The 99942 Apophis observational campaign at the Canary Islands observatories during its 2021 close approach: preliminary results

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Summary

Potentially hazardous asteroid (PHA) 99942 Apophis, with a diameter 380-393 m (Licandro et al. 2016), came to its 2021 close approach on March 6, 2021, at 01:06 UT. It approached at 0.1126 au from Earth, providing an excellent opportunity to obtain good data to do a detailed study of its physical properties.

The Solar System Group of the Instituto de Astrofísica de Canarias (IAC) participated in the International Asteroid Warning Network (IAWN) Observing campaign, an observational effort to better characterize Apophis. We did photometric, spectrophotometric and spectroscopic observations using several state-of-the-art telescopes in the Canary Islands observatories including the world largest optical telescope, the 10.4m Gran Telescopio Canarias (GTC). Observations started mid-January and will end mid-April.

In this work we will present the observing program and some preliminary results.

Observations

Starting on Jan. 18, we contributed with 3 different kind of physical observations that are still ongoing:

Spectroscopy: low resolution spectroscopy in the visible and near-infrared obtained in 5 different runs using the GTC and INT telescopes to study the surface composition of the asteroid

Spectrophotometry: simultaneous *g,r,i,z* photometry in three different nights using the 1.5 TCS telescope to study surface composition and homogeneity, and rotational properties

Light-curve photometry: time-series photometry was obtained in 2 nights with the 1.0m JKT, 10 nights with the 0.82cm IAC-80, 18 nights with the 46cm TAR2 and 7 nights with the 40cm TAR4 telescopes. The aim is to refine the knowledge of its rotational properties.

Telescopes & Instruments

GTC

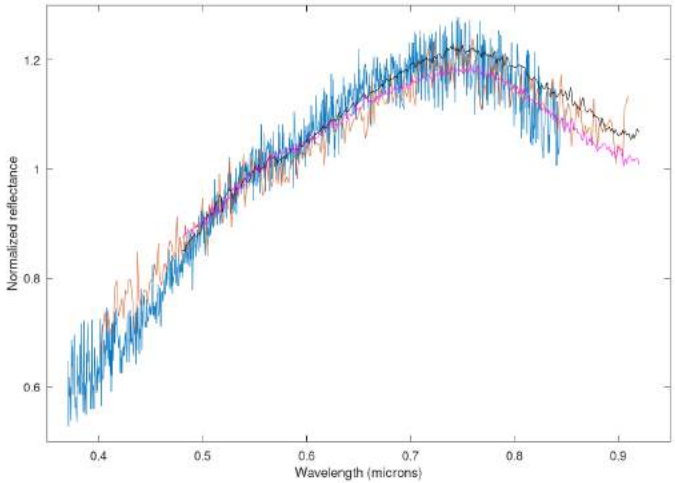
INT

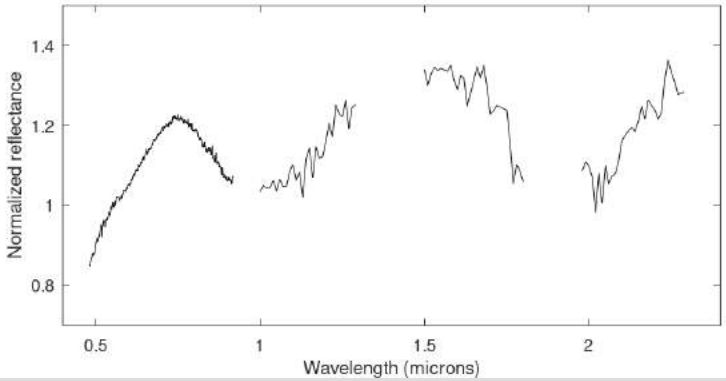
TCS

IAC-80

Tel.	Obs.	D.	Instrument	configuration
GTC	ORM	10.4 m	EMIR	zJ & HK grism, low-res
			DOLORES	R300R, low-res
INT	ORM	2.5 m	IDS	R300B, R158R, low-res
JKT	ORM	1.0m	**Andor** Ikon L-2048	Sloan r filter, 0.34 “/pix
TCS	OT	1.5 m	MUSCAT 2	Sloan g,r,i,z, 4 1Kx1K CCDs, 0.44”/pix
IAC80	OT	82 cm	CAMELOT 2	4Kx4K, 0.33 “/pix, Sloan r filter
TAR2	OT	46 cm	FLI-Kepler KL400	CMOS, 1.8 “/pix, clear filter
TAR4	OT	40 cm	FLI-Kepler KL400	CMOS, 0.6 “/pix, clear filter

Spectroscopic preliminary results





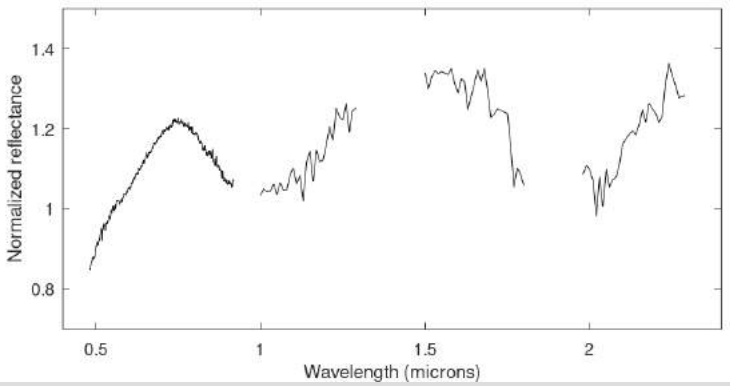
Visible reflectance spectra obtained in 4 different nights: Feb. 11 (blue), Feb. 12 (black), Mar. 19 (magenta), Apr. 04 (orange)

Measured spectral slopes (see Table) in the 500-750 nm spectral region suggests a possible color change after the close approach. Need confirmation.

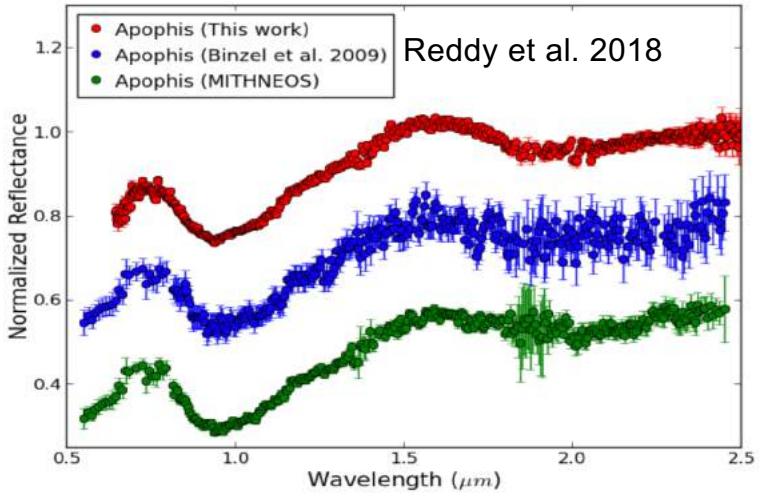
Date	Tel.	Configuration	Slope (%/100nm)
Feb. 11	INT	IDS, R300B	12.6 +/- 0.5
Feb. 12	GTC	DOLORES, R300R	12.9 +/- 0.5
Mar. 19	GTC	DOLORES, R300R	11.2 +/- 0.5
Apr. 01	INT	IDS, R158R	12.0 +/- 0.5

The near-infrared spectrum obtained with EMIR/GTC on Jan. 29 using the zJ and HK grisms

Spectroscopic preliminary results



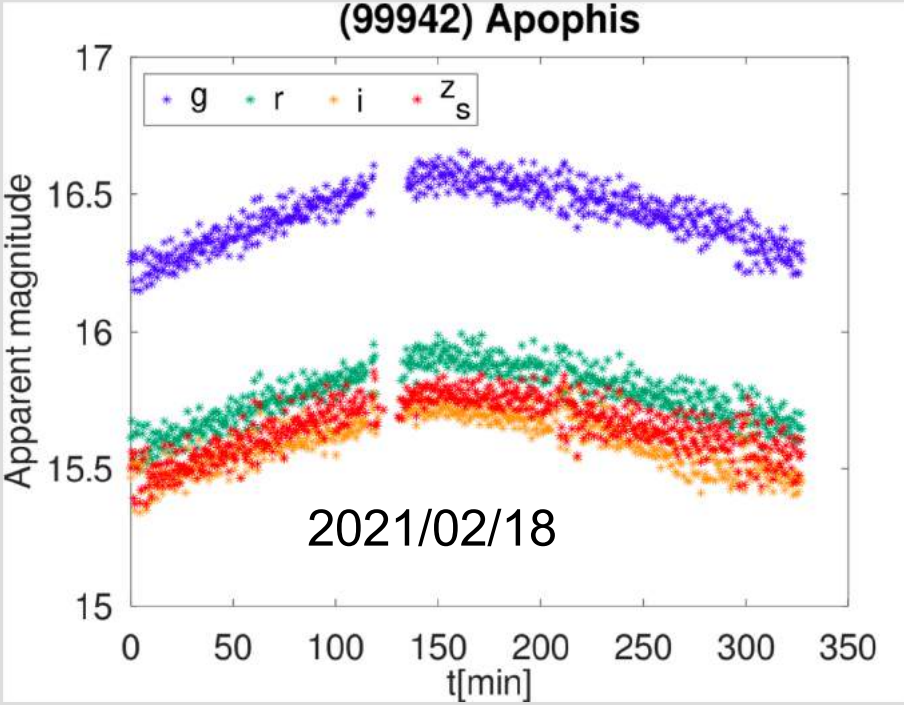
Our VISNIR spectrum is similar to the previously reported ones by Binzel et al. (2009) and Reddy et al. (2018). They report that Apophis spectrum shows that best meteorite analog is an LL ordinary chondrite.

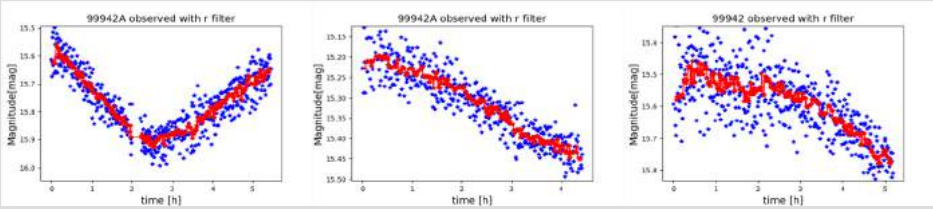


Reddy et al. 2018

The data is under analysis as part of the whole spectroscopic dataset of the IAWN campaign.

Spectrophotometric Preliminary Results





2021/02/18 2021/03/09 2021/03/16

Apophis was observed during 3 nights with the 1.5m Carlos Sanchez Telescope (TCS)
MUSCAT 2 use 4 CCDs that image the field simultaneously allowing to do accurate color determinations
Data is reduced & calibrated using Photometry Pipeline (Mommert 2017)

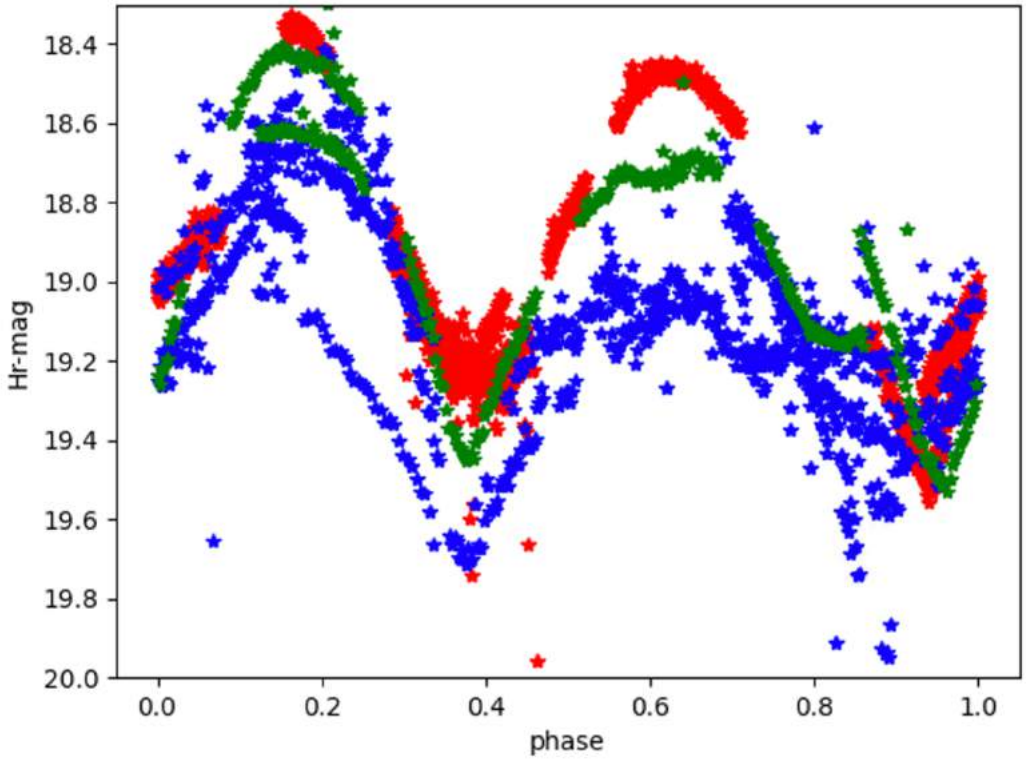
The measured colors are:

g-r = 0.66
r-i = 0.17
i-z = -0.05

Colors are compatible with the observed spectra

The data is under analysis as part of the whole photometric dataset of the IAWN campaign (see Erasmus presentation)

Light-curve preliminary results

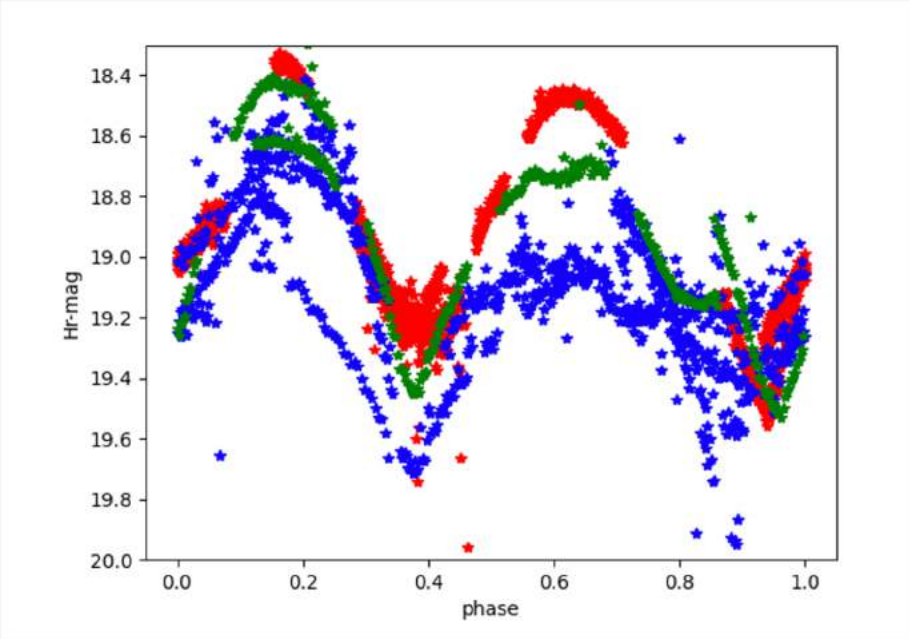


Apophis was observed in 24 different nights.
Most of the data is reduced & calibrated using Photometry Pipeline (Mommert 2017)
Observations are still ongoing.

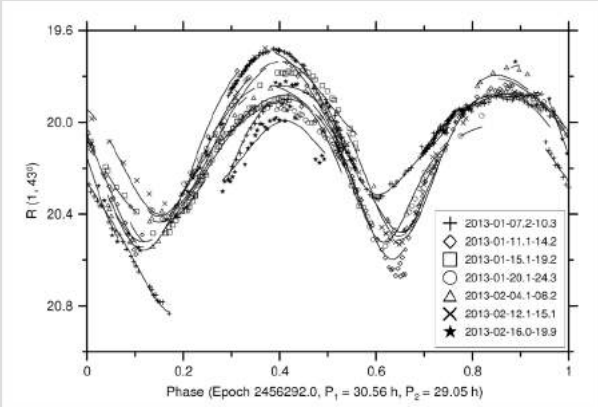
In the figure we show:

a) Photometric data phased to a Period of 30.56hr
b) Data from each telescope in different colors (IAC80 in red, TAR2 in blue, TAR4 in green).
c) H mag is the absolute magnitude corrected by distance and phase angle. Ligh-time correction is also applied

Light-curve preliminary results



Our data is compatible with previous observations by Pravec et al. (2014). They report Apophis is in a non-principal axis rotation state. The precession and rotation periods are 27.38 hours and 263 hours, respectively, with the strongest observed lightcurve amplitude for single axis mode with a 30.56 hours period.



Pravec et al. (2014)

The data is under analysis as part of the whole photometric dataset of the IAWN campaign (see Erasmus presentation)

Conclusions

- IAC participation in the IAWN coordinated observational Apophis program is producing very nice results
- We report visible and near-infrared low-resolution spectroscopy obtained in 5 different nights.
- We also report simultaneous time-series spectrophotometric measurements in *g,r,i,z* obtained in 3 different nights.
- We finally report time-series photometric observations with 4 different telescopes in 24 different nights
- All data will be analyzed together within the IAWN observational campaign

References:

- Binzel, R. et al. 2009, Icarus, 200, 480
- Licandro, J. et al. 2016, A&A 585, 10L
- Mommert, M. 2017, Astron. & Computing, 18, 47
- Pravec, P. et al. 2014, Icarus, 233, 48
- Reddy et al. 2018, AJ 155, 140.