VLBI observations of circumstellar masers with JVN/KaVA/EAVN

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On behalf of: KaVA ESTEMA (Expanded Study on Stellar Masers) Team
new ESTEMA (EAVN Synthesis of Stellar Maser Animations) Team
the Team of the JVN Large Project on Circumstellar H_2O Masers※
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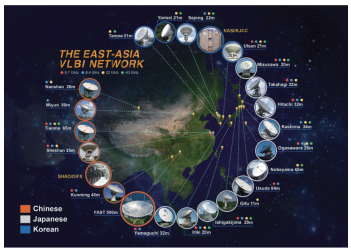

KaVA ESTEMA (Expanded Study on Stellar Masers)

During 2015 October —2017 March, for ~280 hours, towards 80 stars
Snapshot imaging of detected H_2O and SiO masers in circumstellar envelopes around ~40 stars. Using multi-frequency phase-referencing, composite maps will be produced. Automated image scube ynthesis is ongoing.

New ESTEMA (EAVN Synthesis of Stellar Maser Animations)

During 2018 May—2027, for 200—300 hours/year, towards 6 stars with pulsation periods *P*=300—1000 days (Table 1)
Intensive monitoring of SiO and H_2O masers in every 1/20 pulsation cycle over a few pulsation cycles
Producing and archiving stellar maser animation in the database (eDAMS, Nakashima et al. 2018)
Still snapshot imaging (~3 hours), but image quality will be secured by at least five KaVA/EAVN telescopes (Figure 2)

Table 1 Target maser and phase-reference/delay calibation sources in new ESTEMA. In 2018, BX Cam and NML Cyg have been focused.

	Source name (order of priori	reference	Coordinates (J2000) R.A.			Decl.			*Approx. flux density (Jy/b)		Source category
Target maser sources (order of priority)										Period (d)	
1	omicron Cet	symbiotic star	02	19	20.7921	−02	58	39.496	5 (K) / 1303 (Q)	333	A1
2	U Her	Mira	16	25	47.4520	18	53	32.660	27 (K) / 9 (Q)	406	A2
3	BX Cam	Mira	05	46	44.2900	69	58	24.200	78 (K) / 77 (Q)	486	B1
7	Y Cas	Mira	00	03	21.4700	55	40	51.800	3.9(K) / 17.2(Q)	414	B2
9	IW Hya	Mira or OH/IR	09	45	15.2400	−22	01	45.300	8 (K) / 41 (Q)	650	C2
10	NML Cyg	red supergiant	20	46	25.5444	40	6	59.383	45 (K) /3 (Q)	~1000	D2
Delay calibrator/phase-reference sources									(Jy/beam)	Sep. (deg)	
1	J0215−0222	VLBA Cal.	2	15	42.0173	−2	22	56.752	0.14 at K band	1.08	Ref. A1
2	J1620+1736	VCS	16	20	21.8186	17	36	23.951	0.07 at K band	1.82	Ref. A2
3	J0524+7034	Oyama in prep.	5	24	13.4334	70	34	52.906	0.16 at Q−band	1.99	Ref. B1
7	J2353+5518	rfc_2017b	23	53	42.2997	55	18	40.666	0.24 at X band	1.42	Ref. B2
9	J0921−2618	VLBA Cal.	9	21	29.3539	−26	18	43.386	1.22 at X band	6.91	Ref. C2
10	J2046+4106	Zhang et al. 2012	20	46	21.8414	41	6	1.107	0.017 at Q−band	1.00	Ref. D2

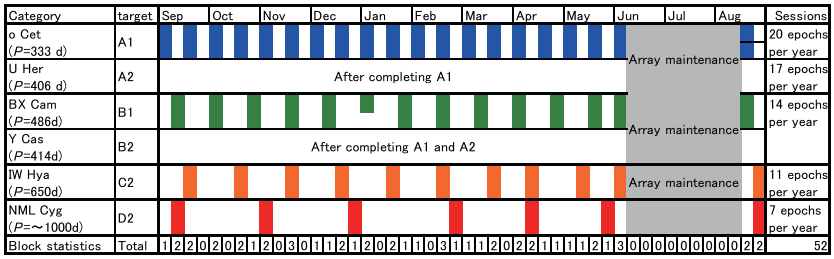

Figure 1 Allocation model of the ESTEMA observation session. In 2018 — 2019, each session is composed of a pair of K-/Q-band blocks (~3 hours) for VERA. Later, each session shall adopt K-/Q-band simultaneous observations with full KaVA and EAVN telescope. Each star shall be monitored in 2 — 3 stellar pulsation cycles (700 — 1500 days).

JVN Large Projecrt on Circumstellar Masers (VERA 15B-111)

2016 May, for ~50 hours, towards 20 stars
Snapshot imaging of H_2O masers
For statistics of maser spot/feature shapes expected to have possible correlation with stellar type and the evolution of circumstellar envelope, which is under investigation (Figure 3)

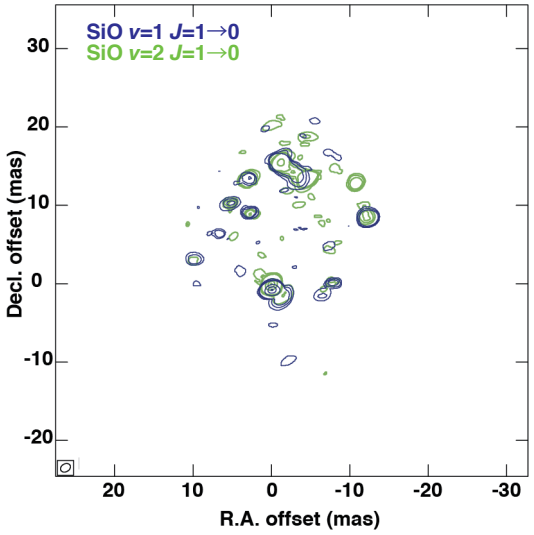

Figure 2 KaVA imaging of SiO *J*=1→0 masers around BX Cam, which was conducted in 2018 May. The registration of the two maser map should be made more relilably on the basis of astrometry.

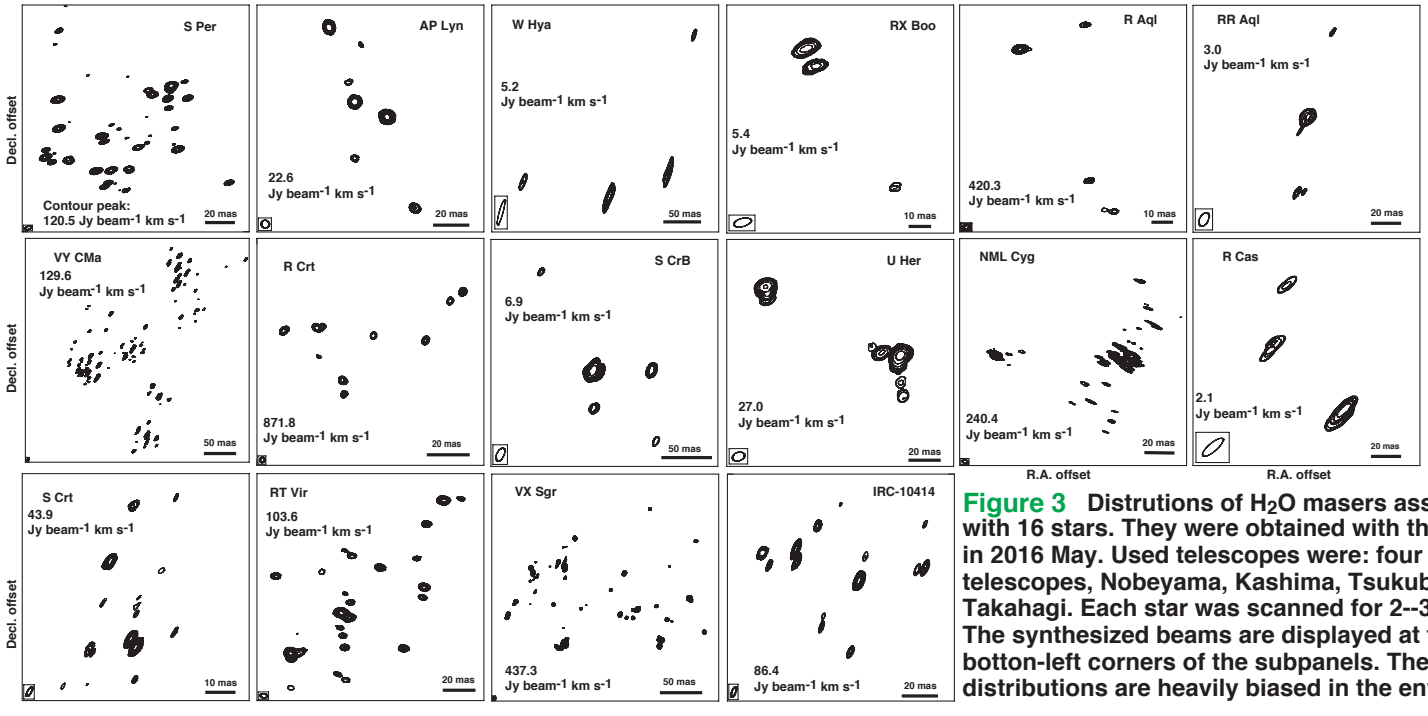

Figure 3 Distrutions of H_2O masers associated with 16 stars. They were obtained with the JVN in 2016 May. Used telescopes were: four VERA telescopes, Nobeyama, Kashima, Tsukuba, and Takahagi. Each star was scanned for 2--3 hours. The synthesized beams are displayed at the botton-left corners of the subpanels. The maser distributions are heavily biased in the envelopes.