

Space Telescopes based on Satellite Tandem Flights

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Abstract

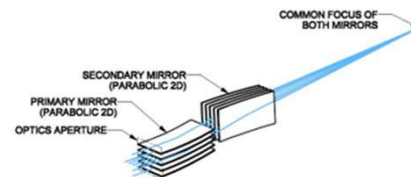
Due to the recent progress in satellite control engineering, tandem flight arrangements of mini-satellites are currently in discussion and under consideration for future space missions. CubeSat technologies offer an interesting possibility for space-born telescope payloads based on this approach. In such a scenario, two small satellites will fly at a constant distance of a few meters up to 100 meters. Thereby, the front satellite will carry the telescope optics and the second satellite the detector system. Related formation flight requirements were addressed in the NetSat-Mission, composed of four 3U-CubeSats, launched 2020. Space technology challenges concern in particular orbit control by an appropriate propulsion system as well as precision attitude pointing towards the joint target, and could be transferred from the NetSat-mission to the proposed Tandem Mission. This will allow space-based telescopes with a long focal length even placed on board of small or miniature CubeSat-type satellites. Cost effective Kirkpatrick-Baez type X-ray telescopes represent an important application here as they have longer focal lengths compared to previous astronomical observatories using Wolter I type X-ray mirrors.

Formation Flying

- Satellite formations
 - satellites using relative navigation, attitude and orbit information
 - networked control via inter-satellite links
 - self-organization in orbit for optimum observation
 - synchronized so that they overlap well in coverage
- Satellite trailing formations
 - multiple satellites orbiting on the same orbit
- Tandem spacecraft
 - large apertures, virtual antennae or occlusion
 - science missions/observation
 - precise relative positioning required
 - small relative distance ($10^2 - 10^3$ m)

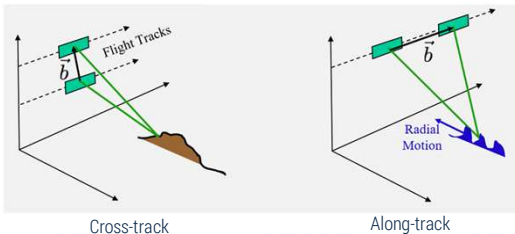
Kirkpatrick-Baez X-ray Optics

- KB optics require long focal distances, which can be accommodated by two formation flying CubeSats.
- One CubeSat carries the Kirkpatrick-Baez module and the other has a suitable detector.
- The CubeSats are expected to be separated by a distance of 1-10 meters in this application.



SAR Interferometry

- Synthetic aperture radar interferometry
- The satellites measure differences in the phase of the waves returning to the spacecraft
- One of the few tandem flight systems with formation flight heritage in orbit



Enabling Technologies

- Propulsion & Micro-Propulsion
 - Chemical propulsion: short lifetime
 - Electrical propulsion: promising candidate
- Navigation
 - GNSS based systems: limited to position in Earth orbit
 - Star sensors: precision attitude determination
- Relative Position and Attitude Determination
 - RF, laser, time-of-flight cameras or visual based systems (in research status)
- Deep Space Communication: in beginning

Conclusions

- Formation flying allows significant baseline distances for virtual distributed observation systems.
- Supporting technologies related to autonomy, navigation, attitude and orbit control become available at nano-satellite level.
- Data preprocessing and reduction supports downlink of payload information at limited communication bandwidth.
- CubeSats offer cost efficient implementation approach due to standardized interfaces.

NetSat (Networked Pico-Satellite Distributed System Control)

NetSat's objective was technology demonstration for formation control at the level of nano-satellites; since 2020 it is in orbit. Current application missions in telecommunication, Earth and space weather observations are in implementation stage.

