Co-phasing of a deployable CubeSat for Earth and Space observation

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Subject's title: Co-phasing of a deployable Cube-Sat for Earth and Space Observation

Subject description:

Space offers unique imaging capabilities, for Earth observation (civil as defense applications) as well as space observation. In both cases, the high angular resolution is a crucial point, ensured by the diameter of the telescope. The future projects of space imagers with high angular resolution are mainly composed of segmented telescopes of large diameter but also of small sizes. In order to reach the large diameters, the future space missions dedicated to space observation call for segmented telescopes (James Webb Space Telescope, 6.50m diameter in 17 segments) and LUVOIR (Large UV Optical IR Surveyor, 11.70m diameter in 36 segments). These telescopes will be launched folded inside the rocket head, and will aim at angular resolution between 50 and 100 milli-arcsecconds in near Infra-red in order to image rocky exoplanet.

Earth observation will benefit from a constellation of Cube-Sat allowing to follow at high sample the clouds and cyclons evolution (project CYGNSS, Cyclone Global Navigation Satellite System). The interest for Cube-Sat is also growing for the solar system science. NASA has selected 10 studies in the frame of program "Small satellites for planetary and deep space program PSDS3", in order to investigate the rocky and outter planets of the solar system, moon and asteroids, small frozen bodies.

The common link between these applications is the phasing of the segmented pupils in space, at the deployment of the satellite but also during its operation. This thematics already exists for ground equipement (giant telescopes of Keck, GranTeCan). In space, if classics techniques already exist for the first generation of segemented telescopes (JWST), more efficient approaches recently developed have to be validated in order to demonstrate their precision in a space environment.

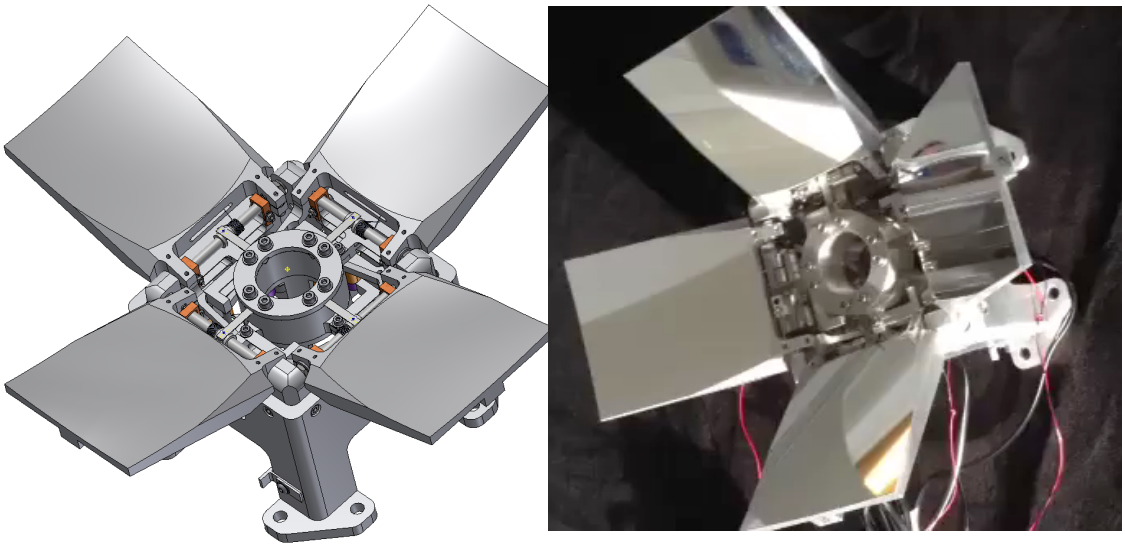
A cube-sat mission represents the perfect environment for the validation of all parts of co-phasing. The constraints of the space environment are multiple:

- Image quality depends of static and dynamic aberrations of the whole system. These aberrations degrade the ground resolution and optical solutions have to be found.
- In a cube-sat more than any satellites, the reduced space available lead to fast optical designs very sensitive to alignment errors. Innovative designs based on free-form mirrors of curved detectors might be a solution to this problem.
- The reduced space calls to re-visit the actuators themselves.
- The vibrations of the structure of the telescope and of the segments during operation is a key limitation to the high performance required by high angular resolution and even more for high contrast imaging

In order to deal with this very demanding environmental conditions, a dedicated wave-front sensing strategy has to be developed in order to guarantee the correct phasing of the segments. The usual wave-front sensing techniques might have to be adapted to the particular aperture shape and to the precision to reach. Moreover, the wave-front sensing is linked to the acquisition of the data (TDI or snapshot, or micro-pointing stage) and to the quality of the detector. In space environment, this is a major limitation on faint SNR objects. The student will benefit from recent studies demonstrating the relevance of focal plane WFS, or Shack-Hartmann for static aberrations (RASCASSE project, CNES / LAM / THALES / ONERA and Clément Escolle PhD). Lastly, the control of the segments has to be developed and should account for the existing technologies for actuators. Concepts have been demonstrated in lab on this topic (Marie Lalandes PhD, projet MADRAS LAM / CNES / THALES).

This PhD is performed in partnership with UK-ATC (Astronomy Technological Center in Edinburgh) and with LAM (Laboratoire d'Astrophysique de Marseille). The student will spend time in both these institutes.

A deployable Cube-Sat named HighRes is currently under development at ATC. In 2018 a laboratory demonstration of deployment of the Cube-Sat is foreseen in a static environment, allowing to begin the PhD with this unique experimental capability.



HighRes CubeSat in development at ATC, in CAO and real system.

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