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Recent progress in Korean VLBI Network (KVN) project

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Korea's new VLBI project to construct the Korean VLBI Network (KVN) began in 2001 as a 7-year project that is fully funded by Korean government. We plan to build three new high-precision radio telescopes of 21-m diameter at three sites in Korea. We will install the 2/8, 22 and 43-GHz HEMT receivers by 2008, and later we will expand the receiving frequency range up to 129 GHz for astronomical, geodetic, and space research. As for the front-end system, we are going to install multi-channel receivers with low-pass filters within a quasi-optical beam transportation plate. With this system, multi-frequency phase referencing for millimetre-wave VLBI as well as simultaneous multi-frequency observations will be carried out. Mark 5B will be used as the recording system. We have completed the design of the KVN data acquisition system of 2 Gsps sampling rate, which will use 4 data streams to meet the multi-channel requirement.

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1. Introduction

The first radio astronomical project of Korea Astronomy & Space Science Institute (KASI) was the construction of the 14-m millimetre-wave radio telescope at Daejeon, Korea, which was completed about 15 years ago. With the completion of the radome-enclosed radio telescope, the Taeduk Radio Astronomy Observatory (TRAO) was inaugurated as a branch of Korea Astronomical Observatory (KAO). At present, a dual-channel (100/150 GHz) SIS receiver made by our engineering team is used, and we are preparing a multi-beam receiver (made by Five Colleges Radio Astronomical Observatory) to be installed on the 14-m telescope.

The main research interests are studies of interstellar molecular clouds and the physical and chemical processes in dense clouds. In particular, the SiO masers, star-forming regions, and interstellar molecular processes have been the major research area of the radio astronomy group in KASI. Although we have been managing our millimetre-wave telescope and receiver systems successfully so far, our radio group has not yet been involved in any VLBI activities, mainly because of our millimetre-wave single-dish facility. Only recently (from 2001) we successfully carried out VLBI experiments at 86 GHz with the Nobeyama VLBI group in Japan.

When the optical telescopes at Mt. Bohyun had been completed, the radio group submitted a proposal to the government for a construction of the Korean VLBI Network (KVN). The project was finally approved in 2000.

2. Scientific goals of KVN

The KVN will be the first VLBI facility in Korea, which will be used for VLBI studies in astronomy, geodesy, etc. The general VLBI research targets will also be targets for KVN, within the KVN limitations. However, the KVN will be constructed as an advanced millimetre-wave (up to $\sim$ 130 GHz) VLBI network. Since millimetre-wave VLBI is still in the developing stages around the world, we expect that KVN will play an important role in promoting millimetre-wave VLBI research activities.

Because of the existing 14-m millimetre-wave telescope facility, the research activities of the present radio astronomy group of KASI are focused on interstellar molecular cloud studies. Therefore, one of the main KVN research areas will be spectral-line observations related to the interstellar molecular processes at millimetre wavelengths. At the same time, we are strengthening our VLBI group by increasing human resources in high-energy astrophysics and AGN-related research fields, in order to promote research activities in various VLBI subjects.

The geodetic research is also an important part of KVN project. Since the tectonic movements of the Korean peninsula, including several important fault plane movements, have never been measured, the monitoring of these movements is an important national issue, which will be carried out with KVN. KVN will also actively participate in international campaigns for geodetic measurements.

3. Outline of the project

In 2001, KVN started a 7-year project to construct the first VLBI facilities in Korea consisting of three new radio telescopes and millimetre-wave VLBI-optimized receiving systems.

Table 1: Site locations of KVN and TRAO

KVN Site	Longitude ° ' " E	Latitude ° ' " N
Yonsei (Seoul)	126 56 35	37 33 44
Ulsan (Ulsan)	129 15 04	35 32 33
Tamna (Jeju)	126 27 43	33 17 18
TRAO (Daejeon)	127 22 19	36 23 53

Table 2: Baselines of KVN observatories and TRAO

KVN	Baseline			
Observatory	Yonsei	Ulsan	Tamna	TRAO
Yonsei (Seoul)	–	305.2	477.7	135.1
Ulsan (Ulsan)	305.2	–	358.5	194.2
Tamna (Jeju)	477.7	358.5	–	356.0
TRAO (Daejeon)	135.1	194.2	356.0	–

3.1 KVN sites

The three KVN observatory sites, Yonsei University at Seoul, University of Ulsan at Ulsan, and Tamna University at Jeju, have been selected from among the many competitors. Table. 1 shows the location of these three KVN sites. The maximum baseline length is about 450 km in the north-south direction. The baseline lengths are given in Table 2. The site preparation work and antenna construction will be finished at all three sites in 2007. In Fig. 1, an example of the *u*-*v* coverage and the synthesized beam shape for the three KVN antennas is shown, including the existing 14-m radio telescope at TRAO, Daejeon. In the future, these four antennas will be connected using the optical fibre networks in Korea, partly for e-VLBI, and partly for the real-time operations of KVN.

3.2 Antennas

We plan to build three new high-precision Cassegrain-type radio telescopes each of 21-m diameter, having reasonable efficiencies at frequencies above 100 GHz (total rms $\leq 150\ \mu$m). Fig. 2 & Fig 3. show the KVN Ulsan station where the first KVN antenna is being constructed. The maximum slewing speed is 3°/sec in both AZ and EL with an acceleration of about $3^\circ/\mathrm{sec}^2$. The requested wind speed tolerance is about 10 (20) m/s for precision (limited) observations, and 90

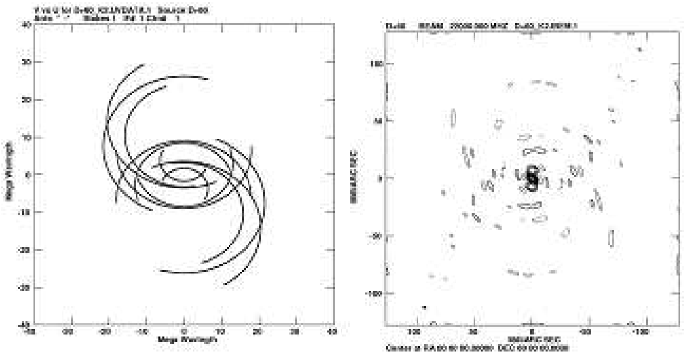

Figure 1: Example *u-v coverage and synthesized beam shape for a source at decl.*= 60° *for KVN and TRAO*

Table 3: KVN receiver specifications

Freq Band	S Band	X Band	K Band	Q Band
Freq [GHz]	2.2 - 2.8	8 - 9	21.5 - 23.5	42 - 44
Rx Noise (K)	< 25	< 25	< 30	< 50
1st IF (GHz)	2.5	8.5	8.5	8.5
IF BW (GHz)	0.6	1	2	2
IF Power (dBm)	-25	-25	-25	-25
Pol. (CP)	full	full	full	full

m/s for survival. The foundation construction was finished in 2006, and the antenna installation will be completed in the second half of 2007.

3.3 RF receivers

For the KVN front-ends, several cryogenic HEMT receivers will be installed at the Cassegrain focus for 2/8, 22, 43 & 86-GHz and SIS receiver for 129-GHz operations. The 2/8-GHz receivers will be mainly for geodetic observations. The 22 and 43-GHz receivers will be installed first, to set up the antennas and for the initial VLBI observations. Since the mm-VLBI is our main goal, the 86 and 129-GHz receivers will be installed as soon as the full test of the KVN system is completed. Some parameters of the first receivers are summarized in Table 3.

For KVN, which is designed for mm-VLBI, we plan to adopt a multi-channel quasi-optical beam transportation system which can be used for simultaneous on-source phase referencing of millimetre VLBI, without losing observing time, and without the necessity to look for reference sources. In addition, this method enables us to observe several frequencies simultaneously.

Fig. 4 shows the prototype of the KVN beam transporting system employing frequency-selective surfaces–low-pass filters (LPFs) [1].

Figure 2: KVN Ulsan station. The photo is taken in Feb. 2007.

Figure 3: KVN antenna back structure at Ulsan site

Figure 4: The prototype of KVN quasi-optics receiver plate

The 22-GHz band can be used as a phase calibration reference for the higher frequency band observations, made toward the same source at the same time. Although there are some limitations [2], this multi-channel idea would give very reliable phase corrections in mm-VLBI.

3.4 KVN DAS and recorder

The KVN data acquisition system (KVN DAS) has been developed and will be installed on the antennas in 2007. For our multi-channel receiver system, we employ four high-speed samplers operated at 1 Gsps. These four data streams of 2 Gbps will be transported via optical fibres to the operation building, and then distributed among sixteen FIR digital filters. With these filters, we can choose a passband whose centre frequency is arbitrarily programmable in the input bandwidth, and then resample the filtered data at 2 bits per sample. These resampled data streams are then formatted and sent to the recorder. We will also prepare the digital spectrometer for single-dish operation and total-power measurements. Given that we plan to use the Mark5 recorder, KVN participated in the Mark5 development [3]. The KVN-Mark5B is designed to support VLBI Standard Interface specification fully.

4. Summary

The construction of KVN is underway. The KVN is the first VLBI facility in Korea, which will be used for astronomy, geodesy, and space mission. It is our wish that KVN will be one of the best VLBI systems in the world, and we will actively participate in various VLBI programmes after completion. We hope that KVN will play a central role in promoting the VLBI research work of Korean societies and international collaborations, through the VLBI Research Center that will be built in Seoul. Various support and manpower exchange programmes to stimulate VLBI activities will be organized by the KVN project. Finally, for the success of the KVN project, it must be essential for us to collaborate with, and get many suggestions and supports from, the leading institutes in VLBI research around the world.

References

[1] Goldsmith, P. F. 1998, ApJ, 553, L31

[2] Sasao, T. 2003, ASP Conf. Series, 306, 53

[3] Whitney, A. R. 2003, ASP Conf. Series, 306, 123