Korean VLBI Network: Current Status and Possible Science Case for Black Hole and Jet Physics

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Abstract

Korean VLBI Network (KVN) is the first VLBI facility in Korea and will be operational from the middle of 2008. It is also the first dedicated millimeter-wavelength VLBI network around the world. KVN consists of three stations and has the maximum observation frequency of 129 GHz with the maximum baseline length of 480 km. KVN employs simultaneous reception system up to four frequency channels, and dual polarization reception system at four frequencies is also available. By taking advantage of these unique systems, we investigate parsec-scale accretion process of warm gas by multifrequency observations and a magnetic structure in an inner core of AGN by polarization observations. We present the current status of KVN project and possible science case toward AGN. See the detail of the current status of KVN project in Wajima et al. (2005).

KVN Overview

Korean VLBI Network (KVN)

- The first dedicated mm-wavelength VLBI facility in East Asia
- Consisting of three stations; Seoul, Ulsan, and Jeju (see Fig. 1)
  - Maximum baseline length: 480 km (Seoul – Jeju)
  - Highest observation frequency: 129 GHz
- Maximum angular resolution: ~1 mas

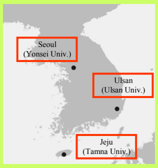

Figure 1: Location of KVN sites.

Unique features in KVN

- Multifrequency reception system
  - Simultaneous reception up to four frequencies
  - Three frequency selective surfaces (FSSs) are used (see Fig. 2).

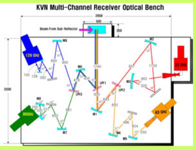

Figure 2: Quasi-optics system of KVN.

- Fast antenna switching capability
  - 3 deg/sec in Az, El
  - Superposition of images at each frequency
  - Phase-referencing VLBI observations

General specification of KVN

- Antenna diameter: 21 m
- Antenna aperture efficiency: 74% (43 GHz), 45% (129 GHz)
- Observation frequency: 22, 43, 86, and 129 GHz (for astronomical observations; dual polarization reception) 2 and 8 GHz (for geodetic observations; left-circular polarization reception)
- Maximum data processing rate: 2 Gbps

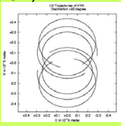

Figure 3: The (u, v) coverage for a source of +60 degree with the duration of twelve hours.

Scientific Targets

0. Image sensitivity

Table 1: Typical image sensitivity by KVN

	Tsys [K]	SEFD [Jy]	Image sensitivity [mJy] Continuum	Line
22 GHz	60	660	3.2	230
43 GHz	130	1400	6.7	480
86 GHz	200	2500	12	860
129 GHz	300	5200	25	1800

* assuming typical parameter for the antenna aperture efficiency, the system noise temperature, and the integration time at each frequency

1. Probing accreting process

- Free-free absorption in dense plasma around AGN (see Fig. 4) (e.g. 3C 84; Walker et al. 2000; NGC 1052, Kameno et al. 2001)
  - Spatial distribution of warm dense plasma
  - Physical condition of the ambient plasma, absorption coefficient with X-ray observations
  - Multifrequency VLBI observations are essential.

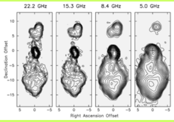

Figure 4: Multifrequency VLBI images of 3C 84 (Walker et al. 2000). Flux degradation of the northern component at lower frequency is due to the absorption by ionized gas associated with an accretion disk.

- CO absorption line as a probe of cold gas (see Fig. 5) (e.g. Evans et al. 1999)
  - Column density and velocity field can be illustrated in parsec scale
  - KVN is the first VLBI facility which will be working at 115 GHz (CO absorption line)

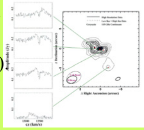

Figure 5: CO absorption line toward FRII radio galaxy 3C 293 detected by OVRO observations (Evans et al. 1999)

2. Core position offset

- Determining the pressure and density gradient from inner to outer jet by measuring core position offset with multifrequency VLBI observation (Lobanov 1998)
- Determining the kinetic luminosity from

$$L_{\rm kin} = C(\alpha)\Omega_{\rm C}^{\frac{2(5-2\alpha)}{7-2\alpha}}\left(\frac{1+z}{\delta}\right)^{\frac{2(3-2\alpha)}{7-2\alpha}} \quad [{\rm ergs\,s^{-1}}] \qquad \Omega_{\rm C} = 4.85\times10^{-9}\frac{\Delta r_{\rm mas} D_L}{(1+z)}\frac{\nu_1^{1/k_r}\nu_2^{1/k_r}}{\nu_2^{1/k_r}-\nu_1^{1/k_r}} \quad [{\rm pc\cdot GHz}]$$

>> Matter content of the pc-scale jet (e^- - p or e^- - e^+) (cf. Hirotani et al. 1999; 2000)

- Mm-wavelength VLBI >> which is the 'real' VLBI core?

3. Polarization observation at mm-wavelength

- Examining the magnetic field structure at the innermost region of AGN core and the root of AGN jet (see Fig. 6) (e.g. Lister & Smith 2000; Sohn et al. 2003).
- Difference of the Faraday rotation measure, parsec-scale magnetic field structure at a high frequency between HPQs and LPQs (Lister & Smith 2000; Zavala & Taylor 2003)

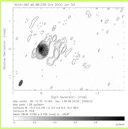

Figure 6: Total intensity image of OVV quasar PKS 1633+382 with EVPA vectors at 86 GHz (Sohn et al. 2003).

4. Other topics

- Black hole shadow in collaboration with the next space VLBI mission (e.g. Takahashi 2004)
- Spectral age of radio galaxy with synchrotron break measurement by determining frequency spectra at higher frequency (e.g. Murgia 2003)
- … and so on.

Current Status of KVN

- Site construction
  - Fundamental construction of Ulsan site has been completed (see Fig. 7).

Figure 7: Antenna tower (front) and observation building (back) at Ulsan site.

  - Antenna installation will be started in the middle of 2006 and be completed at the end of 2007 (see Fig. 8).

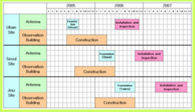

Figure 8: Antenna installation schedule for each site.

- Receiver development
  - Development of MMIC HEMT amplifier at 22, 43, and 86 GHz is in progress.
  - Receiver noise temperature (typical) 65 K (43 GHz), 120 K (86 GHz)

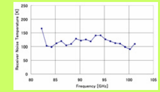

Figure 9: Receiver noise temperature at 86 GHz.

- Data acquisition system
  - Maximum data processing rate of 2 Gbps
  - Basic design of each equipment has already completed

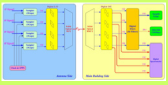

Figure 10: Schematic diagram of KVN data acquisition system.

- Korea-Japan Joint Correlator Project
  - Five-year project since 2004
  - Maximum data processing rate of 8 Gbps
  - Correlation processing of 16 stations acceptable for East Asia VLBI Network (EAVN) observations.
  - Frequency resolution of 0.05 km/s (freq. resolution of 3.7 kHz at 22 GHz)
  - Wide delay compensation window for space VLBI observations
  - The joint correlator will be installed in KVN site at Seoul in 2008.

See the up-to-date information on KVN via internet: http://www.trao.re.kr/~kvn/

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