

NELIOTA: ESA's new NEO lunar impact monitoring project with the 1.2m telescope at the National Observatory of Athens

A. Z. Bonanos¹, M. Xilouris¹, P. Boumis¹, I. Bellas-Velidis¹,
A. Maroussis¹, A. Dapergolas¹, A. Fytsilis¹,
V. Charmandaris¹, K. Tsiganis², K. Tsinganos³

¹IAASARS, National Observatory of Athens, 15236 Penteli, Greece, email: bonanos@noa.gr

²Aristotle University of Thessaloniki, 54124 Thessaloniki, Greece

³University of Athens, Panepistemiopolis, 15784 Zografos, Athens, Greece

Abstract. NELIOTA is a new ESA activity launched at the National Observatory of Athens in February 2015 aiming to determine the distribution and frequency of small near-earth objects (NEOs) via lunar monitoring. The project involves upgrading the 1.2m Kryoneri telescope of the National Observatory of Athens, building a two fast-frame camera instrument, and developing a software system, which will control the telescope and the cameras, process the images and automatically detect NEO impacts. NELIOTA will provide a web-based user interface, where the impact events will be reported and made available to the scientific community and the general public. The objective of this 3.5 year activity is to design, develop and implement a highly automated lunar monitoring system, which will conduct an observing campaign for 2 years in search of NEO impact flashes on the Moon. The impact events will be verified, characterised and reported. The 1.2m telescope will be capable of detecting flashes much fainter than current, small-aperture, lunar monitoring telescopes. NELIOTA is therefore expected to characterise the frequency and distribution of NEOs weighing as little as a few grams.

Keywords. Moon

Near-Earth Objects (NEOs) are ubiquitous in the space environment. They are thought to originate from fragments created during asteroid collisions, asteroids diverted from the asteroid belt through the gravitational influence of planets, or cometary debris. NEOs have orbits crossing into the inner Solar System and intersecting the Earth's trajectory, posing a threat to artificial satellites, spacecraft, and astronauts. The atmosphere of the Earth offers protection from all but the largest NEO impacts, which do not completely burn up as they enter the atmosphere, at speeds of tens of km s^{-1} . However, the surface of the Moon remains susceptible to impacts by small NEOs and can be used to study their properties.

NEO lunar impacts are observed as bright flashes of light. The impacting meteoroids travel at large speeds (20 to 50 km s^{-1}), and thus contain tremendous kinetic energy that causes the rocks and soil on the lunar surface to heat up and glow. Ground-based observers detect flashes lasting from a fraction of a second to several seconds, with light curves showing a sharp rise and an exponential fading tail. Surveys show a peak in impacts during meteor showers, as the Earth-Moon system passes through relatively dense clouds of meteoroids, when crossing the orbits of comets, however, impacts are detected continuously, without them necessarily exhibiting a connection to comet debris or a meteor shower.

In order to quantify the frequency and characteristics of NEOs, several campaigns are underway, such as the Lunar Impact Monitoring at NASA's Marshall Space Flight Center (Suggs *et al.* 2014), the MIDAS project (Madiedo *et al.* 2014, 2015), and the ILIAD Network (Ait Moulay Larbi *et al.* 2015). Suggs *et al.* (2014) reported over 300 impacts down to $R = 10.2$ mag, while surveying an area of 3.8×10^6 km² over 7 years. The analysis of 126 flashes that were detected during photometric conditions, yielded a survey completeness limit of $R = 9$ mag. The association of certain impacts with meteor streams provided constraints on the impact speeds and thus their kinetic energy.

Lunar monitoring surveys for NEO impacts typically involve small, 30-50 cm telescopes, tracking at the lunar rate, that are equipped with video cameras recording at a rate of 30 frames per second (fps). The dark portion of the lunar surface is monitored during the phases corresponding to 10-50% illumination. The aim is to maximize the number of lunar impacts detected, by maximizing the lunar surface observed, while avoiding the illuminated surface of the Moon. The goal of such surveys is to measure the distribution of sizes and masses of objects impacting the Moon, as well as their flux, and detect a significant number of impacts from which to obtain statistical results on their characteristics.

NELIOTA aims to increase the number of detected faint lunar impacts, and therefore increase the statistics to obtain their size distribution, speeds, frequency, and characterize the impact ejecta. Using the 1.2m Cassegrain reflector telescope at Kryoneri Observatory, manufactured and installed in 1975 by the British company Grubb Parsons Co., Newcastle (Figure 1), we aim to push the detection limit for the first time to $V = 12$ mag. Note, that the surface brightness of the earthshine ranges between $12 \text{ m}_V \text{ arcsec}^{-2}$ (New Moon) and $17 \text{ m}_V \text{ arcsec}^{-2}$ (near Full Moon), with variations on the timescale of hours of the order of $0.25 \text{ m}_V \text{ arcsec}^{-2}$ due to terrestrial meteorology (Montanes-Rodriguez *et al.* 2007). Given the expected power law size distribution of NEOs, we anticipate providing significant numbers of small NEOs by detecting faint flashes. These data would be valuable for characterizing the meteor environment and providing guidelines to spacecraft manufacturers for protection of their vehicles, as well as for future space mission planning.

The objective of NELIOTA is to design, develop and implement a highly automated lunar monitoring system using existing facilities at the National Observatory of Athens, Greece. For the first phase of the project, DFM Engineering, Inc. will be retrofitting and upgrading the electronics and mechanical parts of the 1.2m Kryoneri telescope, located in the Northern Peloponnese, in Greece. A dual imaging instrument, also designed and manufactured by DFM Engineering, Inc., along with two Andor Zyla 5.5 sCMOS fast-frame cameras recording at 30 fps, will be used to simultaneously monitor the non-illuminated lunar surface for impact flashes and to reject cosmic rays. Our setup will provide a field-of-view $\sim 17' \times 14'$. Specialised software is being developed to control the telescope and cameras, as well as to process the resulting images to detect the impacts automatically. The NELIOTA system will then publish the data on the web so it can be made available to the scientific community and the general public. Following a 2 month commissioning phase, there will be a 22 month observing campaign for NEO impact flashes on the Moon. The impact events will be verified, characterised and recorded. The 1.2m Kryoneri telescope will be capable of detecting flashes far fainter than telescopes currently monitoring the Moon.

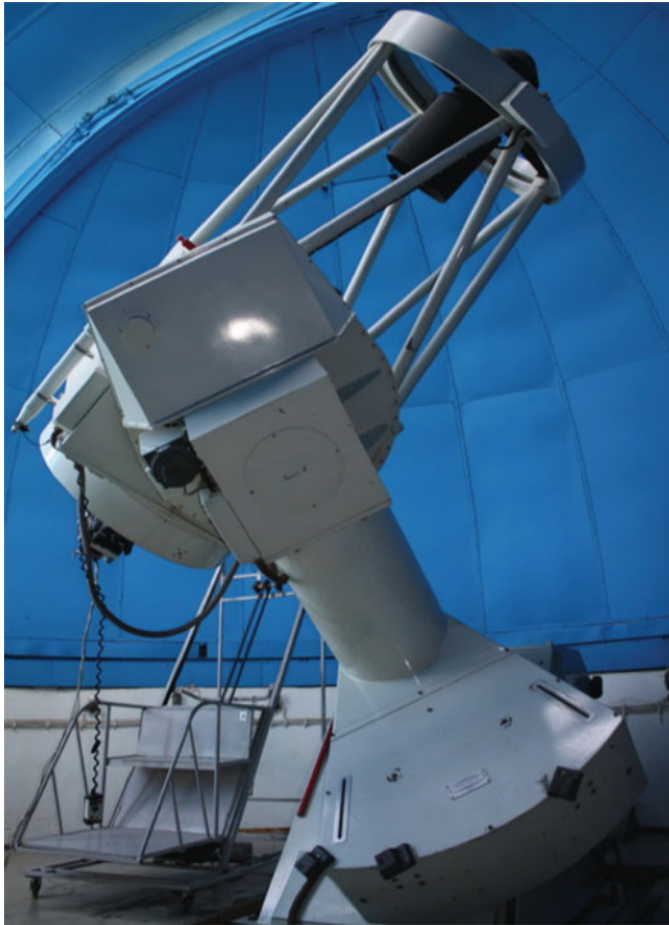


Figure 1. The 1.2 m Cassegrain reflector telescope at Kryoneri Observatory, which is being retrofit and upgraded to detect lunar impacts in the framework of the NELIOTA project.

References

- Ait Moulay Larbi, M., Daassou, A., Baratoux, *et al.* 2015, *Earth, Moon, and Planets*, 115, 1
Madiedo, J. M., Ortiz, J. L., Morales, N., & Cabrera-Cano, J. 2014, *MNRAS*, 439, 2364
Madiedo, J. M., Ortiz, J. L., Organero, F., *et al.* 2015, *A&A*, 577, 118
Montanes-Rodriguez, P., Palle, E., & Goode, P. R. 2007, *AJ*, 134, 1145
Suggs, R. M., Moser, D. E., Cooke, W. J., & Suggs, R. J. 2014, *Icarus*, 238, 23