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Characterization of faint near-Earth asteroids using LBT

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1. Introduction

The Large Binocular Telescope (LBT)[1] offers unique capabilities for characterization of small near-Earth objects (NEOs) that are not available else where in the world. Rotational and spectral characterization of NEOs is critical for understanding their impact hazard potential. Of particular interest to planetary defense is our ability to spectrally characterize NEOs fainter than V. Mag 20 in the near infrared (0.7-2.5 microns). The NASA IRTF, which has been a workhorse for NEO characterization for more than two decades, is limited to objects brighter than V. Mag 19.5 in these wavelength ranges. With new large surveys coming online in the near future (LSST and NEOCam), the task of spectrally characterizing of small NEOs (V. Mag >20.0) including objects on impact trajectory on a short notice is becoming critical. In this abstract we present a proof of concept for physical characterization of a small NEO using the LBT. Our goal here is to demonstrate the vital role LBT plays in NEO characterization.

2. Background

2.1. (469219) 2016 HO3

(469219) 2016 HO3 is a small near-Earth object (NEO) that while orbiting the Sun, also appears to circle around the Earth just beyond the Hill sphere as a quasi-satellite (see figure 1). Due to their far greater numbers, small NEOs such as 469219 pose a more frequent impact hazard than large NEOs. To date only a handful of small NEOs have been fully characterized. Due to Earth's gravitational pull, 469219 never ventures more than 100 lunar distances from us making it a prime target for robotic and human exploration. Dynamical evidence also suggests that objects such as 469219 could be derived from unknown Earth trojan population. This population of objects can remain stable over the course of Solar System history. By constraining the surface composition of 469219 from the recently obtaibed NIR wavelength reflectance spectrum we hope to better understand the conditions under which it formed in the terrestrial planet region.

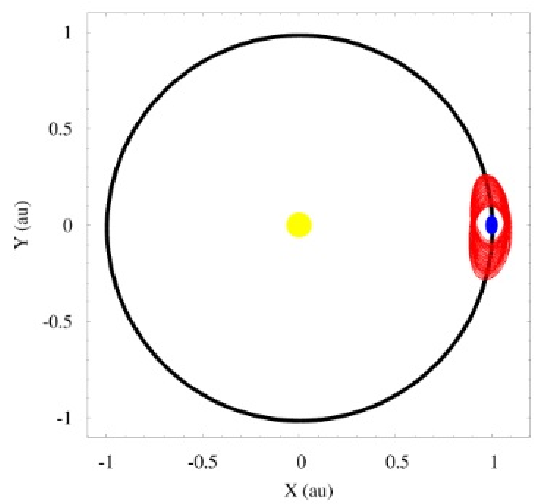

Figure 1: Near Earth Object 469219's orbit (red) around the Sun seen in the rotating reference frame of Earth's orbit. The object shares its orbit with that of our Earth (black).

2.2. Observability

While 469219 is close to the Earth, its small size of less than 100 meters makes it a challenging target to study. 469219 rotates once every 28 minutes and its reflectance spectra is likely that of common asteroids.[2] On the dates of our observation in April, as seen from Earth, 469219 moved at a differential rate of approx. 120 arcseconds per hour and varied by approx. 5 arcseconds per hour over the course of the night. The

[1] The LBT is an international collaboration among institutions in the United States, Italy and Germany. LBT Corporation partners are: The University of Arizona on behalf of the Arizona Board of Regents; Istituto Nazionale di Astrofisica, Italy; LBT Beteiligungsgesellschaft, Germany, representing the Max-Planck Society, The Leibniz Institute for Astrophysics Potsdam, and Heidelberg University; The Ohio State University, and The Research Corporation, on behalf of The University of Notre Dame, University of Minnesota and University of Virginia.

LBT TCS can take spectra of faint objects like 469219 moving at this rate, and varying substantially, thanks to improvements implemented in 2016 which allow for a continuous update of the ephemeris which in turn controls the guide star probe moving at the differential rate. Any object within approx. 5 arcminutes of a guide star brighter than 15th Vmag can be used, thus providing significant sky coverage for this type of observation.

3. Observations

3.1. Visible Spectra

Low-resolution ($R \sim 150 - 500$) spectra of 469219 were obtained on UT 2017 April 14 using the pair of Multiple Object Double Spectrographs (MODS) [3] which are mounted at the direct Gregorian foci of the Large Binocular Telescope (LBT), with MODS1 under the left primary and MODS2 under the right. Approximately two hours on source resulted in spectra from the atmospheric cut on of 3200Å to $\sim 1\mu m$. A characterization of 469219 based on these data was given at the 2017 DPS in Provo, Utah.[2]

4. Infrared Spectra

We observed 469219 with the LBT Utility Camera in the Infrared (LUCI) [1] on UT 08-April-2019 and UT 09-April-2019. Over these two nights we acquired 42 spectra of 300s each for a total of 4.2 hours on source. A preliminary look at these data, sampling raw spectra and binning 5 and 20 in the spatial and spectral dimensions, respectively, yields an SNR of approx. 3 to 5. As we used the G200 grating of LUCI, the unbinned spectral resolution of our data is ~ 750.[2] The object was at a Vmag of 22.2 on the nights of our observation. We will provide a more complete analysis and interpretation of these data at the conference.

Acknowledgements

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[2] We used the 1.5 arcsecond slit yielding one third the documented ~ 2250 resolution for the G200 grating with a 0.5 arcsecond slit.