Developing RSR for Chinese Astronomical Antenna and Deep Space Exploration

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***Abstract*-Following the fast development of Chinese lunar and deep space exploration science 2004, VLBI OD technique and planetary radio science experiments have been involved in the Chinese lunar exploration missions and other deep space missions. In order catch up with above progress and to satisfy the requirements from both of S/C VLBI OD tracking and multi-bands lunar and planetary radio science experiments, we have been developing a software radio defined Radio Science Receiver (RSR) system. The first version of RSR can be used as 4-channel astronomical VLBI receiver with maximum bandwidth of 16 MHz for each channel. It can also work at differential one way range and Doppler model with minimum bandwidth of 50 KHz for each Channel of 8 bits digital resolution. To enhance the application of RSR, real-time Doppler counting mode was developed for signal site observation. Under the Doppler model, it can track 4 separated carrier wave sent from spacecraft(s) simultaneously, with frequency or phase resolution as high as 1/100 circle, when tracking the ESA MEX Martian orbiter and VEX Venus orbiter. In laboratory test, the resolution is about 1 order better at X-band. Additionally, the RSR can work as planetary radio science experiment mode, which will record and retrieve the spacecraft carrier wave signal variation of frequency, phase, amplitude and polarization. The radio science experiment makes a virtue out of a necessity by using the radio propagation techniques that convey data and instructions between the spacecraft and Earth to investigate the planet's atmosphere, ionosphere, rings, and magnetic fields, surface, gravity field, GM and interior, as well as testing the theories of relativity. The experiments have been conducted by most planetary missions and are planned for many future ones. This is almost like getting science for free some way, and has been used also in Chinese lunar orbiting missions to carry out POD and estimate the lunar gravity field successfully.**

4 RSRs had been developed for a joint Chinese-Russian Martian mission in order to carry out the orbiter determination of Yinghuo-1 Martian mission. They were installed and connected to the IF and H-Maser system of Chinese VLBI stations. A series of radio occultation experiments have been carried out. In the techniques, radio frequency transmission from MEX and VEX spacecraft, occulted by center planets, and received on Earth probe the extended atmosphere of the planets. The radio link is perturbed in phase and amplitude, the perturbation is converted into an appropriate refractivity profile, from which, information is derived about the electron distribution in the ionosphere, temperature-pressure profile in the neutral atmosphere, or particle size distribution of the ring material surrounding the center planet, in the case of a ring occultation. In Chang'e-3/4 and Luna-Glob landing missions, the two radio downlinks, S/X-bands or X/Ka-bands, will be used for different types of investigation about the physical mechanisms that brought the changes about. We will use the signal to measure the lunar physical liberations, so as to improve the lunar interior studies together with LLR data. Above method may be used in Chinese Martian mission.

Recently, research group are updating a new version of RSR, which can recode a Maximum VLBI bandwidth of 4 GHz of totally 4 Channels . The new systems will be installed at antennas of Chinese VLBI Network and at other Chinese astronomical large antennas in the future as standard instrument of lunar and planetary radio science experiments, and to support the VLBI experiments.