Twinkle: a space-based observatory for visible and near-infrared spectroscopy

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1 Introduction

Twinkle is a space-based observatory that has been conceived to measure the atmospheric composition of exoplanets, study bright stars and brown dwarfs, and reveal the surface mineralogy of solar system objects. The satellite is based on a high-heritage platform and will carry a 0.45 m telescope with a visible and infrared spectrometer providing simultaneous wavelength coverage from 0.5 - 4.5 μm. The spacecraft will be launched into a low-Earth, Sun-synchronous polar orbit and will operate in this highly stable thermal environment for a baseline lifetime of seven years.

Twinkle will be capable of characterising the atmospheres of hundreds of exoplanets and its rapid pointing and tracking capabilities will also enable the observation of Solar System objects [1, 2]. Twinkle aims to facilitate a visible and near-infrared spectroscopic study of a population of asteroids and comets to uncover their composition as well as obtaining high-SNR spectra of the outer planets and their moons. Its wavelength coverage, and position above the atmosphere, will make it particularly well-suited for studying hydration features, that are obscured by telluric absorption for ground-based observations, as well as searching for other spectral signatures such as organics, silicates and CO_2 [3].

Twinkle is available for researchers around the globe in two ways: 1) joining its collaborative multi-year survey programme, which will observe hundreds of exoplanets and solar system objects; and 2) accessing dedicated telescope time on the spacecraft, which can be freely scheduled for any combination of science cases.

2 Observing 99942 Apophis with Twinkle

Two main factors must be considered when assessing the capability of Twinkle to observe Apophis: 1) the times at which the asteroid can be observed by the spacecraft and 2) the data quality that can be obtained during these potential observation periods.

Twinkle's field of regard, the area of sky in which the spacecraft can be pointed, is a 40° cone centred on the anti-Sun vector (i.e. the ecliptic plane). NASA's JPL Horizons service[1] was accessed to obtain the RA, Dec and visible magnitude of Apophis for the period around its closest approach. Firstly, the ephemerides of asteroid were compared to Twinkle's field of regard and then the rate of movement, in mas/s, was calculated. Twinkle is expected to achieve tracking rates superior to 100 mas/s, with the performance of the updated satellite design currently under study by industrial partners. Considering

[1] https://ssd.jpl.nasa.gov/horizons.cgi

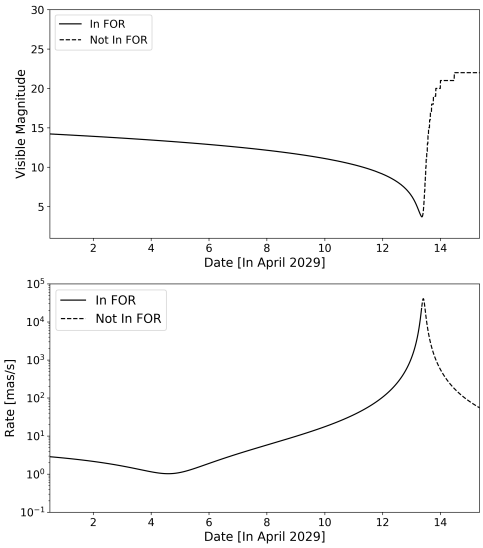

Figure 1: Visible magnitude (top) and rate of movement (bottom) of 99942 Apophis from 1st-15th April 2029.

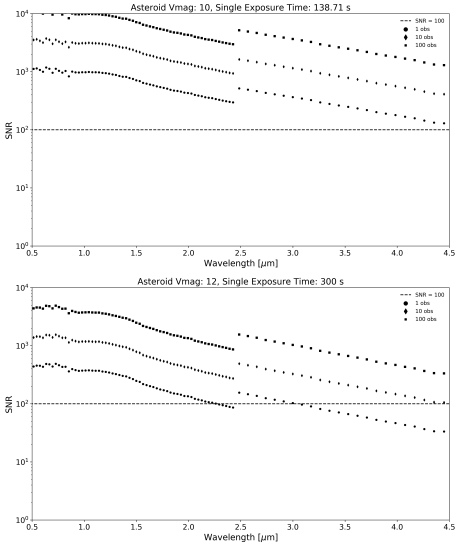

Figure 2: SNR achieved in each spectral band for observations of an asteroid with a visible magnitude of 10 (top) and 12 (bottom) with Twinkle over 1, 10 and 100 observations.

a limit of 100 mas/s would mean that Apophis could be tracked by Twinkle until around 12th April 2029, as shown by Figure 1.

By this time, the asteroid would have a visible magnitude of less than 10 and thus be easily bright enough to obtain high SNR spectra with short exposure times. Updated models from [3] were used to simulate the performance of Twinkle's instrumentation and Figure 2 shows that in just over two minutes, a spectrum at the native resolution of Twinkle (R∼20-70 for $\lambda < 2.42\,\mu m$, R∼30-50 for $\lambda > 2.42\,\mu m$) could be obtained with SNRs of 100-1000 on each data point. Three days earlier, Apophis will be moving at 10 mas/s and have a visible magnitude of approximately 12, allowing Twinkle to obtain a dataset with SNR > 100 for every band with 10 observations of 300s.

While Twinkle could potentially observe Apophis when it is far fainter than this, the 9th - 12th April will likely provide the prime observational period for characterisation.

References

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