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TWINKLE – A BRITISH SPACE MISSION TO EXPLORE FARAWAY WORLDS

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On behalf of the Twinkle Payload Consortium

Twinkle is a space mission dedicated to the observation of the atmospheres of extrasolar planets (planets orbiting other stars) through the use of optical and infrared spectroscopy. The study of exoplanets has been incredibly successful over the past 20 years: nearly 2000 planets have been discovered in our galaxy, and along these discoveries fundamental parameters such as the planetary mass, size and distance to the parent star have been acquired.
In the past decade, pioneering results have been obtained using transit spectroscopy with the Hubble and Spitzer Space Telescopes and ground-based facilities, which have enabled the detection of a few of the most abundant chemical species, the presence of clouds, and have also permitted the study of the planetary thermal structure. The next step is Twinkle: a small dedicated satellite designed to understand these newly found worlds through the measurement of their atmospheric signatures. Twinkle will observe the chemical composition and weather of at least 100 exoplanets in the Milky Way, including super-Earths (rocky planets 1-10 times the mass of Earth), Neptunes, sub-Neptunes and gas giants like Jupiter.
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 by 2019, using flight proven spacecraft systems designed by Surrey Satellite Technology Ltd and high TRL instrumentation built by a consortium of UK institutes. The Twinkle instrument will be composed of a visible-IR spectrograph (between 0.5 and 5µm) with resolving power R~300. The funding for Twinkle will be provided through a combination of private and public sources.

I. SCIENCE AND TECHNICAL ASPECTS

Twinkle is a space mission built to observe the atmospheres of extrasolar planets through the use of optical and infrared spectroscopy [1].

Scientific rationale

Nearly 2000 exoplanets have been confirmed and several thousand planetary candidates have been detected. Statistical estimates indicate that most stars host planets [2]. Current and upcoming space missions, as well as ground-based surveys, will dramatically increase the planet count over the next 10 years. Many of the exoplanets found so far are very different from those in our solar system: from hot-Jupiters (giant planets that orbit very close to their star) to super-Earths (rocky planets up to ten times the mass of Earth). However, we know very little about these planets beyond their mass, size and distance to their star.

In the past decade, pioneering results have been obtained using transit spectroscopy with Hubble, Spitzer and ground-based facilities, which have enabled the detection of a few of the most abundant chemical species, the presence of clouds, and have also permitted the study of the planetary thermal structure. Despite these early successes, currently available data are still too sparse to allow a comprehensive and meaningful understanding of the physical and chemical properties of these planets. Most importantly, with the degraded performance of Spitzer, current data are restricted to wavelengths shorter than 1.7μm. The scientific community is faced with having to wait 5 to 10 years for the next generation of space and ground based facilities with IR capabilities to come online (JWST, E-ELT). Even then, the exoplanet community will still not have gained access to a specially designed instrument, and will have to share observation time with other science communities.

Twinkle is a small, dedicated satellite designed to understand these newly found worlds through the spectroscopic measurement of their atmospheres. The instrument is built by a consortium of UK institutes and the satellite is based on an existing platform by Surrey Satellite Technology Ltd. (SSTL). Twinkle will be launched into a low-Earth orbit by 2019.

Technical instrument

The Twinkle instrument is composed of an optical-IR spectrograph (0.5 - 5μm) with resolving power R~300. The payload is made of off-the-shelf components built by UK institutes and industries. The instrument design benefits from the expertise developed at UK institutions over a wide number of funded space missions (e.g. Planck, Herschel, JWST-MIRI, ISO [3,4,5,6]) as well as the phase-A study of the EChO mission concept [7].

The Twinkle satellite will orbit the Earth on a sun-synchronous polar orbit, at ~700km altitude. SSTL will build the spacecraft using the SSTL-300 platform developed for high-resolution Earth imaging (See Figure 1). The first generation SSTL-300 platform has delivered over four years of in-orbit operations and in turn builds upon SSTL's flight proven systems and operational architectures. The second generation SSTL-300 based constellation was launched in July 2015. Managing changes from this flight proven baseline includes benefits that extend beyond the flight-proven architecture and technologies, but also in being able to re-use much of the ground support equipment, test tools and existing ground segment and operations infrastructure. This enables maximum focus to be directed on supporting the payload accommodation and performance requirements to enable world-class science to be delivered on time and on budget.

Figure 1: A representation of the Twinkle satellite, based on an SSTL-300 platform.

Science goals

Twinkle's highly stable instrument will allow the spectroscopic observation of a wide range of planetary classes around different types of stars, with a focus on bright sources close to the ecliptic. The planets will be observed through transit and eclipse spectroscopy, as well as phase curves, eclipse mapping and multiple narrow-band time-series. The 100+ targets observed by Twinkle will be composed of known exoplanets mainly discovered by existing and upcoming ground surveys in our galaxy (e.g. WASP, NGTS and radial velocity surveys [8,9]) and will also feature new discoveries by space observatories (Cheops, TESS [10,11]). The wavelength range adopted covers all the expected key atmospheric gases, e.g. H_2O, CO_2, CH_4, NH_3, HCN, H_2S, including exotic metallic compounds, such as TiO, VO, SiO [12] and condensed species. It will also permit the simultaneous monitoring of the stellar variability and the presence and distribution of clouds and hazes in the exoplanet atmosphere. Monitoring the weather and thermal properties of these planets, through repeated measurements in the optical and infrared wavelength bands will be a key aspect of this mission. Figure 2 shows an example of the data quality that Twinkle is expected to provide.

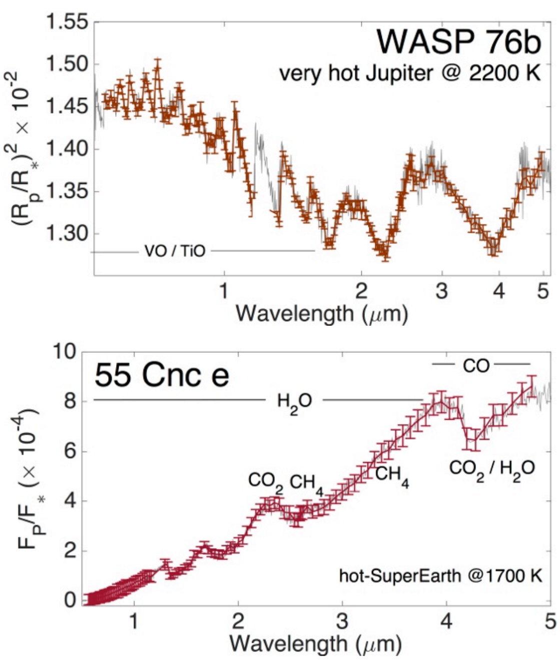

Figure 2: simulated spectra as observed by Twinkle. Top: hot Jupiter observed during the transit. Bottom: hot super-Earth observed during the eclipse.

II. PROGRAMMATIC ASPECTS

Payload consortium

Twinkle is led by University College London (UCL) and SSTL, and involves a consortium of UK research institutes and companies with a strong heritage in infrared (IR) instrumentation (JWST-MIRI, Herschel, Planck, ISO). The consortium includes: Cardiff University, Mullard Space Science Laboratory, Open University, Selex ES, Rutherford Appleton Laboratory (RAL Space), UCL, UK Astronomy Technology Centre (UKATC).

Project status

Twinkle is on track for a launch by 2019. The payload study is currently underway and will be completed by the end of December 2015. Preliminary work and the on-going payload study are funded through a grant from the European Research Council and UK universities. Funding for the overall mission will come from a combination of public and private sources.

We are open to explore international interest in this project. Please contact Dr Marcell Tessenyi for further discussion.

III. REFERENCES

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