CHEOPS GTO program

GTO v1.4

Executive Summary

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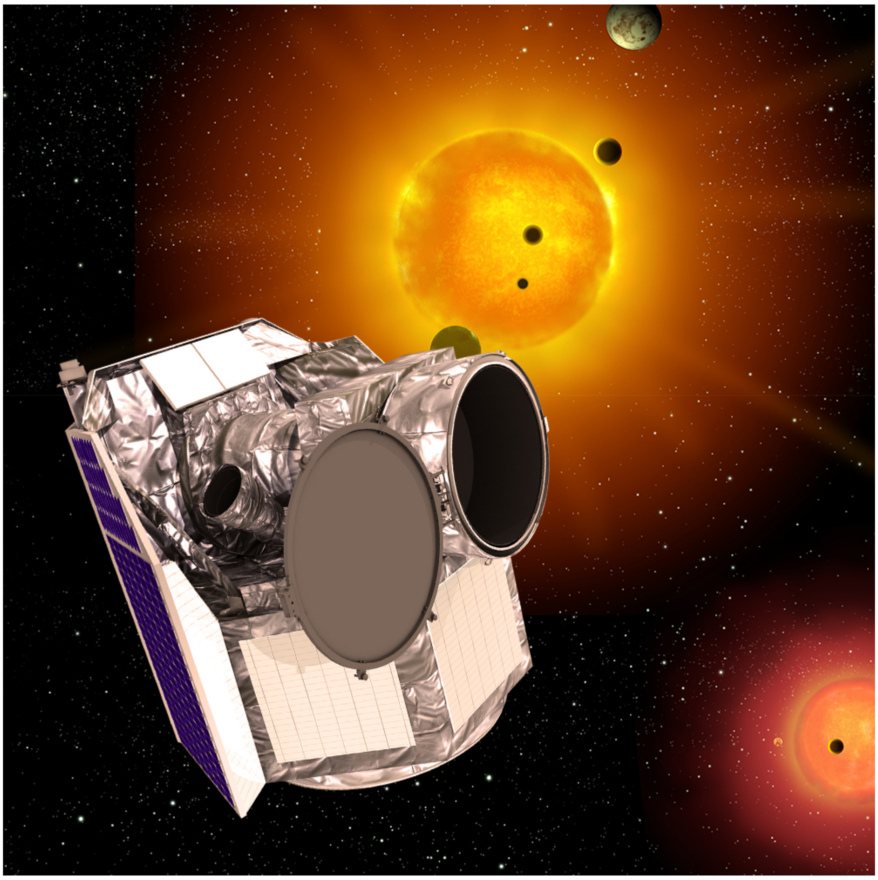

CHEOPS is a satellite designed to conduct follow-up observations programs on known target of interest. The Guaranteed Time Observation (GTO) of the CHEOPS consortium reflects this situation and is made of a series of specific programs. In essence, together, this ensemble aims at providing us with a comprehensive scientific program on exoplanet science to make progress in our understanding planets structure. It shall improve universal model for planetary systems and further explore diversity in planetary systems with the prospect to make progress in planet formation evolution and understanding life in the Universe.

The GTO program detailed in this summary has been assembled by CHEOPS Science Team and CHEOPS board members. It was initiated in 2016 by a call for ideas ("white call") followed by rounds of ranking, critical reviews and updates.

The science GTO program is technically structured in different science topics with the goal to provide us with an easy reading and tracking of the whole science program. Each science topic are called *theme* and is made of a series of specific *programs*. Each programmes has it own scientific objective but may share targets with other programs. A short description of each of them is listed below:

Transit.Find: It aims at searching for transits of known planets discovered by other techniques, in particular radial velocity. Monitoring these systems with CHEOPS around the predicted transit times of their planets offers a straightforward way of obtaining both mass and radius for a sample of super-Earths and Neptunes orbiting bright stars.

MR.improve: It aims at improving the determination of the mass-radius relationship for exoplanets in the low-mass range (below Saturn mass), and to relate it to planet formation and evolution models.

Atmo.Characterize: It aims at measuring phase curve and secondary eclipses of transiting planets to gather information about their atmospheres.

Feature.Characterize: It aims at the study of "transit detailed features" on known transiting planets with the goal of gathering information about their structure: love number or tidal factors, exo-moons and rings.

Explore: Planetary systems transiting bright nearby stars are cornerstone objects for exoplanetary science, as they are ideal targets for extensive follow-up studies. Programmes in this theme aim at discovering and characterizing new planetary systems either by direct transit detection, or indirectly by detecting TTV in systems known to host transiting planets. This theme include as well program searching for dust clumps in edge-on debris disks and transiting "exo-Trojans".

Ancillary Science: This theme includes a set of programs related to planetary or stellar science relevant to the analysis and interpretation of data on exoplanets.

Transit.Find (∼15% of GTO orbit request)

This science theme is at the heart of the original CHEOPS proposal: to study low-mass exoplanets orbiting nearby, bright stars, for which a wealth of information can be obtained with various instruments. The sample of RV-detected exoplanets is the starting point of this endeavour. Monitoring these known systems with CHEOPS around the predicted transit times of their planets offers a straightforward way of obtaining both mass and radius for a sample of nearby super-Earths and Neptune. Originally it was seen as the only path forward to find the nearest transiting planets, including rocky bodies within the habitable zone of their host star. As of today the scientific context has evolved, particularly with the TESS mission in operation. This change of landscape has been considered and in particular how to best build up on the expected dozens of transiting systems TESS will find around nearby bright stars. Considering the fast changing landscape, Transit.Find theme has optimized its target list and will adjust according to TESS results.

MR.improve (∼25% of GTO orbit request)

The mass-radius relation is the first step towards the characterisation of planetary bulk properties. The knowledge of the planetary composition, in turn, is a key element to constrain planet formation, as it can be used to demonstrate, for example, transport of material in the proto-planetary disk. In this context, the structure of low mass planets is the most relevant.

The goal of MR.improve is to determine the mass-radius relation of planets, focussing on objects of small radius (and/or low mass if this one is already known), rare objects, and planets in multi-planetary systems. The theme addresses as well planets in multiple systems or rare objects of special interest (extreme to the density, unusual radius,...) This category bares similarities with TESS program but open prospects of fantastic opportunity of synergies and follow-up when further observations with exquisite precision may be needed to better constrain planet structure.

Atmo.Characterize (∼20% of GTO orbit request)

Much of the observational effort in atmospheric characterization is focused on infrared observations. Key to this interpretation effort is the need to overcome degeneracies associated with the presence of aerosols and clouds in the atmosphere. A more realistic route towards breaking these degeneracies is to empirically determine the properties of the aerosols and clouds, including their reflectivity (on a global scale), sizes and compositions. This may be accomplished by measuring the geometric albedos and visible/optical phase curves of exoplanetary atmospheres, a scientific goal that CHEOPS is in a unique position to exploit, because of its ability to perform targeted, high-precision photometry. 55 Cnc for example is the second brightest star known to host a transiting super-earth exoplanet with an unknown source of variability likely associated with the exoplanet itself. Exoplanets with extended envelopes believed to contain refractory species detected using Kepler and K2 would be interesting targets as well. On practical aspects, the program is targeting intensively few high priority targets and studying more global properties exo-planetary atmospheres on a representative sample of transit planets.

Feature.Characterize (~5% of GTO orbit request)

Planets close to their host star have an ellipsoidal shape due to the tidal effects of its star. Potentially this effect is detectable in the transit light curve with the prospect to measure the planet Love number and an insight in planet structure. The main challenge of this program is to identify this effect from the limb darkening. Another potential visible dynamical effect is tidal dissipation resulting in a secular shrinking of the orbit. Measuring orbiting changes would allow us to obtain a direct measure of the quality factor Q of a star. Unexpected features (asymmetry, bumps, etc.) observed in transit light curve could also lead to detections of moons and rings.

Explore (~15% of GTO orbit request)

This theme includes a comprehensive set of program related to planet detection. By priority order, they aim at (1) detecting new planetary systems around bright stars, focusing on both multi-planet systems and systems hosting hot Jupiters; (2) enlarging the parameter space of both planets and host stars, with particular emphasis on hot stars; (3) exploring the architecture of systems hosting small planets in relatively long-period orbits via transit timing variation (TTV); (4) discerning planet migration scenarios using TTV; (5) studying in details dust clumps in edge-on debris disks around young stars; (6) searching for exo-Trojans.

Ancillary Science (~20% of GTO orbit request)

Programs useful to the analysis of exoplanets data and to the interpretation of properties of exoplanetary systems have been grouped together under the theme "Ancillary Science". It includes stellar physics programs (study of stellar micro-variability, the derivation of precise limb darkening laws as function of stellar temperature) affecting the measurement of exoplanet parameters, as well as programmes to address very specific questions in planetology, such as the frequency of planets around evolved stars, or the detection of rings, jets, dense comas and even atmospheres around Centaurs/TNOs in the Solar System.