NEOMIR: ESA'S SPACE-BASED NEO INFRARED MISSION. L. Conversi[1,2,*], J. Licandro[3], M. Delbo[4], A. Fitzsimmons[5], K. Muinonen[6], T. Müller[7], M. Popescu[8], P. Tanga[4], L. Berthelsen[2], D. Föhring[2], M. Micheli[2], and R. Moissl[1,2]
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Introduction: To be able to provide advanced warning of future or imminent impacts of asteroids or comets, the first step is to observe the sky and discover these objects. This task is performed by means of dedicated NEO surveys. Currently, the main survey programmes are the US-funded Pan-STARRS, Catalina and ATLAS sky surveys: however, they first two are only able to scan about 10% of the available sky every night, while the latter can only detect objects brighter than 19.5 mag$_V$. ESA is developing the first European observatory dedicated to NEO surveying, the Flyeye telescope, whose first light is expected in 2024 [1].

Most current and planned NEO surveys are ground-based and carried out in the visible wavelength range. However, this approach has some limitations, such as (1) weather dependency, (2) that only a portion of the night sky is visible from any given location on Earth, (3) NEOs are difficult to be detected at low ecliptic latitudes and (4) that visible-light surveys can only determine the motion and apparent magnitude of an object, but its physical properties (such as size) can only be inferred indirectly and therefore require additional observations for characterisation.

A space-based mission working in the thermal infrared (IR) and placed at the first Sun-Earth Lagrange point (L1) would overcome most of these issues: in fact, by regularly scanning an area not easily accessible from ground or other space-based NEO surveys, it will be capable of detecting and characterising new NEOs and - in the worst case of an imminent impactor - serve as an early warning system.

NASA has been studying a space-based mission to detect NEOs in the IR since the early 2010s: NEO Surveyor. In October 2021, ESA conducted at its Concurrent Design Facility (CDF hereafter) an initial study to explore the viability of an NEO Mission in the InfraRed (NEOMIR hereafter) and its costs for development and operation.

Mission objectives: NEO Surveyor is designed with the primary goal of discovering larger NEOs while they are still far away. NEOMIR, on the other hand, is designed with the main goal of discovering the smaller NEO population that can only be observed when the asteroids get closer to Earth and serve as an early warning in the case of an impactor. This is achieved by (1) pointing closer to the Sun and at all Ecliptic latitudes; (2) shortening exposure times and increasing cadence of revisit, ensuring that faster and therefore closer NEOs crossing the field of regard are not missed.

Mission requirements: During the initial NEOMIR study, many spacecraft design requirements of NEO Surveyor [2] were taken as baseline. In general, it is expected that NEOMIR will cover two IR bands, 4-6 μm and 6-10 μm, hosting a 55 cm cryogenically cooled three-mirror anastigmat telescope, huge data rate (400 Gbit/day) and a survey design that will find all detectable NEOs moving at < 10"/min in the fields surveyed.

Detection capabilities: To evaluate the performance of the observational strategy, we analysed the orbits of 3000 synthetic impactors as provided by S. Chesley [3] by propagating them. Our simulations show that 700 of them were bright enough to be potentially detected by NEOMIR on their collision course with Earth - the others impacting on the "night side" and thus detectable from the ground. Of these 700, NEOMIR was able to detect 610 - on average, 29 days before impact. The missed ones were mostly due to these NEOs crossing the field of regard when very close to the spacecraft, thus the survey cadence does not allow for at least 3 detections. However, it is expected that they would be much brighter, and thus an alternative algorithm (e.g. streak detection) could be employed: this will be the subject of further studies.

Conclusions: The CDF study demonstrated NEOMIR is viable and would fall within the cost range of a typical ESA medium-size mission. It is currently in the so-called phase 0/A and two industrial parallel studies have started in March 2023. The mission was further supported at the last ministerial meeting (Nov. 2022) and sufficient funds are available to study the mission until phase B1. The current plan is compatible with a launch date around 2030.

References:

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