HINOTORI and future 3 mm EAVN capability

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On behalf of HINOTORI team

EAO Sub-mm Futures, on 2019 May 20
HINOTORI
Hybrid Installation Project in Nobeyama, Triple-band Oriented

- Simultaneous triple-band (20—25 GHz/ 42.5—44.5 GHz/ 80—90 GHz) observation system
- New VLBI backend with a recording rate of up to 48 Gbps (4 GHz per band at maximum)

HINOTORI
Final (FY2019 — 2020)
Perforated high-pass band separation plates

- Remote plate changing
- Relative pointing offset ~3” (Okada et al. in prep.)
- Used for single-dish open-use in 22 GHz & 43 GHz bands since 2018 (Imai et al. in prep.)
- Commissioning in VLBI in 22 GHz & 43 GHz bands in 2019
Transmission and reflection fractions of the band separation plates

Okada et al. (in prep.)
Wide band VLBI signal processing in HINOTORI

- OCTAD-V1&V2 A/D converters
  - 2 GHz/IF x 3 IFs/set x 2 sets
  - 48 Gbps in total
- OCTADISK2 + VSREC (2 sets) recorders
  - 32 Gbps in OCTADISK2
  - 8 Gbps x 2 in 2 VSRECs
  - VDIF format
  - Internet data transfer
HINOTORI development timeline

- Final completion in 2021 mid
- Open to EAVN
  - 2020A (22 GHz & 43 GHz)
  - 2021B (22 / 43 / 86 GHz)
- Available time?
  - 72 hours /year (general use)
  - 150 hours /year requested by HINOTORI (for Large Projects)
Uniqueness of 3 mm VLBI in East Asia

- Fringe phase calibration with 13 mm / 7 mm data
- Dense network with 4 telescopes within 1000 km
- Compensating time zone in the globe
- Connectivity with the Global Millimeter VLBI Network (GMVA) and other telescopes (GLT, ATCA, JCMT, etc.)
Multiple-band VLBI Network

South Korea (KVN, SNU)

Japan (Nobeyama)

Japan (VERA)

Spain (Yebes)

Australia (ATCA)

Italy will join From others (GLT, JCMT)?

AP-RASC 2016 @Seoul
Triple-band VLBI (KaVA @22GHz+KVN @22/43/86GHz)

Red supergiant
S Per
(Asaki et al. in prep.)

Calibration solution transfer from 22 GHz to 43 GHz and 86 GHz

Tracing decadal history of mass loss from stellar surface

Discontinuous mass ejection uncorrelated with stellar pulsation

H$_2$O (22GHz) SiO $J=1\rightarrow 0$ $v=1$ (43GHz) SiO $J=1\rightarrow 0$ $v=2$ (43GHz)
SiO $J=2\rightarrow 1$ (86GHz, one KVN baseline)
“Core shift” effect

- Optical thickness dependent on radio frequency
- Very close to a high-frequency radio core
- Wide opening angle of the jet in M87
- Resolving BH accretion torii/disks and roots of jets in 3 mm and higher bands

Hada et al. 2011, Nature, 477, 185
VLBI diagnostics with molecular lines in circumnuclear disks

NGC 1052 HCN absorption (with KVN, Sawada-Satoh et al. 2016)
Interstellar tiny-scale structures towards background quasars

\begin{figure}
\centering
\includegraphics[width=\textwidth]{interstellar Structures.png}
\end{figure}

\textsuperscript{12}C-bared line  \textsuperscript{13}C-beard line (x30)

Galactic molecular absorptions detected with ALMA (Band-3) toward J1717-337 (Ando et al. 2015)
Representative Science Use Cases in 3 mm

1. Dynamics of inner circumstellar envelopes probed in multiple maser lines
   – Temporary switching of maser pumping schemes
   – Propagation of pulsation driven-shock waves enhancing stellar mass loss

2. Accelerations of AGN jets
   – Angular momentum transfer from accreting material to jet bullets

3. Kinematical and physical diagnostics of circumnuclear disks
   – Physical phase transfer of materials towards AGNs

4. Galactic interstellar tiny-scale (~1 AU) structures
   – Seeds of molecular gas grown to hierarchical ISM structures?
1.3 mm VLBI in East Asia

VLBI signal transfer from SPART 10 m to NRO 45 m telescope via RAINBOW network?

SPART 10 m telescope (Osaka Prefecture University) joining 1.3 mm VLBI (2019 March) VLBI signal converted and recorded at 8—48 Gbps via NRO 45 m telescope in future?

Networking with SPART+GLT+SNU(+KVN)+JCMT?
Thank you

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