A 170 mm hollow corner cube retro-reflector on Chang'e 4 lunar relay satellite

Qi Liu [1], Yun He [1], Hui-Zong Duan[2], Hsien-Chi Yeh [2]

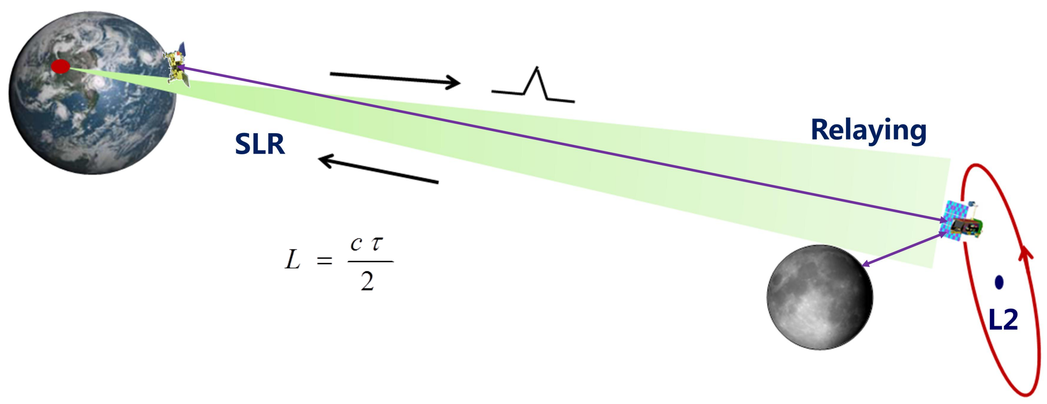
[1]Huazhong University of Science and Technology, Wuhan, P. R. China.

[2]Sun Yat-Sen University, Zhuhai, P. R. China.

I. Introduction

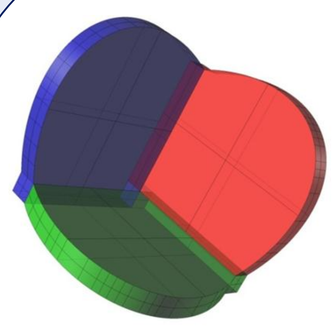
We are developing a single 170mm aperture and hollow corner cube retro-reflector (CCR) that will be carried by the Chang'e 4 lunar relay satellite (June 2018) to verify the performance of next generation of LLR. This satellite will operate round the second Lagrange point (L2) of earth-moon system with Halo orbit of radius 12,000 km. The averaging distance is 450,000 km from the earth. The CCR is formed by three pieces of ULE glass using the Hydroxide Catalysis Bonding technique. Each dihedral angles aim for ≤ 0.6 arc second to ensure the approximately equivalent reflecting property as the Apollo 15 CCR array on the moon. To simulate the experience of space environment, the CCR will be tested by a series of experiments, such as acceleration, vibration, impact, thermal vacuum, ultraviolet radiation and charged particle radiation experiments.

II. Chang'e 4 relay satellite



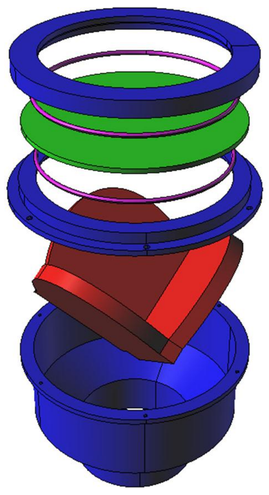
- Communication Relaying
- Halo orbit round L2 point with ~12,000 km radius
- Satellite laser ranging distance: ~450,000 km
- Launch time: June 2018

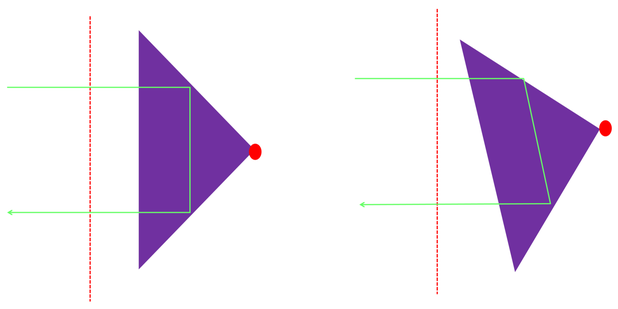
III. CCR design



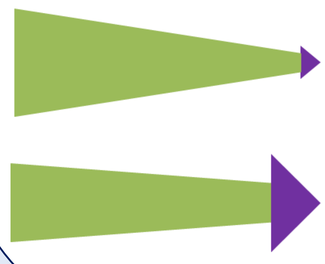
The CCR has a single 170mm aperture with hollow design, which shows four remarkable advantages.

- **Small weight**: <1.6 kg (less than 1/2 of the solid one with same aperture).
- **Less temperature influence**: The light is reflected from the front surface by reflecting coating rather than refracted inside the CCR medium.





- **The single reflecting center**: Eliminate a systemic error of laser ranging caused by CCR array, hence can be used for the next generation of LLR.
- **Small divergence angle**: A concentrated far-field diffraction pattern (FFDP) because of the relative larger aperture and higher dihedral angle precision.



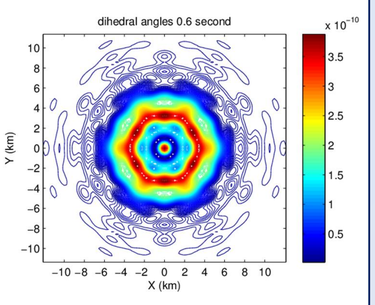
IV. CCR technique requirement

The CCR presents the approximately equivalent reflecting property as the Apollo 15 CCR array on the moon.

Reflecting property: $\frac{I_{Apollo15}}{I_{170mm}} = \frac{300}{1} \cdot (\frac{3.8}{17})^2 \cdot (\frac{3.8}{17})^2 \cdot \frac{0.9}{0.6} = 1.12$

(area; Reflectance; CCR number; divergence angle)

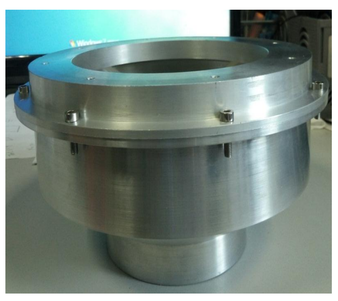
	Item	Parameter
CCR	Aperture	Φ170 mm
	Weight	≤ 1.6 kg
	Dihedral angle precision	< 0.6 arc second
	Divergence angle	≤ 2 arc second
	Material	Corning ULE 7972
Spacecraft payload	Weight	≤ 3.5 kg
	Reflectance	> 0.6
	Life time	5 years



FFDP of 0.6 arc second Dihedral angle

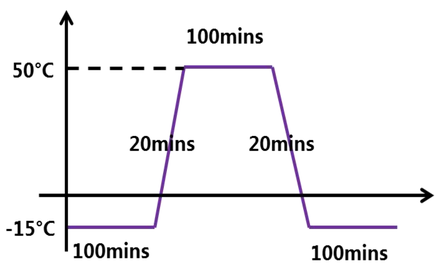
V. Experiment and result

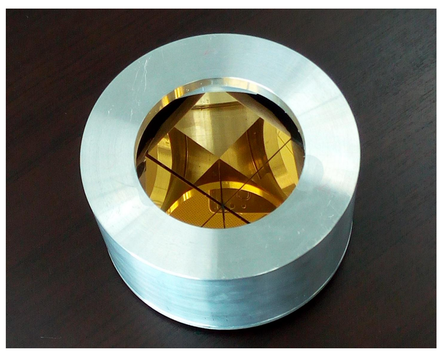
To manufacture the hollow CCR, we use the Hydroxide Catalysis Bonding technique to bond three polished ULE glass together. To simulate the experience of space environment, the CCR will be tested by a series of experiments, such as acceleration, vibration, impact, thermal vacuum, ultraviolet radiation and charged particle radiation experiments. The most challenging parameter is the dihedral angle precision of < 0.6 arc second, which currently just reaches the level of ~2 arc second.



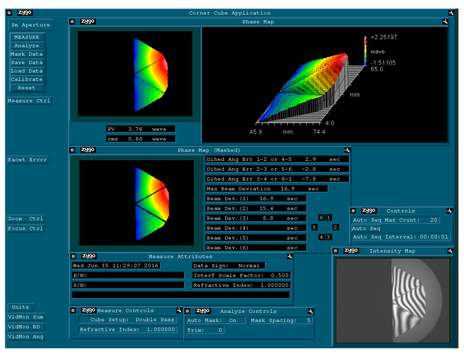
Spacecraft payload

Temperature circulation experiment





Prototype of CCR



ZYGO measurement

Contact information: Qi Liu (louis_liuqi@hust.edu.cn) Yun He(heyun2008@yeah.net) Hui-Zong Duan(duanhuizong2014@sina.com) Hsien-Chi Yeh (yexianji@mail.sysu.edu.cn)