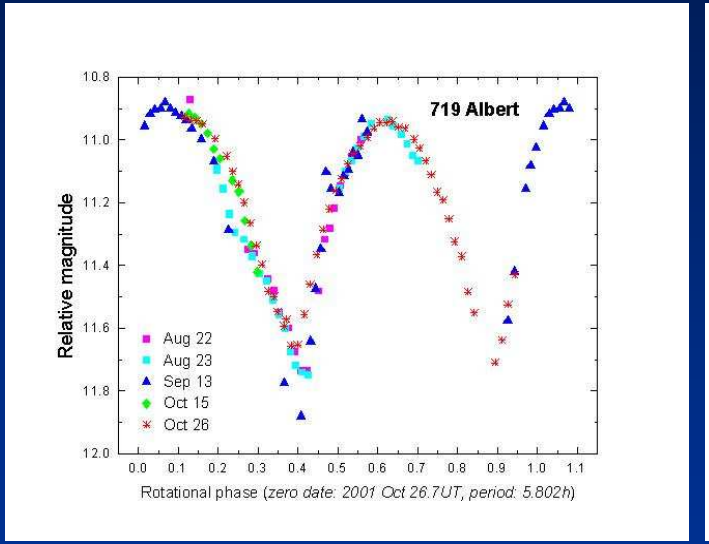
ISON Observatory in New Mexico
45-cm telescope

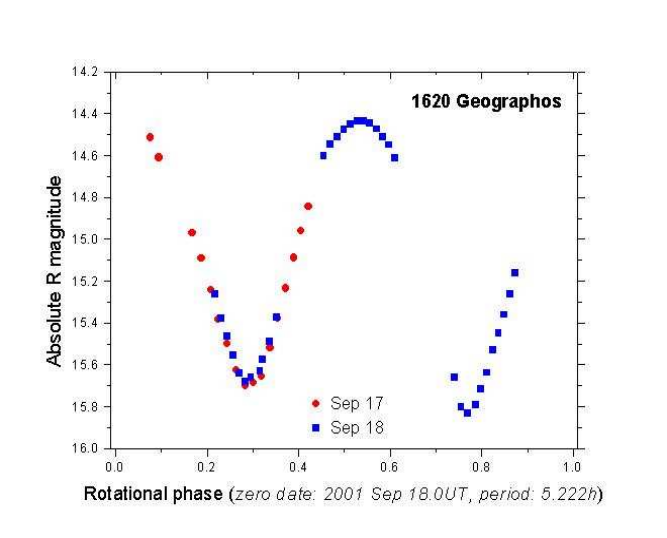
Photometry of Asteroid 433 Eros

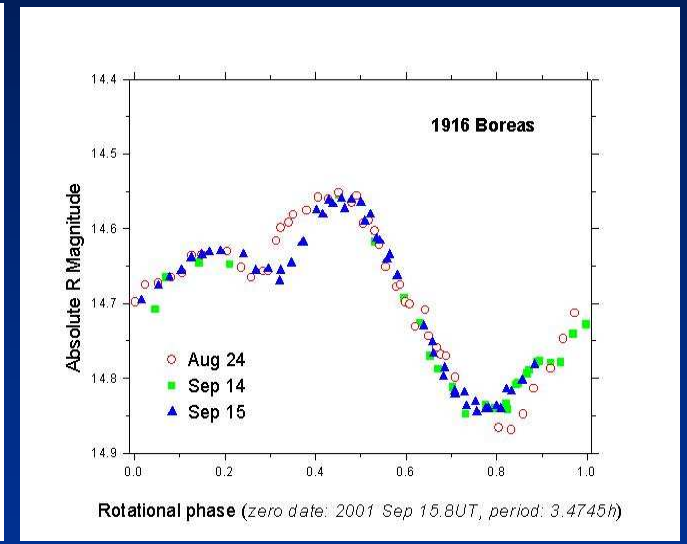
CCD camera precision test

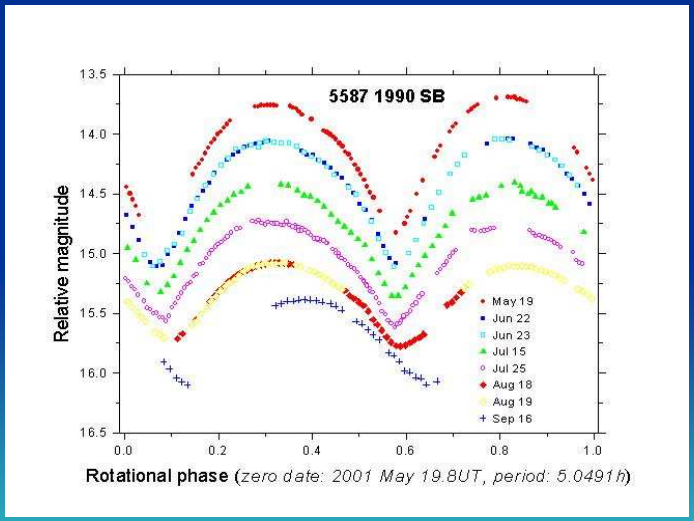


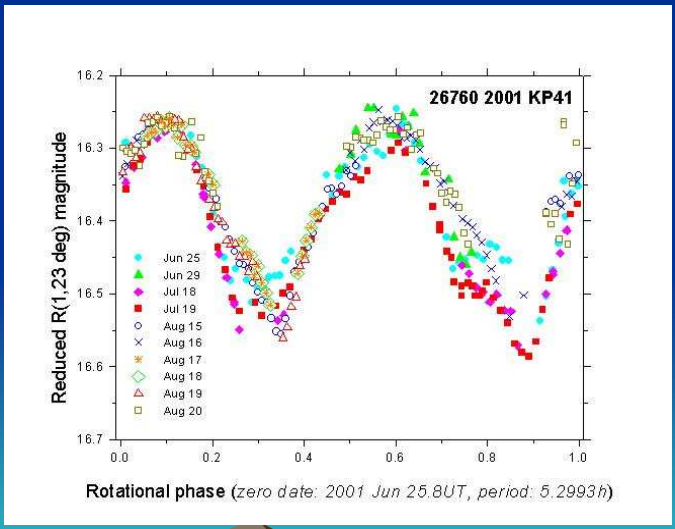
NEAR-EARTH ASTEROID LIGHTCURVES

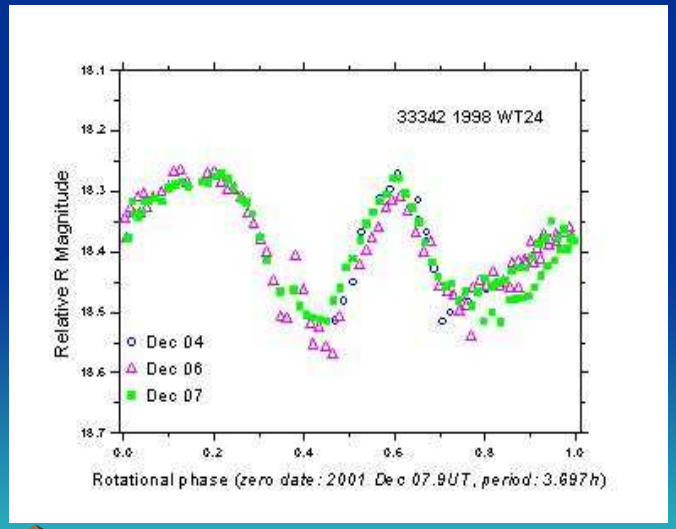




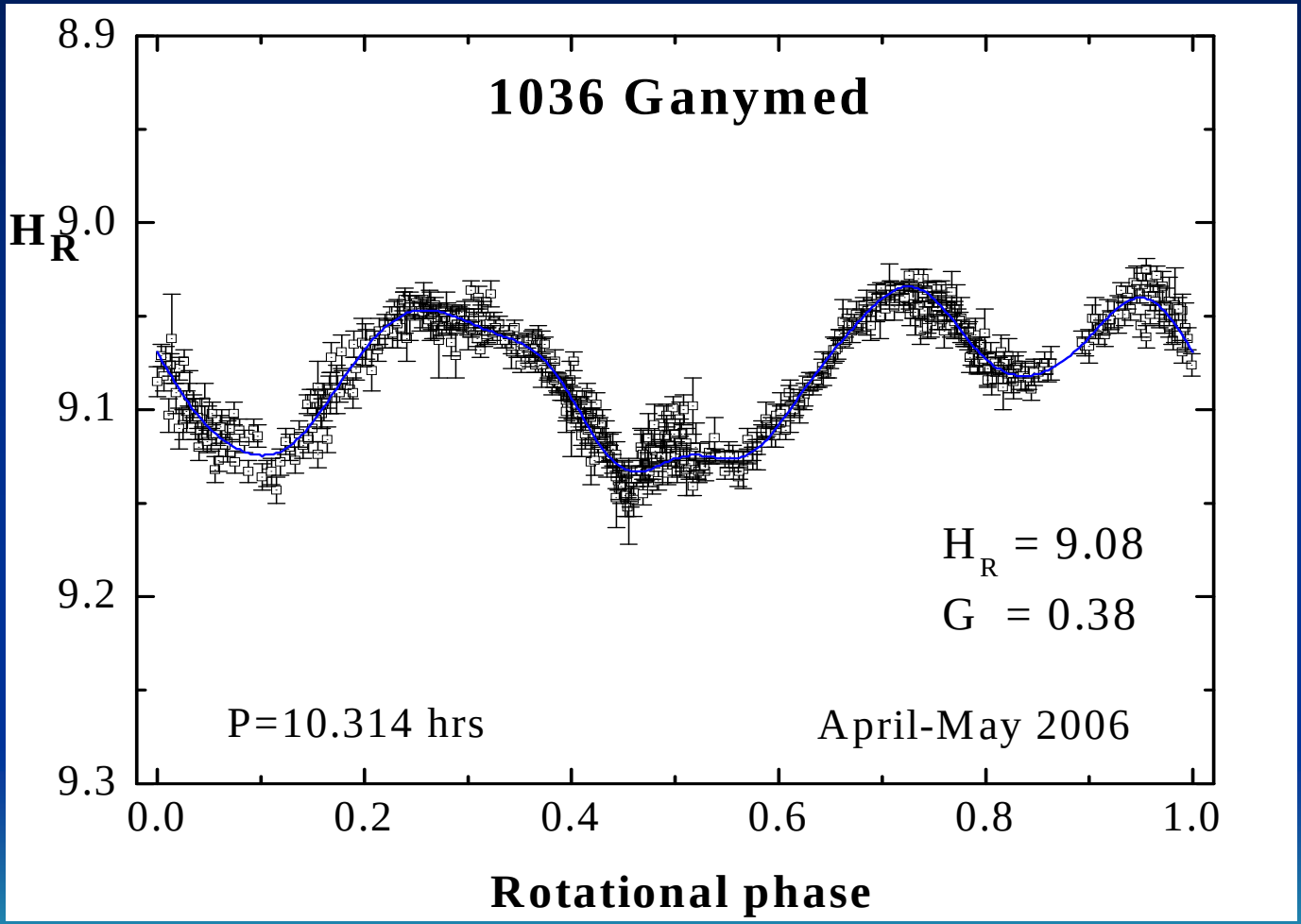




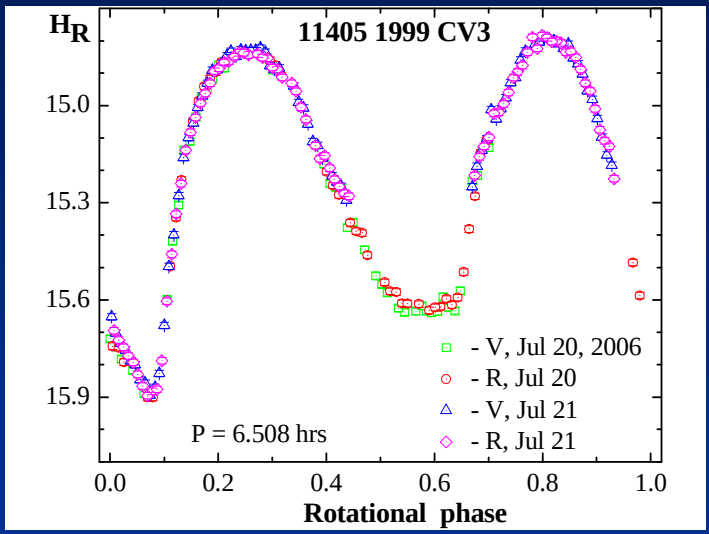


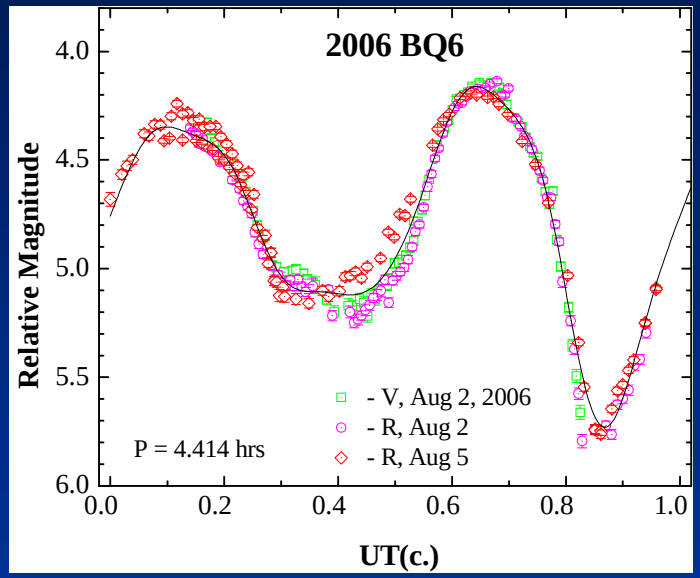


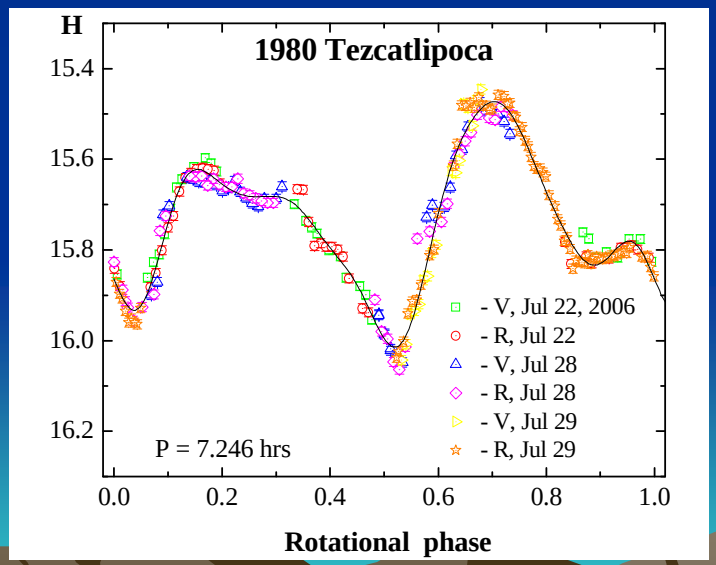
The largest NEA1036 Ganymed

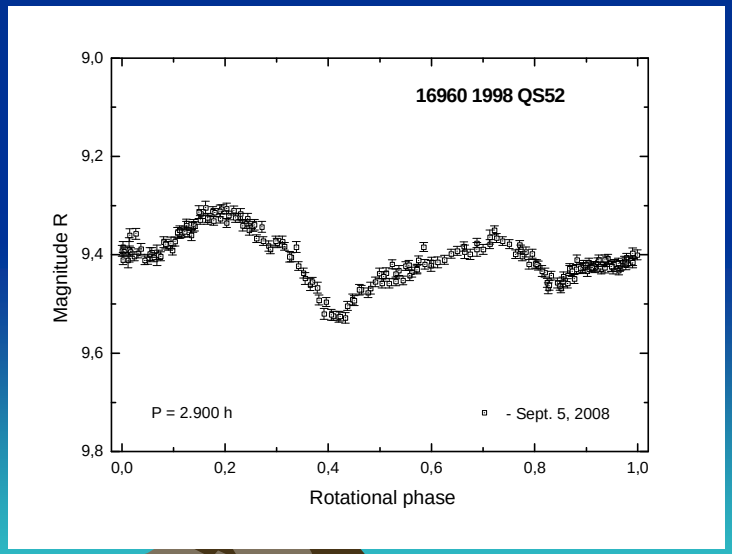


Photometry of NEAs



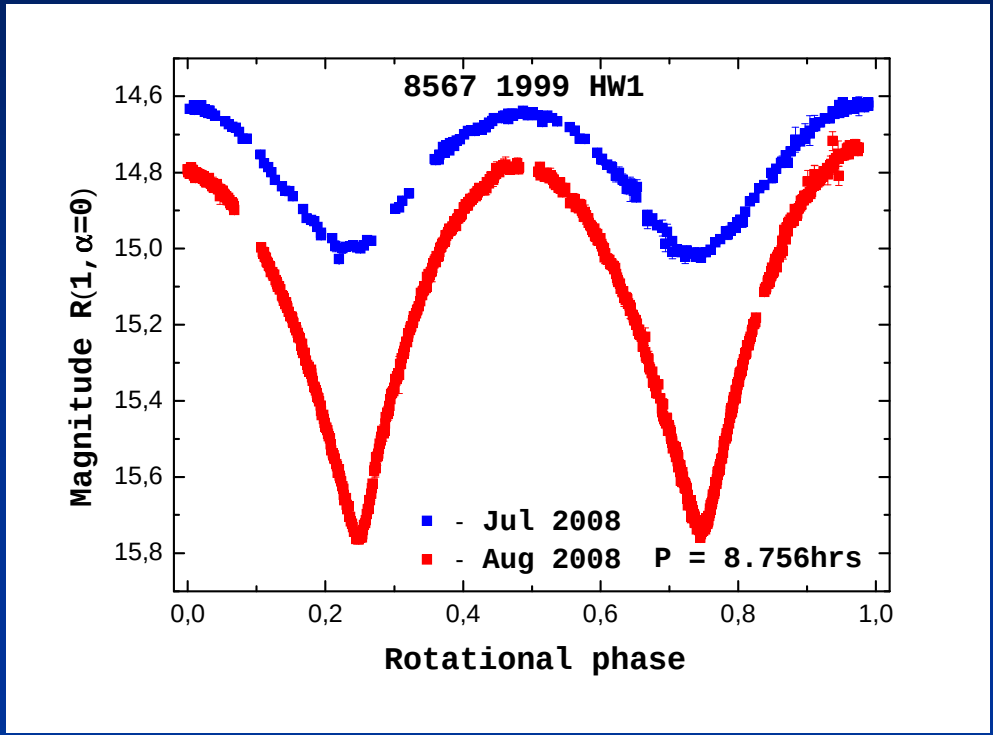


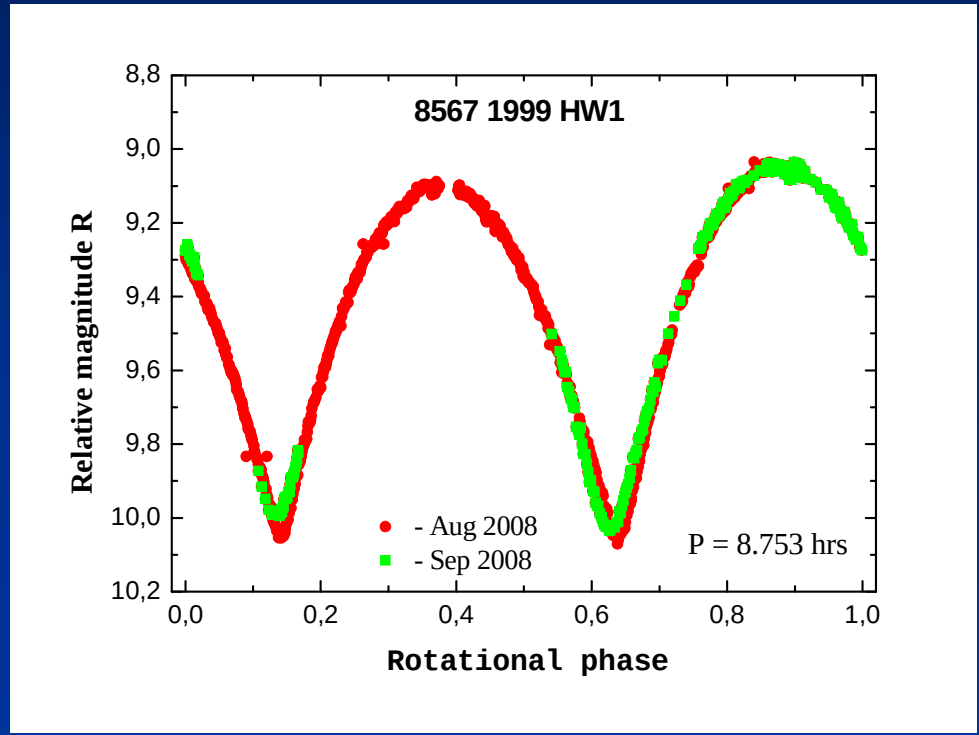




ASTEROID RADAR SHAPE MODELS:

Lightcurves of NEA 8567 1999 HW1



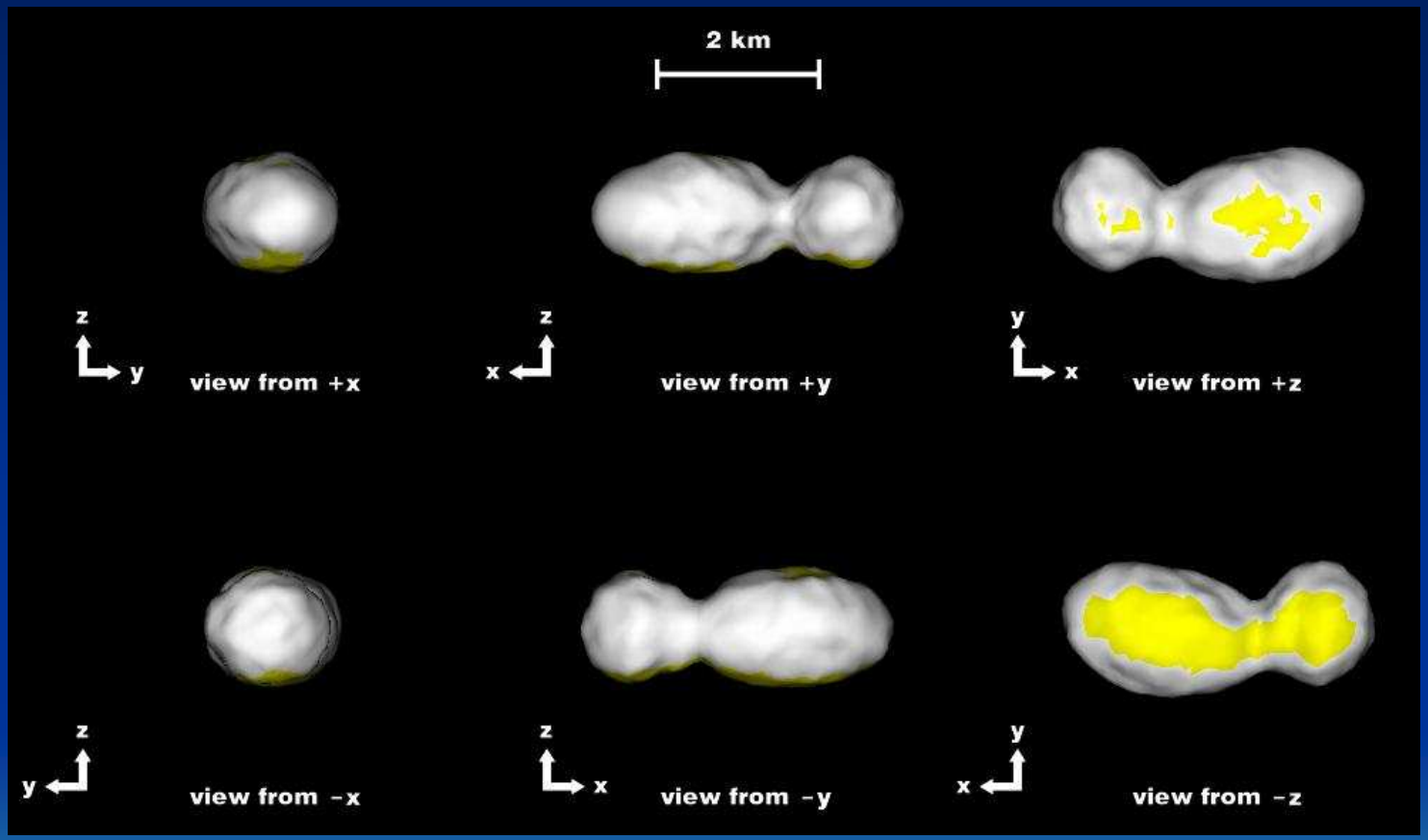


July-August 2008

August-September 2008

SHAPE MODEL OF *8567 1999 HW1:*

radar and photometry

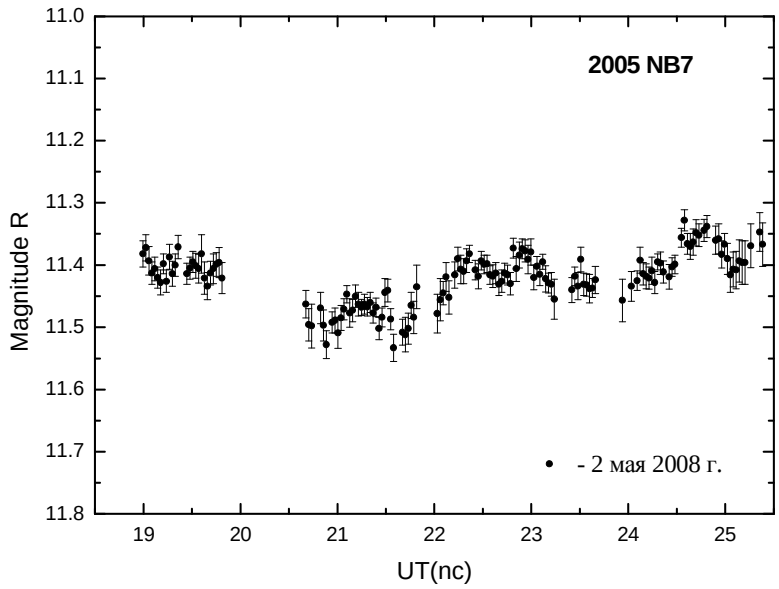


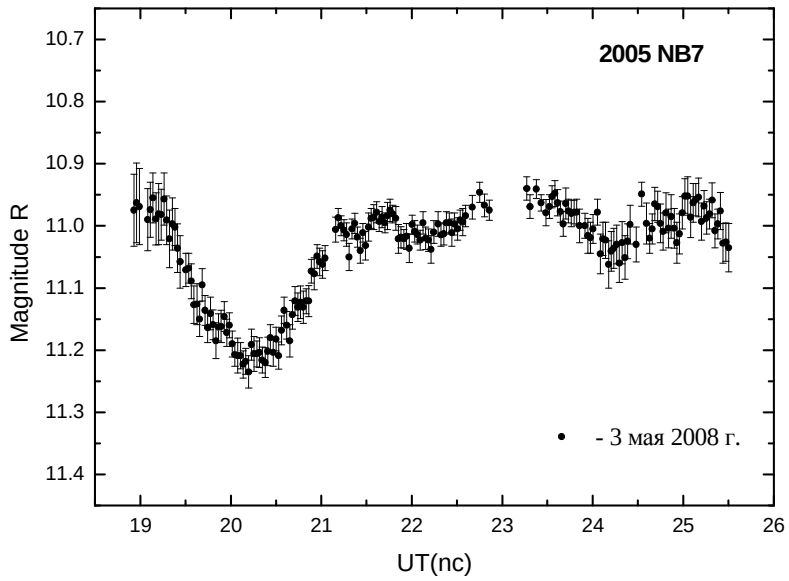
Magri et al. (2010), prepared for Icarus submitting

BINARY NEAR-EARTH ASTEROIDS:

Asynchronous Binary NEA 2005 NB7

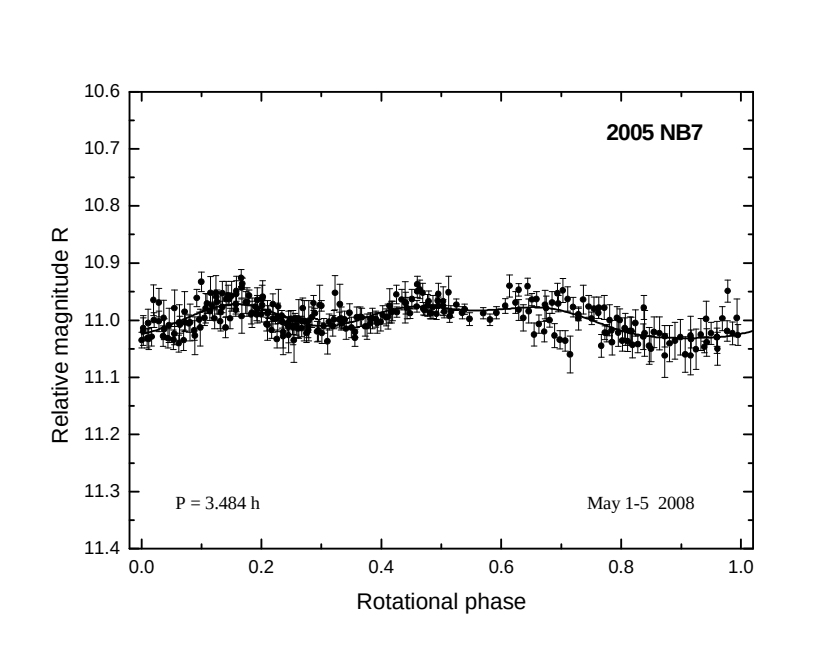
Observations in May 2008

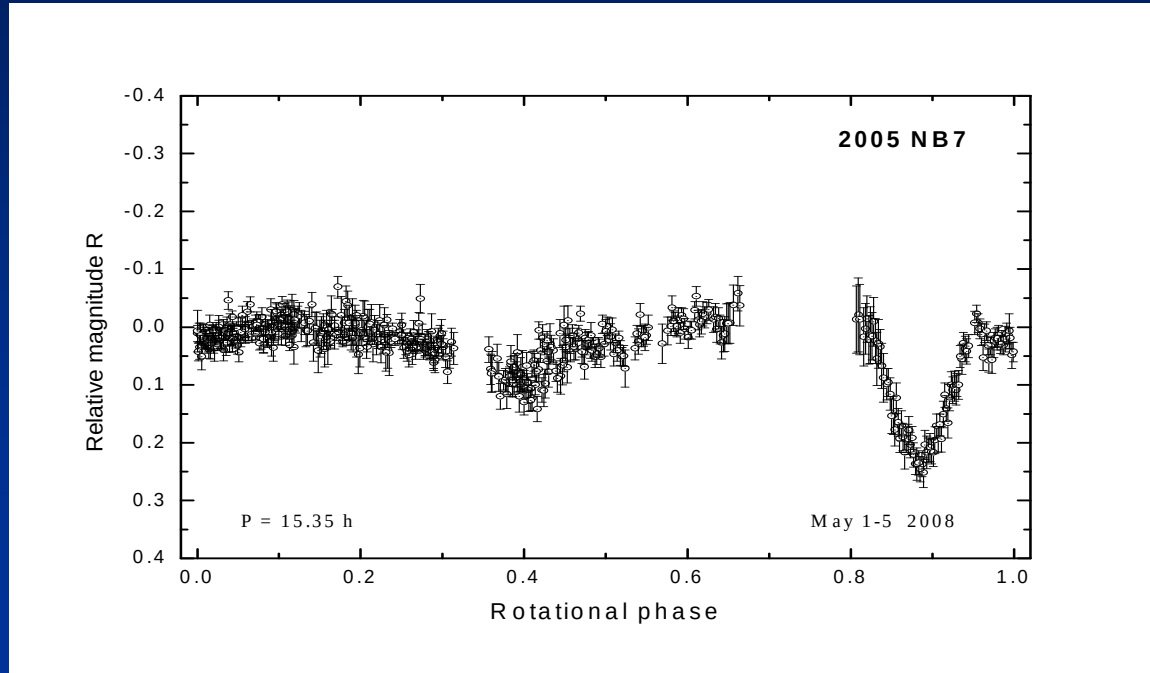




BINARY NEAR-EARTH ASTEROIDS:

Composition lightcurve of 2005 NB7





Short-period component:

Primary body rotation

Long-period component:

Orbital and secondary body rotation

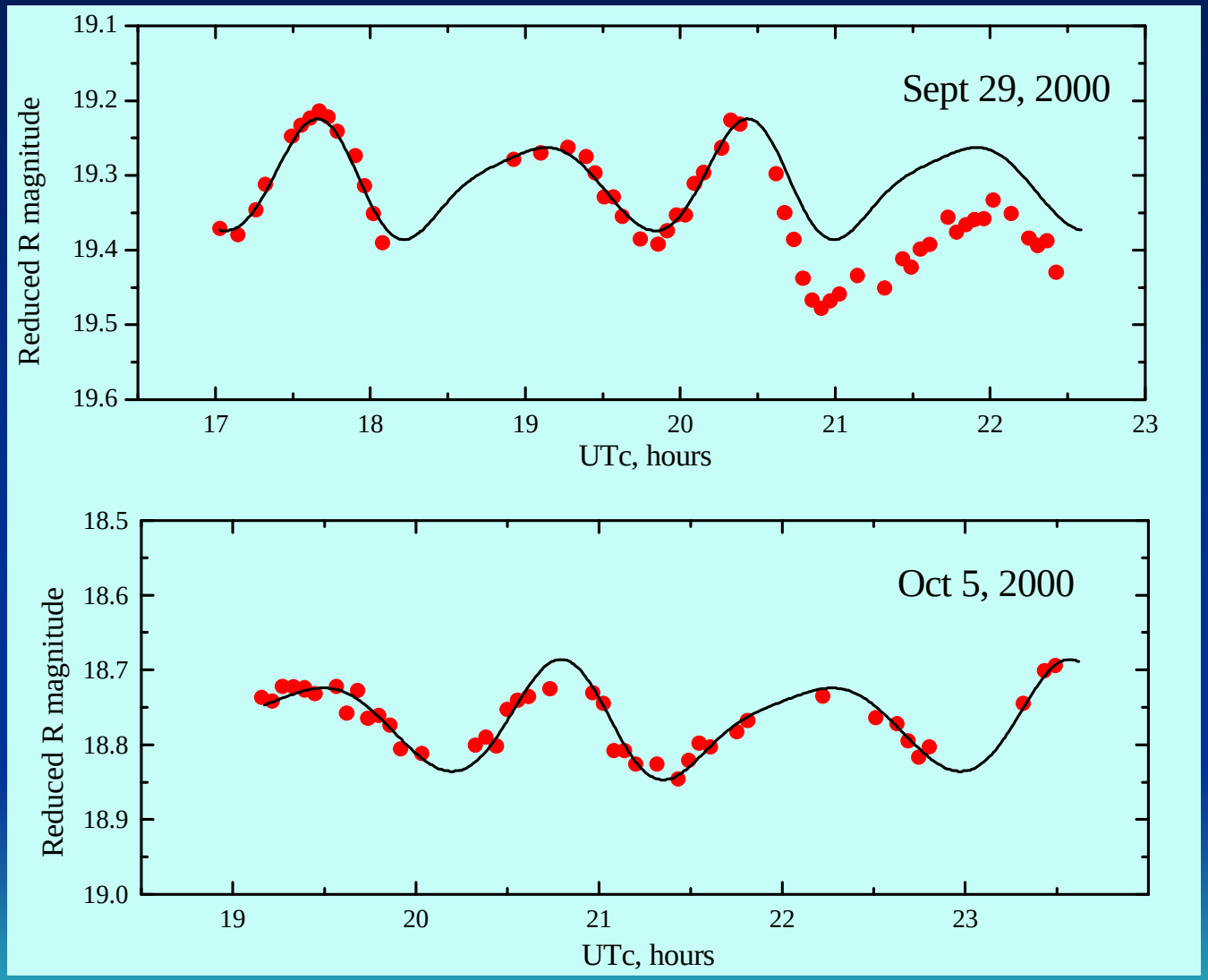
FIRST RADAR BINARY 2000 DP107

discovered in 2000

Margot et al. (2000) IAUC 7503

Tower of Eiffel

LIGHTCURVES OF 2000 DP107



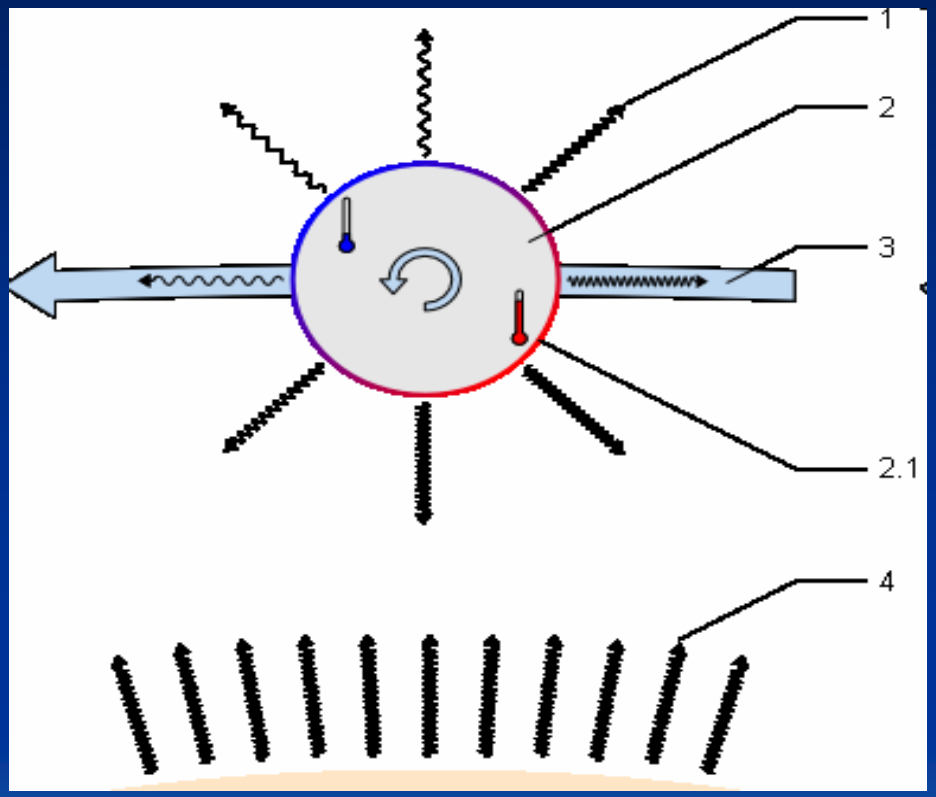
Survey for Asynchronous Binary Asteroids

Installed by Petr Pravec (Ondrejov Observatory, Czech Rep.)

- The goal of the survey is to discover asynchronous binary asteroids among small NEAs, MCs, and inner MBAs, and to do it in a controlled way that will allow to simulate selection effects and biases in obtained sample
- We take part in this project

Yarkovsky and YORP effect

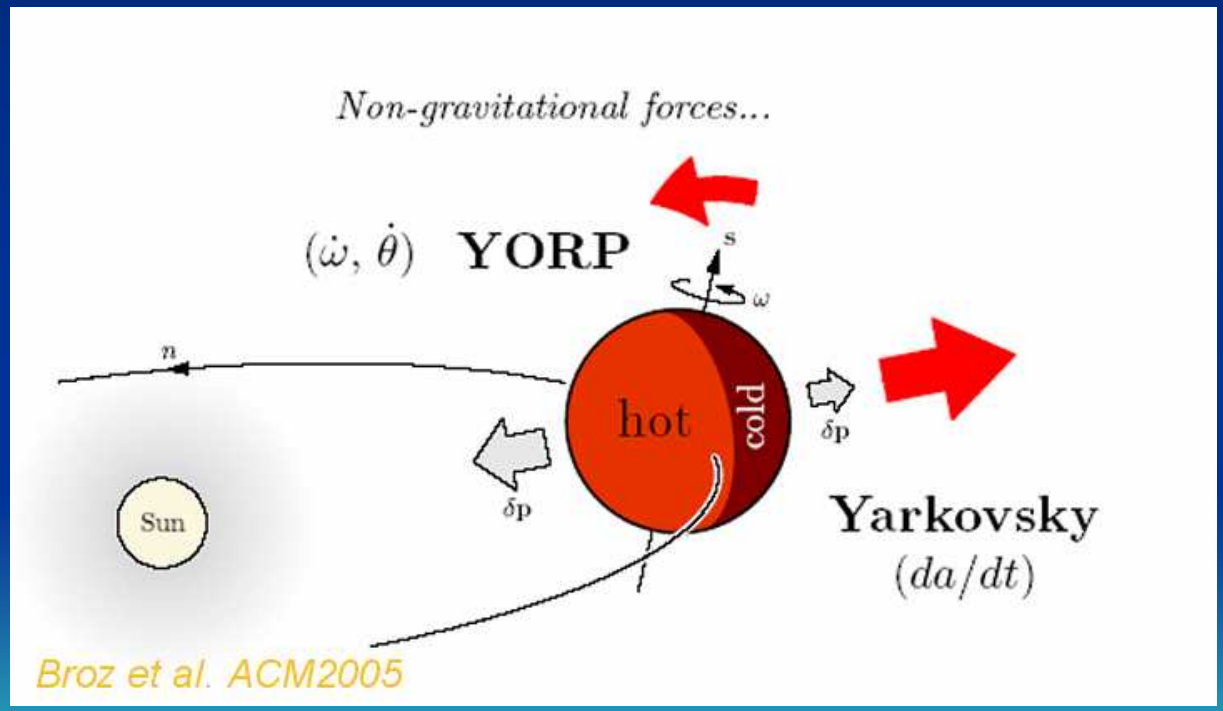
Each photon escaping from asteroid surface carries away a momentum $p = hv/c$. When sunlight from an asteroid's surface is reflected and re-emitted at thermal, infrared wavelengths then it produces a torque.
The thermal forces of the Yarkovsky effect can cause small bodies to drift slowly towards or away from the Sun.
(*Rubincam, 2000*)



http://upload.wikimedia.org/wikipedia/en/5/51/YarkovskyEffect.svg

YORP effect

These thermal torques can cause small asteroids to spin up or down with time – the Yarkovsky-O'Keefe-Radzievskii-Paddack effect or YORP effect. The direction and acceleration of the spin being determined by the shape and orientation of each body.



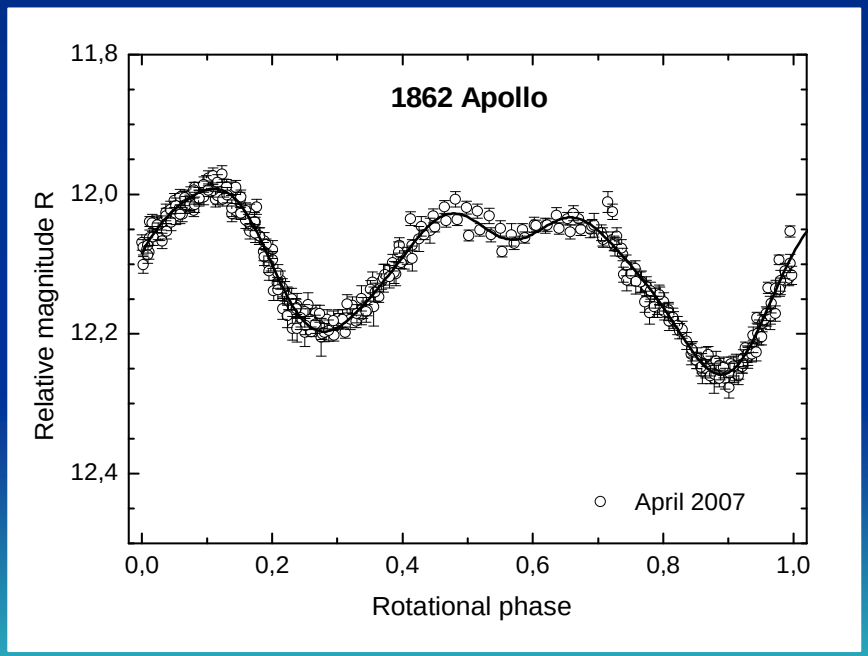
YORP-effect: 1862 Apollo

The direct observational detection of the YORP effect on the NEA 1862 Apollo have been done in 2007 (*Kaasalainen et al. 2007, Nature 446, 420*). New observations in April 2008 have confirmed influence of the YORP effect on Apollo's rotation period (*Durech et al. 2008, Astron. Astroph submitted*). It was found that Apollo's spin behaviour cannot be explained with a simple assumption of a constant sidereal rotation period *P*. To achieve a data fit down to the noise level, the standard lightcurve inversion model had been extended by a linear increase in time t in the rotation speed $w=2\pi/P$:

$$w(t) = w(t_0) + dw/dt(t - t_0)$$

Apollo's model: λ_p = 48 deg, β_p = -72 deg
P (JD 2444557.0) = 3.065448 ± 0.000003 h
dw/dt = (5.5 ± 1.2) x 10^{-8} rad/day^2
⇨ dP/dt = -1.25 x 10^{-6} hr/year

For ρ = 2.7 g/cm3, D = 1.45 km, Bond albedo = 0.1, thermal conductivity K = 0.02 W/m K predicted value of YORP acceleration is dw/dt = 8.0 x 10^{-8} rad/day^2



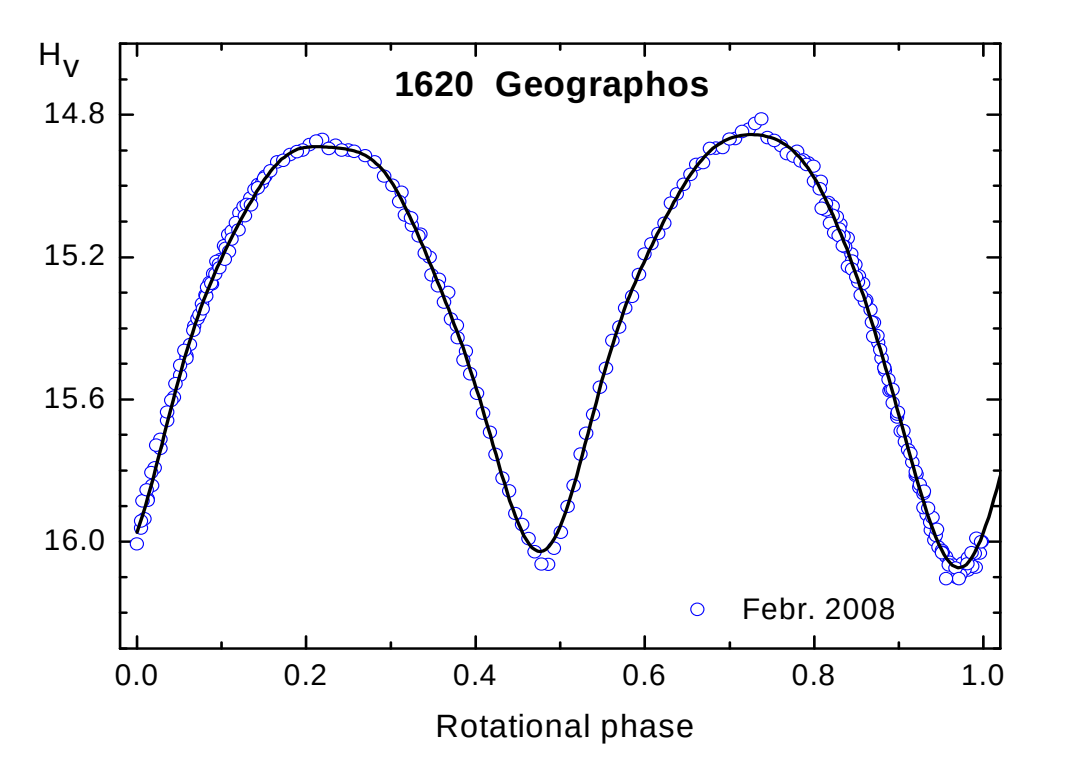
YORP-effect: 1620 Geographos

Geographos' rotation modeling with new observations in January-March 2008 has revealed the YORP acceleration of the rotation period (Durech *et al. 2008, Astron. Astroph.* 489, L25–L28): $dw/dt = 1.1 \times 10^{-8}$ rad/day^2

P = 5.2224 ± 0.001 hr
Amp = 1.3 mag (a = 15 deg)

S-asteroid with D = 2.2 km
H = 15.33, G =0.15
albedo = 0.26

λ_p = 56 deg, β_p = -47 deg
(Magnusson et al. 1996)

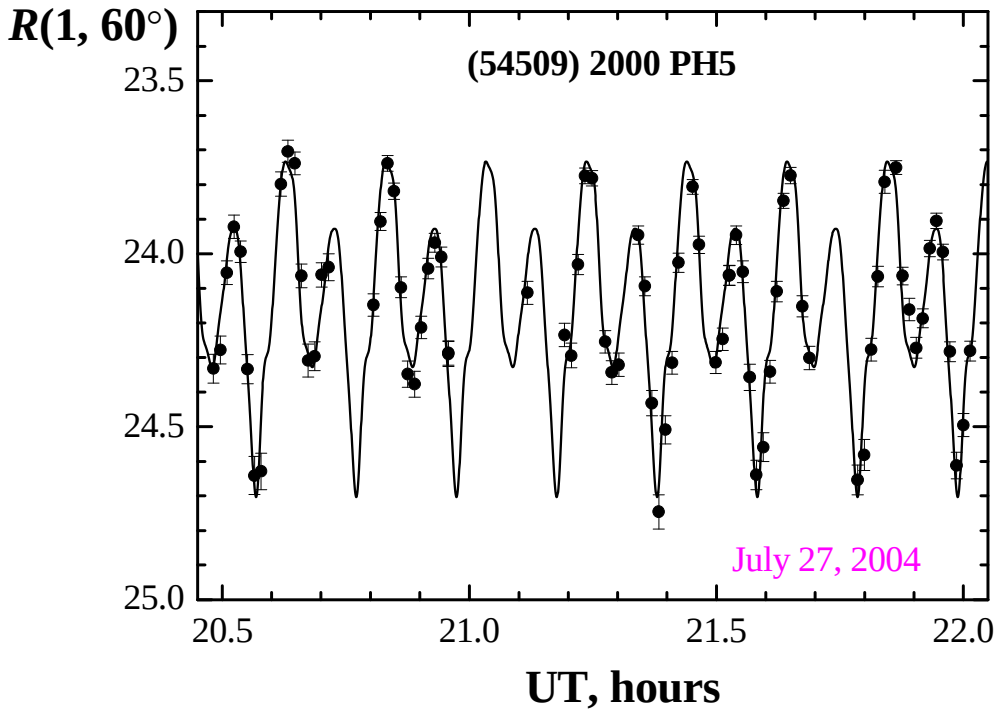


SUPERFAST ROTATING ASTEROIDS:

NEA (54509) YORP (=2000 PH5)

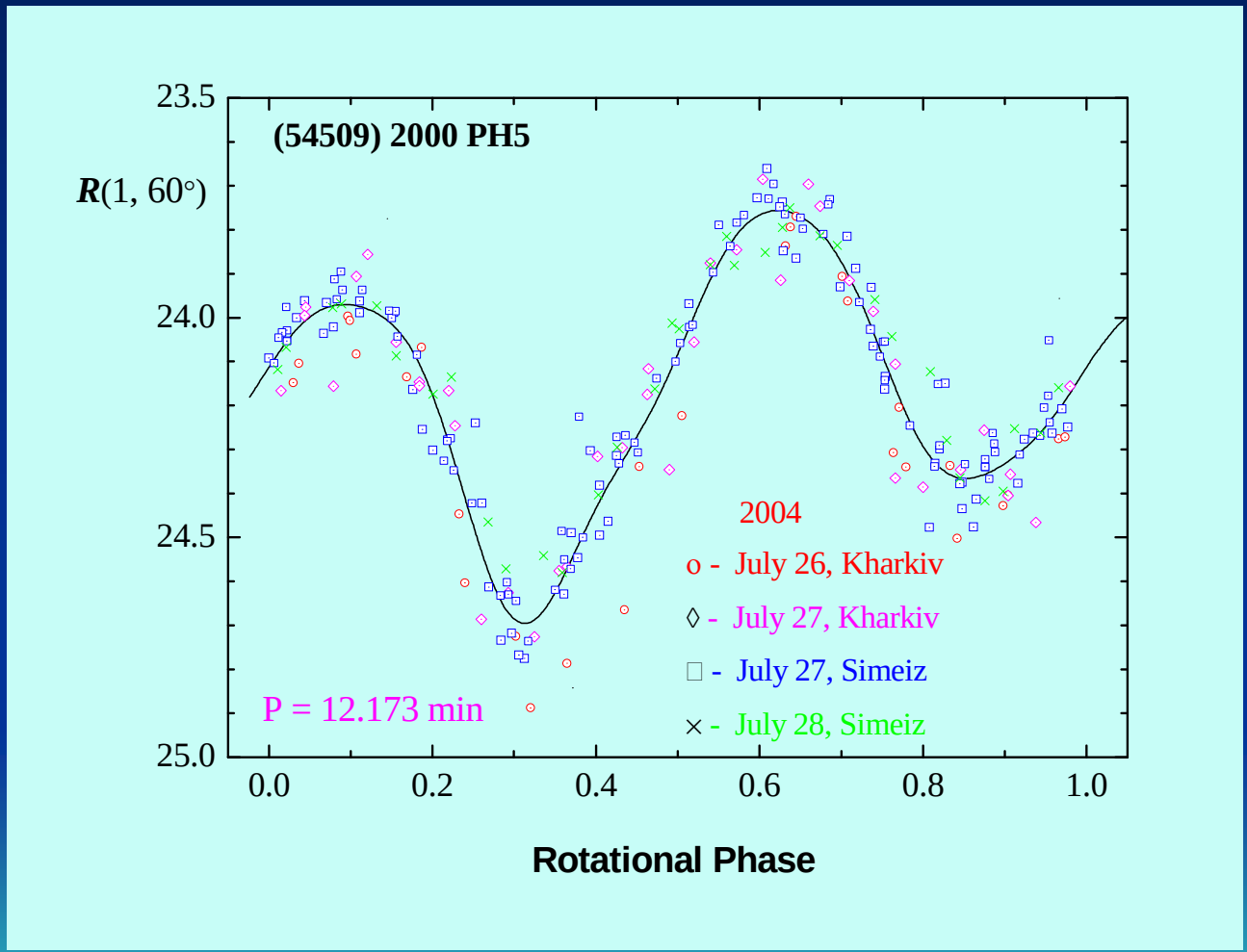
Diameter = 180 m

Period = 12.173 min



COMPOSITE LIGHTCURVE of

(54509) 2000 PH5



ISON OBSERVATIONS IN THE FRAME OF ASTEROID HAZARD PROBLEM

- Discovery of new near-Earth asteroids

  Searching of NEAs in frame of ISON project was started in June 2010 and now one NEA have been discovered

- Follow-up of newly discovered objects to obtain the coordinates and estimate their diameters

- Study of physical parameters of near-Earth asteroids, the first of all newly discovered

New ISON Observation Station at Macon: under *construction*

- We have a protocol of intentions between ISON, IATE-UNC-CONICET and administration of Salta province about scientific and technical cooperation
- In frame of this cooperation we are planning to install wide-field 25 and 50 cm telescopes at Macon in close future. It is supposed inputting from both IATE and ISON in constructing and exploration these telescopes
- The telescopes will be worked in automatic regime and used both IATE and ISON for several tasks: for space debris, asteroid observations and so on

New ISON Observation Station at Macon: under *construction*

25-cm reflector with FOV 4x4 deg^2

50-cm reflector with FOV 2x2 deg^2

Thank you!