

VERA Users Meeting 2003

Star-formation study and VERA

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Star-formation study and VERA

Contents:

- Interested in H₂O masers
in star forming regions ?
 - Previous studies
 - Future prospective
- Interested in VERA observations
toward SFR H₂O masers?
 - Technical requirements from the study and users

Interested in H₂O masers in star-forming regions?

Why H₂O masers?

- Targets for high angular resolution with VLBI
- Important for star-formation study
ONLY WITHIN 10 YEARS (c.f. EVLA/ ALMA)

Tracing the earliest phase of a star's birth

- First 10⁵ years in massive-star formation (Genzel & Downes 1977)
- Statistics based only on maser radial-velocity distributions

Table 2. Possible phases of H₂O emission in an evolutionary scheme for OB stars.

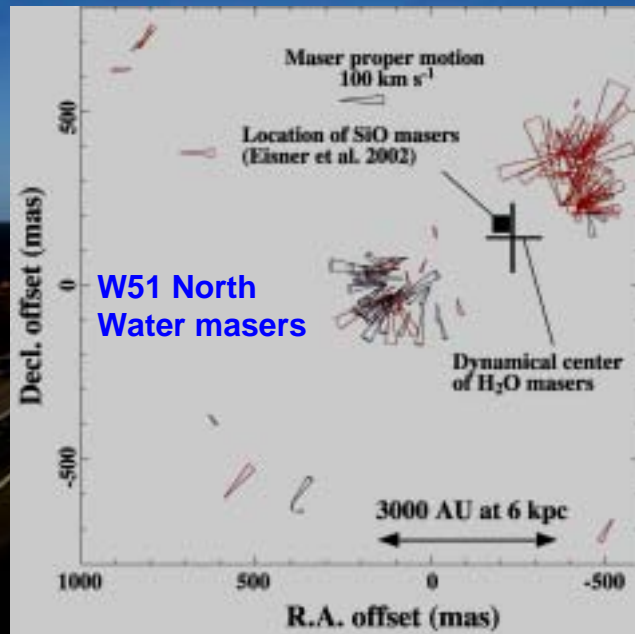
Evolutionary stage	Duration	Quantitative effects	Observational appearance	Reference
(1) Pre-main-sequence phase	-	None	None	1
(2) Main-sequence phase	10 ⁵ yr	Reduction in angular momentum, contraction of envelope, formation of disk, etc.	None	2, 3, 4
(3) Disappearance of disk	10 ⁵ yr	Reduction in angular momentum, formation of disk, etc.	None	5, 6, 7, 8
(4) Development of a disk	10 ⁵ yr	Formation of disk, etc.	None	9, 10, 11, 12
(5) Disk phase	10 ⁵ yr	Formation of disk, etc.	None	13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100
(6) Post-disk phase	10 ⁵ yr	None	None	101, 102, 103, 104, 105, 106, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119, 120, 121, 122, 123, 124, 125, 126, 127, 128, 129, 130, 131, 132, 133, 134, 135, 136, 137, 138, 139, 140, 141, 142, 143, 144, 145, 146, 147, 148, 149, 150
(7) Main-sequence phase	10 ⁵ yr	None	None	151, 152, 153, 154, 155, 156, 157, 158, 159, 160, 161, 162, 163, 164, 165, 166, 167, 168, 169, 170, 171, 172, 173, 174, 175, 176, 177, 178, 179, 180, 181, 182, 183, 184, 185, 186, 187, 188, 189, 190, 191, 192, 193, 194, 195, 196, 197, 198, 199, 200
(8) Post-main-sequence phase	10 ⁵ yr	None	None	201, 202, 203, 204, 205, 206, 207, 208, 209, 210, 211, 212, 213, 214, 215, 216, 217, 218, 219, 220, 221, 222, 223, 224, 225, 226, 227, 228, 229, 230, 231, 232, 233, 234, 235, 236, 237, 238, 239, 240, 241, 242, 243, 244, 245, 246, 247, 248, 249, 250

Variety of 3-D maser kinematics

- Expanding flows

examples:

- W49 North (Gwinn et al. 1994)
- W51 North, (Imai et al. 2002)

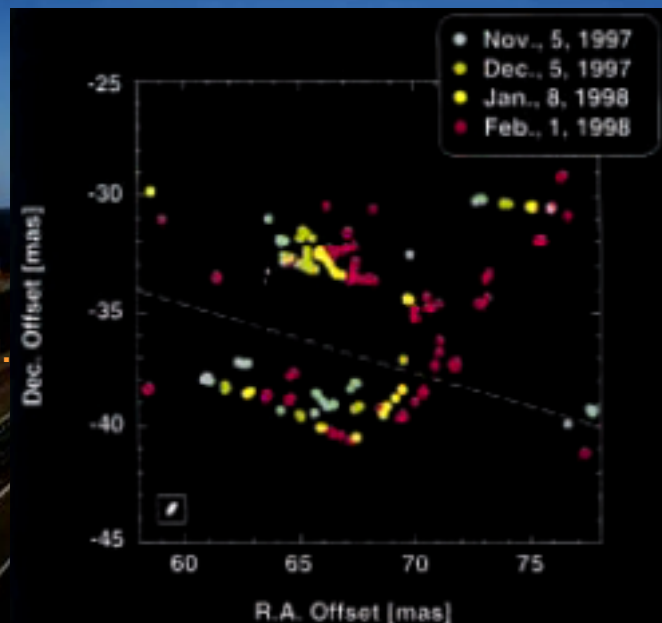


Variety of 3-D maser kinematics

- Bow shocks

examples:

- S106FIT (Furuya et al. 2000)
- IRAS 05413-0104, (Claussen et al. 2002)

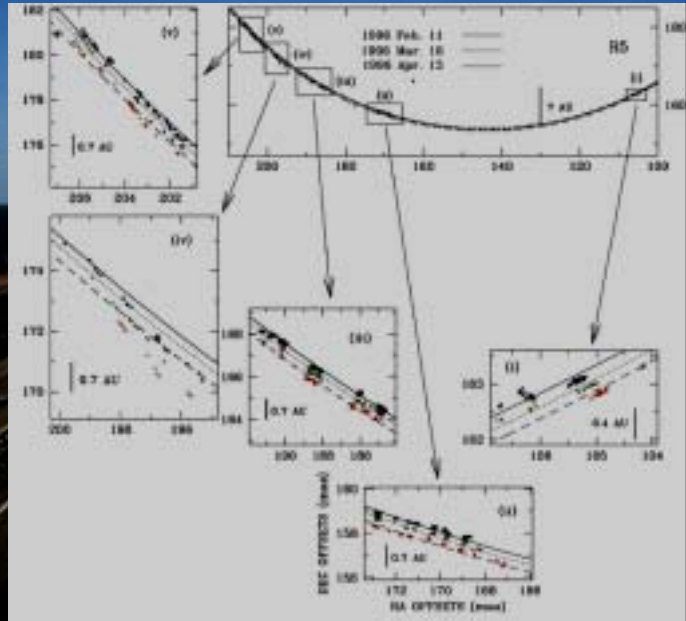


Variety of 3-D maser kinematics

- Bubbles

example:

- Cepheus A (Torrolles et al. 2001)

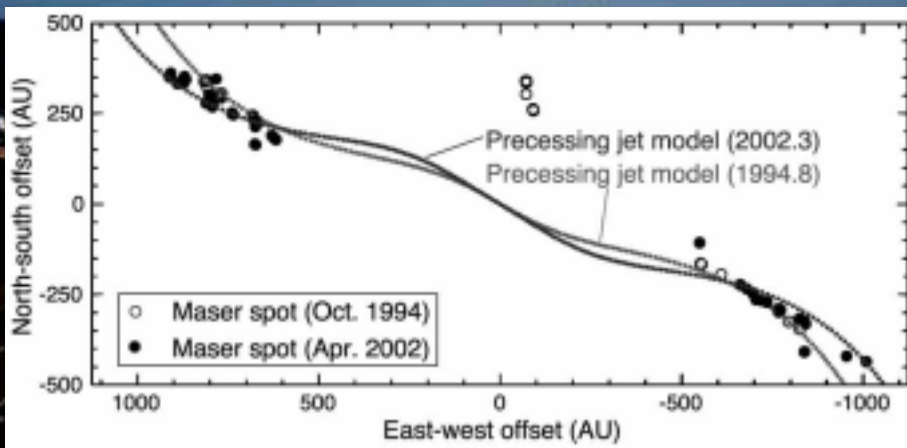


Variety of 3-D maser kinematics

- Molecular Jets

example:

- W43 A (Not SFR) (Imai et al. 2002, 2003)



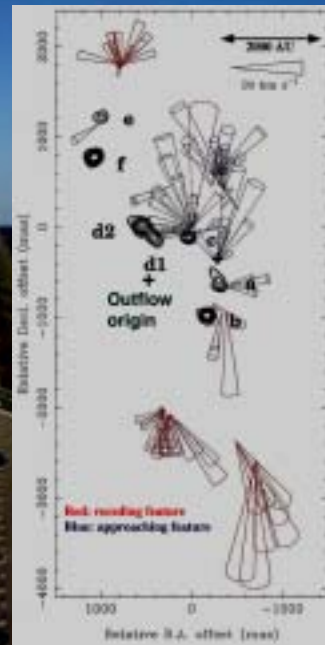
Variety of 3-D maser kinematics

- Multiple outflows within 10^5 years

examples:

- W3IRS5 (Imai et al. 2000)
- Cepheus A, (Torrelles et al. 2001)

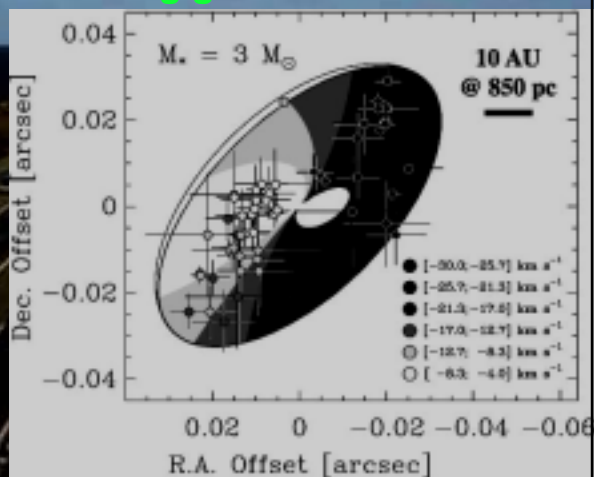
Maser kinematics correlated with evolutionary status of star formation ?
(HII region, molecular outflow, cloud destruction)



Access to protostellar disks and protostars

- Only 2 or 3 candidates for H_2O masers tracing gas contraction

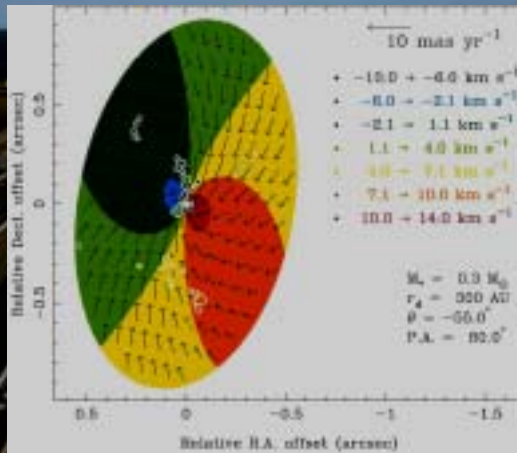
- IRAS 00338+6312 (Fiebig 1996)
- IRAS 16293-2422 (Imai et al. 1999)
- NGC2071 (Seth et al. 2003)



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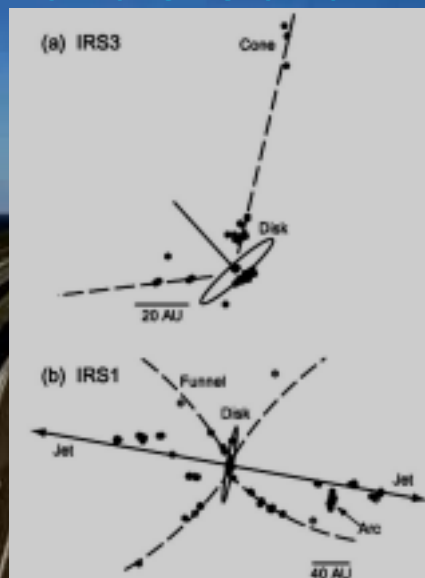
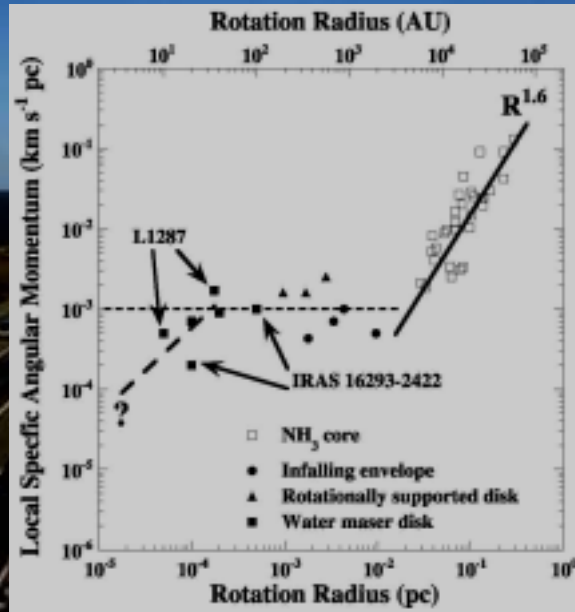


FIG. 4.—Components of our proposed models for (a) IRS 3 and (b) IRS 1.

How to provide material to a protostar?

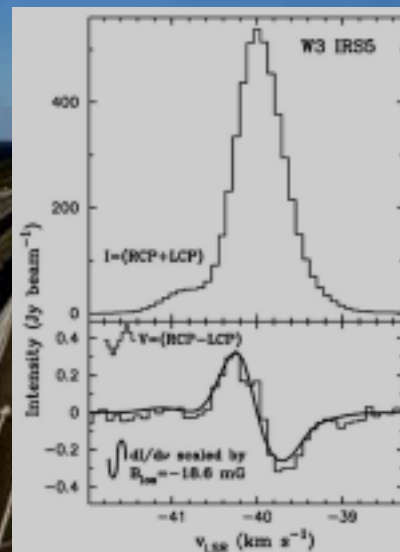
LSAM diagram
(Ohashi et al. 1998)

- Dynamical infall within 0.03 pc
- Reducing LSAM within 10 AU?



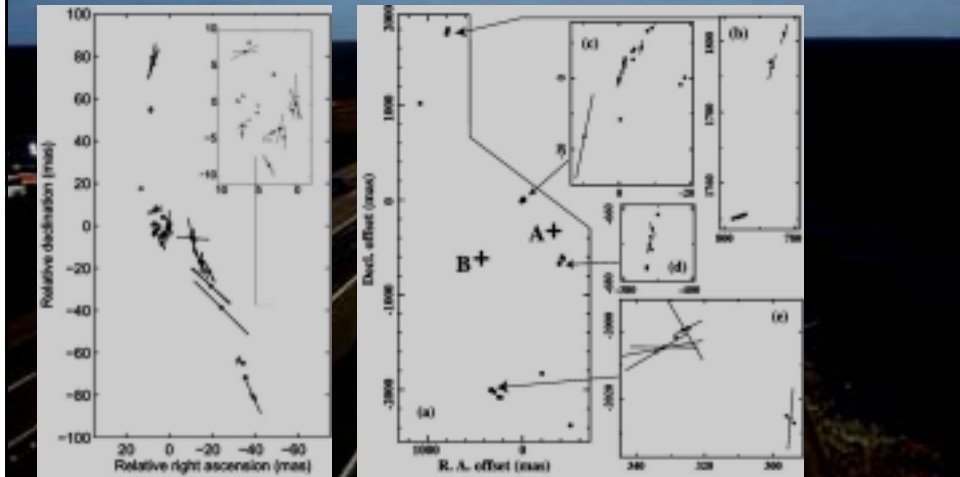
Diagnostics for SFR using H_2O masers: magnetic fields

- Zeeman splitting (W3 IRS5, Sarma et al. 2001)



Diagnostics for SFR using H₂O masers: magnetic fields

- **Electric vector position angle**
(W51 Main, Leppanen et al. 1998; W3 IRS5, Imai et al. 2003)



My frustrations in H₂O maser study

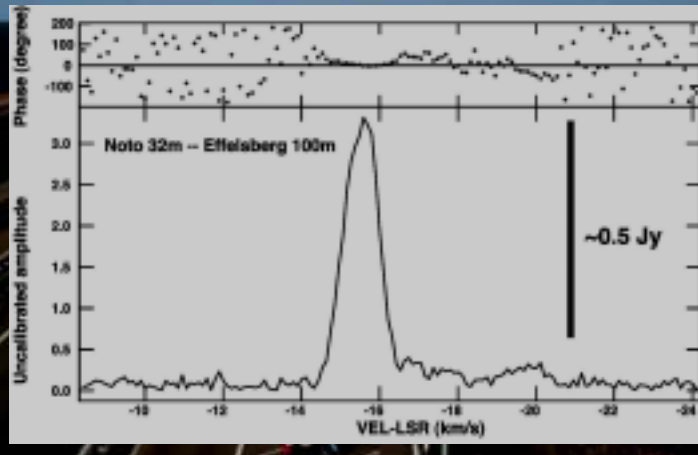
- **Severely obscured kinematics**
(few maser spots/source)
- **Limited information on physical conditions in SFR**
- **Limited sample number of H₂O maser sources**
with known kinematics
- **H₂O maser might not be able to trace**
gas-contracting motions
- **Difficulty in coordinating**
VLBI monitoring observations
(mainly due to proposal system)

Interested in VERA observations toward SFR H₂O masers?

Why with VERA, not EVN or VLBA?

H₂O masers
in L1287

Imai,
van Langevelde,
Umemoto (2003)



Interested in VERA observations toward SFR H₂O masers?

Competition between advantages

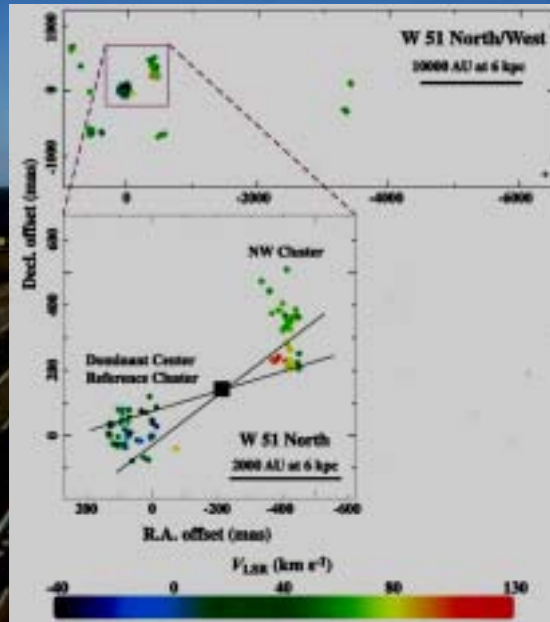
- Advantages in EVN/ VLBA
 - Higher sensitivity
 - Higher dynamic range
 - Quicker data reduction in AIPS (automatic pipeline)
 - More friendly for users
 - Service observation for calibrator search
- Advantages in VERA
 - Higher quality in phase-compensation
 - More systematic monitoring observations

Masochistic maser data analysis in VERA?

(c.f. *Diamond 1989*)

- 10,000² grids
- 1000 vel. channels
- Finding a reference channel
- unknown absolute coordinates

H₂O masers in W51A
(Imai, et al. 2002)



Automatic pipeline in AIPS

- Providing standard calibration tables
- Creating standard plots for data checking
- Quick checking preliminary images
- Encourage for users to start data reduction
- Standard information for data archive

2 image cubes per week

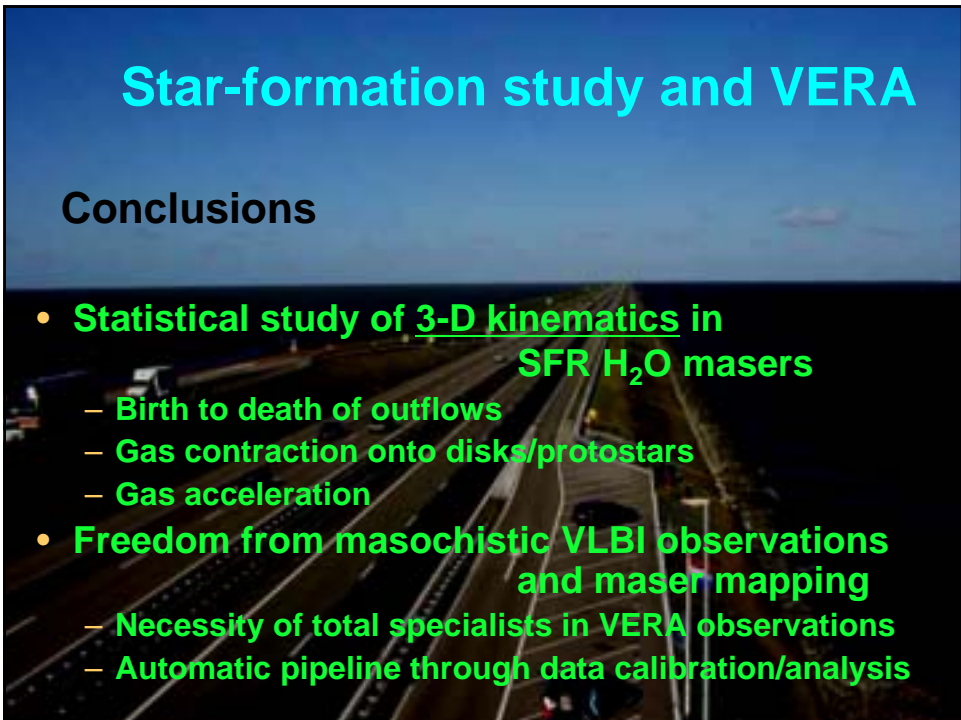
TX Cam SiO masers (Gonidakis, Diamond, Kemball 2002)




Star-formation study and VERA

Conclusions

- **Statistical study of 3-D kinematics in SFR H₂O masers**
 - Birth to death of outflows
 - Gas contraction onto disks/protostars
 - Gas acceleration
- **Freedom from masochistic VLBI observations and maser mapping**
 - Necessity of total specialists in VERA observations
 - Automatic pipeline through data calibration/analysis





**Lamplight or break-through
before
new-generation facilities?
(EVLA/ ALMA/ VLT/ JASMIN)**