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Solar System Science with the Twinkle Space Mission

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Abstract

Twinkle is a space-based telescope mission designed for the spectroscopic observation (0.4 to 4.5 µm) of exoplanet atmospheres and Solar System objects. The system design and mission implementation are based on existing, well studied concepts pioneered by Surrey Satellite Technology Ltd for low-Earth orbit Earth Observation satellites, supported by a novel international access model to allow facility access to researchers worldwide.

Whilst Twinkle's primary science goal is the observation of exoplanet atmospheres its wide spectroscopic range and photometric stability also make it a unique platform for the observation of Solar system objects.

1. Introduction

Twinkle is a medium (450 mm diameter) aperture space-based telescope that is designed for operation in low Earth orbit [1]. The main instrument is a spectrometer that covers the spectral range 0.4 to 4.5 µm with a variable spectral resolving power of *R*=70 -300, depending on spectral band. Twinkle's primary mission is the observation of exoplanet atmospheres via techniques such as transit and eclipse photometry and spectroscopy. However, as a point source observatory above the Earth's atmosphere it can also provide significant new data on Solar System objects, especially in regions of the spectrum dominated by telluric absorption.

2. Examples of Twinkle's contribution to the spectroscopy of asteroids.

The spectroscopic and photometric performance requirements for Twinkle are set by its primary, exoplanet science, mission [1]. These ensure that a highly stable platform is also available for observations of our Solar System. For measurements of small bodies such as main belt asteroids, Twinkle will provide information on regions of the near-IR spectrum that are inaccessible from Earth for all but the brightest targets (e.g. Figure 1).

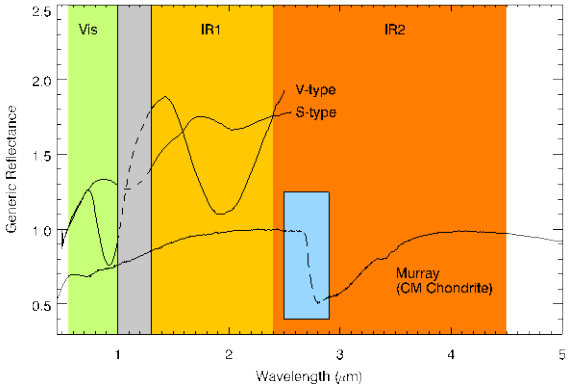

Figure 1. *Example spectra of a CM chondrite meteorite and two spectroscopic classes of asteroid in the visible/near-infrared.. The blue inset window represents the 3 µm region of the spectrum obscured by the Earth's atmosphere (spectrum from the RELAB database [2], composite figure courtesy S. Lindsay, Univ. Tennessee/Univ. Oxford).*

Spectral regions that are related to hydroxyl (OH) and water (ice and gas) should be fully resolved by Twinkle. Also of particular interest are absorption features at 0.7 and 3.0 µm that are often associated with primitive asteroids (e.g. [3], [4]). The 0.7 µm feature is readily observable by ground-based telescopes and *may* be diagnostic of aqueously altered mineral phases (e.g. phyllosicicates [3]), however without access to the other diagnostic bands its usefulness, as a compositional indicator is limited.

The 3 µm feature (e.g. Figure 1) can be made of a complex blend of several different features, including both bound water, hydroxyl (e.g. in phyllosilicate

minerals [4]) or water ice). The shape of this band can be highly diagnostic of the different of the type of water/hydroxyl present [5].

Twinkle will provide an opportunity to understand the relationship between the 0.7 and 3.0 µm feature and their importance in mapping aqueous alteration in primitive asteroids. This in turn has implications for mapping the distribution and transport of volatiles in the inner Solar System.

Twinkle's spectral range also captures spectral features in the 3.2 to 3.6 µm range that may be associated with organic material on the asteroid's surface (e.g. [4]). The shortwave edge of this region can be blended with the 3 µm feature, however techniques developed by [4] can be used to infer the presence of e.g. organic compounds of varying complexity. Currently the strongest detections for organics in this spectral range are for the asteroids 24 Themis and 65 Cybele [6], making the Themis family (~1600 asteroids around 3.2 AU) a survey priority.

3. Composition of Comet Comae

Comets are reservoirs for some of the most primitive material in the Solar system. Twinkle's spectral range and sensitivity can provide access to key volatile bands (e.g. water ice, CO_2, NH_3). The ability to resolve the CO_2 emission feature at ~4.3 µm, again obscured by the Earth's atmosphere for ground-based telescopes, will allow Twinkle to map the abundance of this volatile species for a large number of targets for the first time.

4. Summary and Conclusions

Twinkle is a cost-effective space mission taking advantage of lowered costs of access to space. The Twinkle satellite is being built in the UK and will be launched into a low-Earth sun-synchronous polar orbit in 2020, using flight proven spacecraft systems designed by Surrey Satellite Technology Ltd and high Technology Readiness Level science payload components.

Although primarily designed to be an exoplanet survey mission Twinkle's wide spectral range (0.4 to 4.5 µm), sensitivity and resolving power (R=70-300) also make it well suited for observing a wide range of Solar system objects. Access to key spectral features at e.g. 2.7 -3 µm make Twinkle especially well suited to surveying the larger objects in the asteroid belt. This is a particularly timely investigation with recently selected small bodies missions due for launch as part of NASA's "Discovery" program in the early to mid 2020s.

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