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The Mission Accessible Near-Earth Objects Survey (MANOS): first results from the visible spectroscopic survey

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Abstract

The Mission Accessible Near-Earth Objects Survey (MANOS) aims at characterizing sub-km, low delta-v, newly discovered Near-Earth Objects (NEOs). This survey, started in August 2013, is collecting astrometry, lightcurve photometry, and reflectance spectra of this under-studied portion of the NEO population. The MANOS program is using 1 to 8 meter telescopes located around the world. Here we present the first results of the visible reflectance spectroscopy survey obtained with the 8.1-meter Gemini North and South telescopes, the 4.3-meter Discovery Channel Telescope and the 4.1-meter SOAR telescope.

1. Introduction

Near-Earth objects (NEOs; defined by perihelia $<$1.3 AU) are small objects in the Solar System which regularly make close approaches with the Earth. For more than two decades these objects have been increasingly targeted for observations in photometry, spectroscopy, and radar ranging. These observations have provided valuable information about their physical characterization.

Scientifically, NEOs are essential to understand the formation and origin of the Solar System. They are the source of the meteorites, but assessing the link between them and NEO physical characteristics is not an easy task. The surface properties of NEOs are modified over time due to phenomena such as space weathering, and the meteorites examined on Earth have also undergone physical and chemical changes due to environmental weathering. In that sense, studying NEOs is essential to clarify these processes. Their full characterization (composition, size, density) is also of great importance in assessing defense strategies and damage previsions on the ground in the event of a potential impact. Lastly, NEOs are potential targets for in-situ resource utilization either for mining or life support for manned mission. They will be the subject of several spacecraft missions in the next decades (OSIRIS-REx, Hayabusa2, DART, DESTINY+)

The physical properties of NEOs seem to be size dependent. Whether or not these objects can be covered by regolith, or must be necessarily monolithic, is still an open question. Laboratory measurement have proven that grain size is an important parameter and could be responsible for variation in the slope or band depth [3, 2]. Compositional discrepancy is also observed between large NEOs (>1km) and meteorites [7, 10].

2. What is MANOS ?

The Mission Accessible Near-Earth Objects Survey (MANOS) started in August 2013 and is a multi-year survey supported by the National Optical Astronomy Observatory (NOAO) and Lowell Observatory, and funded by the NASA NEOO (Near-Earth Object Observations) office. The MANOS program consists of a physical characterization survey at visible and near-infrared wavelengths which is providing light-curves, astrometry, and reflectance spectra of sub-km, low delta-v (typically $<$7 km/s) NEOs. MANOS often targets newly discovered objects, which typically do not have a brighter apparition for the next several years or even decades. First MANOS results can be found in [8].

3. Data reduction

All spectroscopic data have been reduced using a new python based pipeline for long-slit spectroscopy reduction developed specifically for this project. This pipeline is intended to be easily portable to any visible spectrograph and is optimized for asteroid spectral reduction. The use of the same pipeline for all data obtained by this survey allows us to obtain a consistent data set of spectral properties of small NEOs. This

pipeline will be released as an open source package in the near future. An example of a reduced spectra can be see in Fig. 1

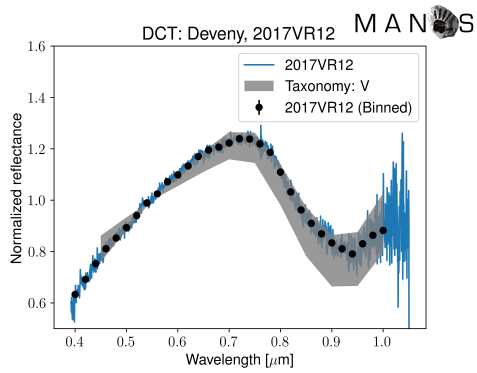

Figure 1: Example of spectrum obtained by the Deveny instrument from the 4.3m Discovery Channel Telescope (DCT).

4. Spectroscopic survey

We report here the first results of the visible spectroscopic survey of small NEOs. We have determined the taxonomic type of more than 300 asteroids with a mean size around 40 to 100 meters (H = 25) and as small as few meters (H=30). Fig. 2 shows the distribution of H magnitude of the NEOs observed by the MANOS project. This is the first comprehensive dataset of NEOs smaller than 100 meters with taxonomic type determined for each object. We will discuss the compositional properties of the NEO population (km and sub-km) [6, 9, 4], and how these populations compare to Main Belt asteroids [1, 5]. We will also compare the population of small NEOs with the meteorite population.

Acknowledgements

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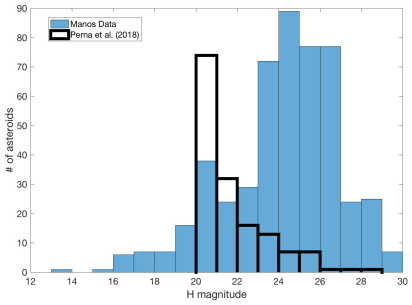

Figure 2: Distribution of H magnitude of the MANOS observed NEOs in spectroscopy compared to the data presented in Perna et al. (2018).

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