Development of hollow corner cube retroreflector for the future lunar and deep space satellite laser ranging

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Over the past 50 years, lunar laser ranging has made great contributions to the study of the Earth-Moon system and the tests of General Relativity. However, because of lunar libration, the Apollo and Lunokhod corner-cube retroreflector arrays placed on the moon currently limit the ranging precision to a few centimeters for a single photon received. Therefore, it is necessary to deploy a new retroreflector with a single and large aperture to improve the ranging precision by at least one order of magnitude. In the past two years, we have manufactured several hollow retroreflectors with 170-mm aperture using hydroxide-catalysis bonding technology. The precisions of two dihedral angles are achieved by the mirror processing with a sub-arc-second precision perpendicularity and the rest one is adjusted utilizing an auxiliary optical configuration including two autocollimators. The best achieved precisions of three dihedral angles are 0.1, 0.4 and 0.3 arc-second, indicating the 82.8% return signal intensity of ideal Apollo 11/14 based on the far field diffraction pattern simulation. This hollow retroreflector has been tested with series of experiments including acceleration, vibration, impact, solar radiation and vacuum thermal cycling test. To verify the performance, it has been launched along with the Change 4 lunar relay satellite called “Queqiao” (about 450,000 km from the Earth) on May 21, 2018. The first stage of laser ranging experiment will be carried out after March, 2019.