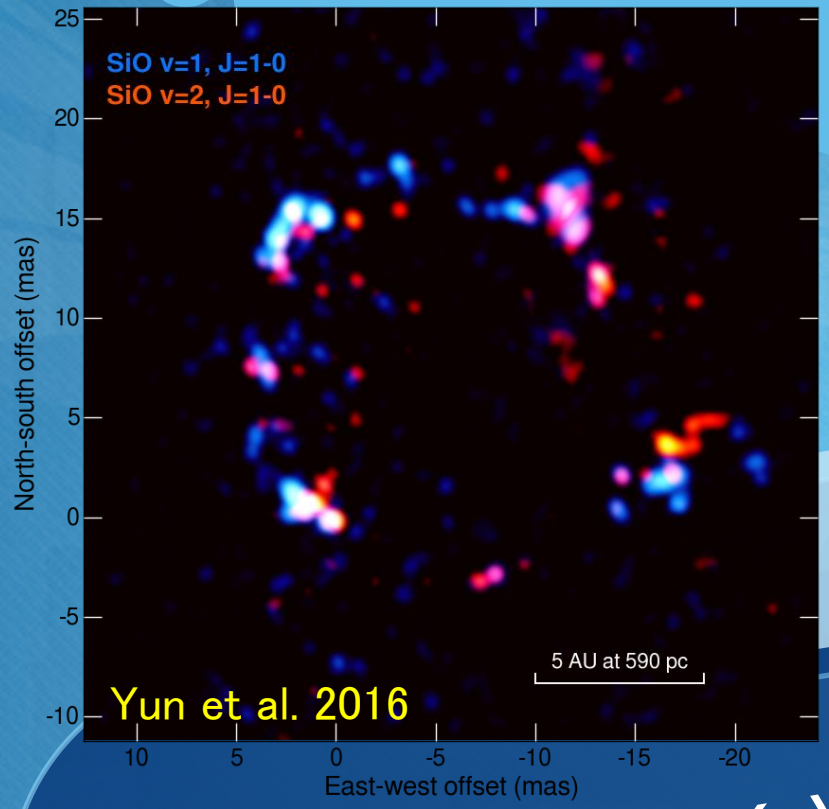


KaVA ESTEMA Status Report

(Expanded Study on Stellar Masers)

Hiroshi Imai
(Kagoshima University)
On behalf of the KaVA ESTEMA Team

Results of KaVA commissioning observations

Red supergiant

S Per

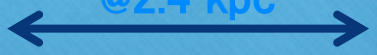
(Asaki et al. in prep.)

Band-to-band transfer of phase calibration Solutions

Continuous tracing of mass loss flows from stellar surface to accelerated zone of circumstellar envelope

Episodic mass ejection on decade scale?

50 mas~120 AU
@2.4 kpc



H_2O (22GHz) SiO J=1→0 v=1 (43GHz) SiO J=1→0 v=2 (43GHz)

SiO J=2→1 (86GHz, one KVN baseline)

KaVA ESTEMA (2015–2016)

- First stage of KaVA Large Program on circumstellar H_2O and SiO masers
  - Snapshot imaging or ~80 stars in H_2O and SiO masers
  - ~200 hr project during 2015 October–2016 Autumn
- Finally selecting ~20 stars for the one-decade intensive monitoring project in the KaVA second stage Large Program
  - Yielding maps of ~40 stars in H_2O and/or SiO masers
  - Statistical view of circumstellar maser on microscopic (maser spots) to macroscopic (circumstellar envelopes) scale

KaVA ESTEMA team

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Target 80 stars in KaVA ESTEMA

See KaVA HP

ESTEMA source list (1st year)

No.	Maser source (Type)	Priority	R.A. (J2000)	Dec. (J2000)	Vstar (km/s)
41	RS Vir (Mi*)	A	14 27 16.39	+04 40 41.1	−14
46	U Her (Mi*)	A	16 25 47.47	+18 53 32.9	−15
51	AH Sco (SG)	A	17 11 17.02	−32 19 30.7	−13
53	RW Sco (Mi*)	A	17 14 51.68	−33 25 54.6	−70
86	V1111 Oph (Mi*)	A	18 37 19.26	+10 25 42.2	−30
99	RT Aql (Mi*)	A	19 38 01.60	+11 43 18.2	−33
111	OH83.42−0.89 (OH*)	A	20 50 58.60	+42 48 11.0	−39
116	IRC+60370 (Mi*)	A	22 49 59.20	+60 17 55.0	−54
118	MY Cep (SG)	A	22 54 31.71	+60 49 38.9	−50
119	V627 Cas (Sy*)	A	22 57 40.99	+58 49 12.5	−52
1	Y Cas (Mi*)	A	00 03 21.47	+55 40 51.8	−17
34	R UMa (Mi*)	A	10 44 38.47	+68 46 32.7	38
122	R Cas (Mi*)	A	23 58 24.87	+51 23 19.7	21
32	R Leo (Mi*)	A	09 47 33.49	+11 25 43.7	−1
57	OH358.23+0.11 (OH*)	A	17 40 53.40	−30 23 09.0	−10
70	V4201 Sgr (sr*)	A	17 53 18.80	−26 56 37.0	−4
103	IRAS 19422+3506 (OH*)	A	19 44 07.00	+35 14 08.2	−49
79	V5102 Sgr (sr*)	A	18 16 26.03	−16 39 56.4	48
88	IRC+00363 (Mi*)	A	18 41 25.00	−04 20 36.0	55
93	OH38.10−0.13 (pA*)	A	19 01 20.05	+04 32 31.6	53
100	IRAS 19371+2855 (OH*)	A	19 39 07.77	+29 02 38.6	24
52	V2108 Oph (Mi*)	A	17 14 19.39	+08 56 02.6	16
56	IRC−30308 (OH*)	A	17 38 40.49	−31 57 18.2	5
71	V4120 Sgr (Mi*)	A	18 03 56.54	−20 19 00.4	15
80	OH16.1−0.3 (pA*)	A	18 21 06.44	−15 03 29.8	22
16	U Ori (Mi*)	A	05 55 49.17	+20 10 30.7	−45
22	Z Pup (Mi*)	A	07 32 38.06	−20 39 29.1	3
27	R Cnc (Mi*)	A	08 16 33.83	+11 43 34.6	18
42	S CrB (Mi*)	A	15 21 23.93	+31 22 02.4	−1
4	o Cet (Mi*)	A	02 19 20.79	−02 58 37.4	47
15	S Col (Mi*)	A	05 46 56.31	−31 41 28.4	65
24	QX Pup (pA*)	A	07 42 17.16	−14 42 49.9	29
120	R Peg (Mi*)	A	23 06 39.17	+10 32 36.1	23
25	V353 Pup (sr*)	A	07 46 34.15	−32 18 16.3	28
26	HU Pup (sr*)	A	07 55 40.16	−28 38 54.8	44
30	IW Hya (Mi*)	A	09 45 15.24	−22 01 45.3	46
20	IRC−10151 (OH*)	A	07 07 49.38	−10 44 05.9	45
36	R Crt (sr*)	A	11 00 33.85	−18 19 29.6	11
37	RT Vir (sr*)	A	13 02 37.98	+05 11 08.4	15
40	RX Boo (sr*)	A	14 24 11.84	+25 42 21.1	1

Group 1
Group 2
Group 3 *
Group 4
Group 5
Group 6
Group 7
Group 8
Group 9 *
Group 10 *

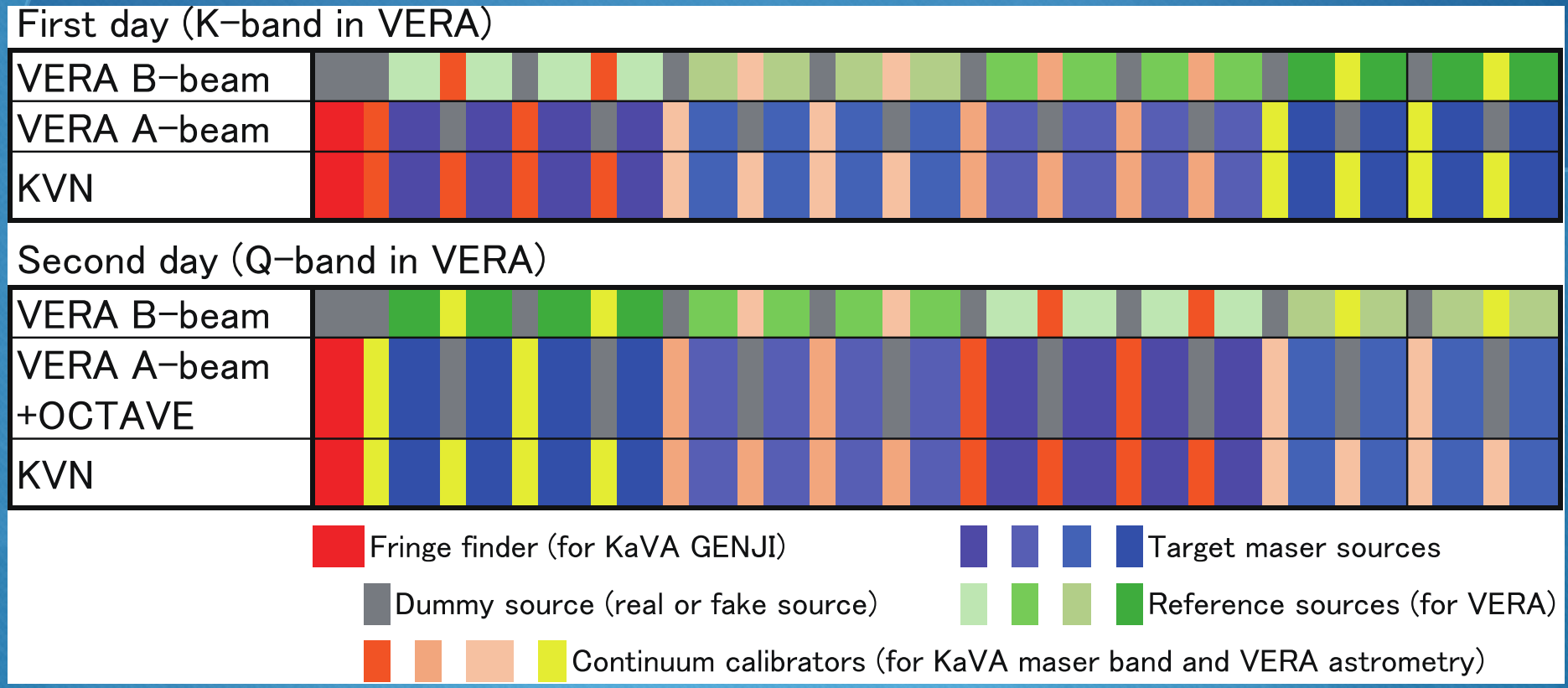
* Group 3, 9, 10 can be grouped together in a 2x15h session

ESTEMA source list (2nd semester, Priority B)

Group	No.	Maser source (Type)	Priority	R.A. (J2000)	Dec. (J2000)	Vstar (km/s)
B1	6	RR Per (Mi*)	B	02 28 29.40	+51 16 17.3	9
B1	11	BW Cam (Mi*)	B	05 19 52.56	+63 15 55.8	50
B1	19	GX Mon (Mi*)	B	06 52 47.04	+08 25 19.2	−8
B1	23	OZ Gem(Mi*)	B	07 33 57.75	+30 30 37.8	7
B2	2	V524 Cas (Mi*)	B	00 46 00.12	+69 10 53.4	−27
B2	109	IRAS 20381+5001 (Mi*)	B	20 39 39.60	+50 12 15.0	−38
B2	115	AM Cep (Mi*)	B	21 41 27.08	+76 23 11.3	−50
B2	117	V386 Cep (sr*)	B	22 53 12.33	+61 17 00.4	−49
B3	17	AP Lyn (Mi*)	B	06 34 33.92	+60 56 26.2	−23
B3	18	U Lyn (Mi*)	B	06 40 46.49	+59 52 01.6	−16
B3	29	X Hya (Mi*)	B	09 35 30.27	−14 41 28.6	27
B3	33	V Ant (Mi*)	B	10 21 09.11	−34 47 18.7	−18
B4	35	VX UMa (Mi*)	B	10 55 39.88	+71 52 09.8	−50
B4	40	RX Boo (sr*)	B	14 24 11.84	+25 42 21.1	1
B4	44	WX Ser (Mi*)	B	15 27 47.38	+19 33 42.9	7
B4	47	T Oph (Mi*)	B	16 33 43.54	−16 07 54.3	−33
B5	66	MHSOM100	B	17 48 18.11	−28 07 38.9	111
B5	76	OH10.1−0.1 (pA*)	B	18 08 16.38	−20 16 11.6	52
B5	87	V438 Sct (Mi*)	B	18 41 14.33	−06 15 00.7	71
B5	89	IRC+00364 (IR)	B	18 42 08.43	−02 45 15.4	50
B6	49	V446 Oph (sr*)	B	16 46 39.11	−11 38 53.1	10
B6	54	IRAS 17187−3750 (IR)	B	17 22 11.20	−37 53 13.0	−26
B6	82	UY Sct (sr*)	B	18 27 36.53	−12 27 58.9	26
B6	102	V1415 Aql (Mi*)	B	19 43 45.29	+03 44 30.4	−31
B7	55	IRAS17313−1531	B	17 34 10.80	−15 33 02.0	−49
B7	62	MHSOM75	B	17 46 12.46	−28 07 05.3	−39
B7	68	V2211 Oph (Mi*)	B	17 51 09.95	−08 01 21.3	−20
B7	90	V837 Her (Mi*)	B	18 43 36.47	+13 57 22.8	−9
B8	72	IRC−20427 (Mas)	B	18 05 35.49	−21 13 42.2	17
B8	73	IRC−10395 (IR)	B	18 06 42.88	−08 13 12.0	20
B8	77	V2302 Oph (Mi*)	B	18 09 18.55	+09 12 15.6	−13
B8	84	OH24.7+0.2 (OH*)	B	18 35 29.20	−07 13 08.0	42
B9	92	V1366 Aql (Mi*)	B	18 58 30.09	+06 42 57.8	20
B9	98	UV Cyg (sr*)	B	19 31 13.28	+43 38 13.6	33
B9	105	OH65.4+1.3 (OH*)	B	19 51 21.20	+29 13 01.3	−21
B9	108	V1828 Cyg (Mi*)	B	20 36 57.04	+37 52 33.9	−2
B10	101	V391 Cyg (Mi*)	B	19 40 52.39	+48 47 41.5	−20
B10	106	V468 Cyg (Mi*)	B	19 55 38.15	+32 45 33.8	−45
B10	112	UX Cyg (Mi*)	B	20 55 05.52	+30 24 52.1	2
B10	121	R Aqr (Sy*)	B	23 43 49.46	−15 17 04.1	−21

Scan pattern in KaVA/ESTEMA observations

First two hours of observation block



6-9 hours per session for 4—6 sources

20 pairs of K/Q-band sessions with VERA

ESTEMA results as to 2016 September

- Observations and data handling
  - 95% of observations scheduled as to 2016 October
  - 85% of observations complete
  - 80% of correlation complete
  - ~70% of inspection complete
  - Ingest processing ongoing
  - Calibration pipeline in development/tested
- Man power previously focused on observation preparation
  - keyin in SCHED → vex for KVN → vex for VERA dual beam
- Ingest pipeline script still in development
- Basic data calibration pipeline tested
  - Tools for scientific analysis tools in design discussion

ESTEMA fringe inspection

- H_2O masers: 19/44 fringe detections
- ^{28}SiO $J=1\rightarrow0$ $v=1\&2$ masers: 17/40 fringe detections

  7 stars simultaneously detectable in H_2O and ^{28}SiO $J=1\rightarrow0$ $v=1\&2$ masers
- ^{29}SiO $J=1\rightarrow0$ $v=0$ masers:

  not yet inspected (KVN or VERA/OCTAVE wide only)
- ^{28}SiO $J=2\rightarrow1$ and $3\rightarrow2$ $v=1$ masers:

  not yet inspected (KVN only)
- ^{28}SiO $J=1\rightarrow0$ $v=3$ masers:

  not yet inspected (VERA/OCTAVE wide only)

Fringe detection rates slightly lower than planned in proposal submission

Future perspectives

- Proposing one of KaVA "legacy" projects
  - Targeting ~20 stars for one decade monitoring
  - biweelky—quarter monthly maser mapping

light curve phase spacing: $\Delta\phi \sim 1/20$

  - Observations for <500 hours/year
  - Proposing by the middle of 2017
- Final goals
  - Detecting pulsation-driven shock waves and/or periodic behaviors in circumstellar envelopes
  - Finding evolution of inhomogeneity in CSEs
- Synergies with

★ALMA (thermal/sub-mm masers)　★VLTI (star images)

★JASMINE (stellar astrometry)　★SKA-VLBI (OH masers)