URSI AP-RASC, Sydney, Australia, 17 – 22 August 2025

Advances in the Chinese VLBI Network

Weimin Zheng * (1), Juan Zhang (1)
(1) Shanghai Astronomical Observatory, CAS, Shanghai China, 20030, e-mail: zhwm@shao.ac.cn

Abstract

This paper presents the new progress of the Chinese Very Long Baseline Interferometry Network (CVN). CVN currently consists of six ground based radio telescopes and a data processing center at the Shanghai Astronomical Observatory. Two newly commissioned 40-meter telescopes in Shigatse, Tibet and Changbai Mountain, Jilin, along with a 4.2-meter space VLBI telescope on the Queqiao-2 lunar relay satellite added in 2024, have expanded the network. These new telescopes, with S/X dual-frequency receiving systems and designed to operate from 700 MHz to 50 GHz (up to W-band), are equipped with thermal insulation and advanced technologies to ensure performance in extreme environments. The upgrade from a "4-station 1-center" to a "6-station 1-center" configuration extends the longest baseline from 3200 km to 3800 km, enhancing capabilities in various astronomy and deep space studies. The six-telescope setup enables the construction of two 3-station subnetworks for simultaneous observations, supporting space VLBI observation and deep-space probe orbit determination. CVN is evolving towards an integrated space-ground network, with Queqiao-2 becoming its first space VLBI unit. Currently, CVN has obtained VLBI fringes of radio source blazar AO0235+164 and the Chang'e-6 telemetry signal on the lunar - ground baseline. In the future, with the addition of more large-scale ground-based and space VLBI telescopes, CVN's sensitivity and resolution will be further improved, providing powerful tools for studying black holes, life origin, and transient source mechanisms. .

1. Introduction

The Chinese VLBI Network (CVN) plays a vital role in China's deep space exploration endeavors and also join some astronomical observations. In recent years, with the continuous advancement of astronomy and deep space science, there is an increasing demand for more precise and comprehensive observational capabilities. The development of CVN is crucial for meeting these requirements. This paper aims to provide a overview of the new progress of CVN, including its infrastructure expansion, technological improvements, and new scientific capabilities.

2. New 40-Meter Telescopes

The Chinese VLBI Network (CVN) consists of six ground-based radio telescopes and a VLBI data processing center located at the Shanghai Astronomical Observatory. The network includes the Shanghai Tianma 65-meter Telescope, the Shanghai Sheshan 25-meter Telescope, the Urumqi Nanshan 26-meter Radio Telescope, the Kunming 40-meter Radio Telescope, and two newly commissioned 40-meter telescopes: the Tibet Shigatse 40-meter Telescope and the Jilin Changbai Mountain 40-meter Telescope.

In September 2023, the construction of the Shigatse and Changbai Mountain 40-meter radio telescopes commenced. By December 2024, the first-phase construction was completed, and trial observations began. These two high-precision, fully steerable alt-azimuth telescopes are equipped with an S/X dual-frequency receiving system, covering an observational frequency range from 700 MHz to 50 GHz, with potential operation up to the W-band.

The Shigatse telescope, located at an altitude of 4100 meters, and the Changbai Mountain telescope, enduring extreme temperatures as low as -41° C, are designed with advanced thermal insulation, conformal antenna structures, and active subreflectors to maintain surface-shape accuracy. Initial performance tests indicate that both telescopes exceed their design specifications. On December 19, 2024, the first fringes of the radio source 3C84 on the " Changbai Mountain (Cb) – Shigatse (Zf) "

Figure 1. Shigatse (Zf) 40m-antenna (left), Changbai

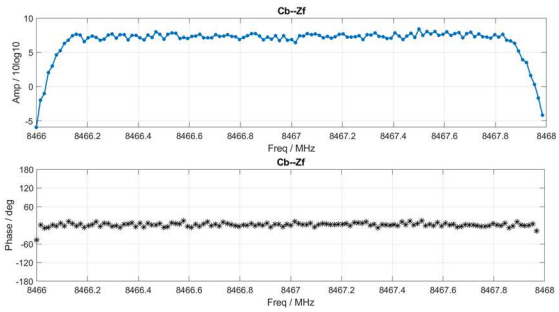

Figure 2. First fringe of the radio source 3C84 on the " Cb – Zf" baseline.

baseline were obtained. Ongoing activities include VLBI station coordinate measurements and further system performance evaluations.

3. Network Expansion and Scientific Capabilities

The addition of the two new stations has upgraded CVN from a "4-station 1-center" configuration to a "6-station 1-center" network, extending its longest baseline from 3200 km to 3800 km. With further receiver system enhancements, CVN is poised to improve research in supermassive black holes, transient astronomical phenomena, Milky Way dynamics, and high-precision spatiotemporal reference frameworks.

With its six radio telescopes, CVN can form two independent three-station subnetworks, allowing for simultaneous observation of two radio sources. This configuration supports space VLBI observations and deep-space probe orbit determination. One subnetwork can focus on space VLBI telescope orbit determination while the other collaborates with a space VLBI telescope for astronomical observations. Additionally, both subnetworks can independently track separate deep-space probes when needed.

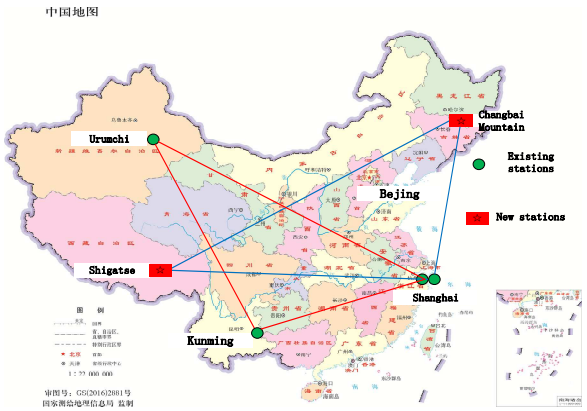

Figure 3. Two subnets configuration of CVN.

4. Space VLBI and Queqiao-2 Lunar Relay Satellite

In March 2024, China launched the Queqiao-2 lunar orbit relay satellite, equipped with a 4.2-meter parabolic antenna, an X-band cryogenic receiver, a lightweight hydrogen , and a VLBI terminal. This satellite marks China's first space VLBI capability and the first space VLBI telescope operating in lunar orbit.

CVN has played a key role in the precise orbit determination of Queqiao-2 and has conducted the Lunar Orbit VLBI Experiment (LOVEX). The collaboration between CVN's ground-based telescopes and Queqiao-2 has achieved a maximum lunar-ground baseline of 400,000 km and an observational bandwidth of 512 MHz. Initial observations have successfully detected VLBI fringes of blazar AO0235+164 and the Chang'e-6 telemetry signals. Future experiments will explore jet base size and brightness temperature, general relativity tests, and deep-space navigation.

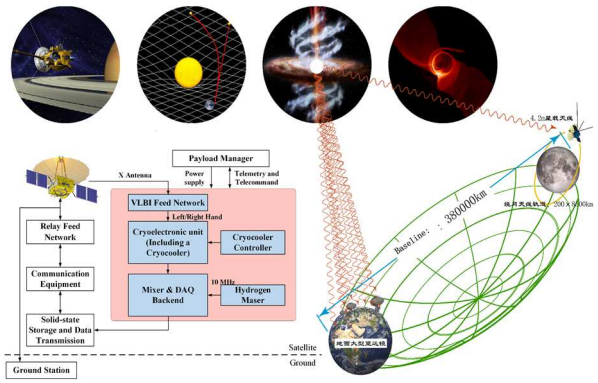

Figure 4. Lunar Orbit VLBI Experimental (LOVEX) system.

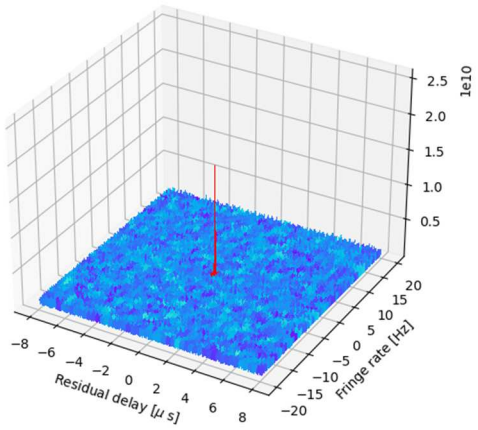

Figure 5. Lx-Tm fringe fitting result for blazar AO0235+164. Time: 2024-10-18T13:30:00 UTC. Frequency range: 8428-8460 MHz. Accumulation time: 300 seconds. Lx and Tm refers to the onboard 4.2-meter antenna and Tinanma 65, respectively.

5. Future Prospects

CVN aims to evolve into a fully integrated space-ground VLBI system. The planned inclusion of larger radio telescopes, such as the 110-meter telescope in Qitai, Urumqi, and the 120-meter telescope in Jingdong, Yunnan, will further enhance its sensitivity. Additionally, the introduction of new space VLBI telescopes will enable

CVN to leverage its high-resolution imaging and precise celestial positioning capabilities for cutting-edge research on compact objects, the origin of life, and transient astronomical sources.

6. Conclusion

The recent advancements in CVN, including new ground-based telescopes and space VLBI capabilities, have enhanced China's radio astronomy infrastructure. Future developments will further strengthen CVN's role in high-resolution imaging, deep-space navigation, and astrophysical research.

7. Acknowledgements

We would like to express our sincere gratitude to all the teams involved in the construction, operation, and research of the Chinese VLBI Network. Their hard work, expertise, and dedication have been essential for the achievements described in this paper.