# VLA OBSERVING APPLICATION

A

rcvd:

DEADLINES: 1st of Feb., June., Oct. for next configuration following review
INSTRUCTIONS: Each numbered item must have an entry or N/A
E-MAIL TO: propsoc@nrao.edu (different for some Rapid Response Science)
OR MAIL TO: Director NRAO, 520 Edgemont Rd., Charlottesville, VA 22903-2475

**(1)** Date Prepared: 11 August 2005

**(2)** Title of Proposal: Interpretation of the VLBA+Y27 Observations of the $H_2CO$ Masers in Sgr B2 using Exploratory VLA Observing Time



| **(3)** AUTHORS (Add * for new location) | INSTITUTION | E-mail | G/U | Students Only For Thesis? | Ph.D. Year |
|---|---|---|---|---|---|
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| Patrick Palmer | U Chicago | ppalmer@oskar.uchicago.edu | | | |
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**(4)** Related VLA previous proposal number(s): BH114, AM0387


**(5)** Contact author for scheduling: Ian M. Hoffman
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**(7)** Scientific Category: ○ solar system ⊗ galactic ○ extragalactic ○ other:

Rapid Response Science: ○ Known Transient ⊗ Exploratory ○ Target of Opportunity
Joint Proposal: ○ VLA/VLBA ○ VLA/GBT ○ VLA/VLBA/GBT

| | | | | | |
|---|---|---|---|---|---|
| **(8)** Configurations (one per column) (A+Pt, A, B, C, D, BnA, CnB, DnC, Any) | Any/move | | | | |
| **(9)** Wavelength(s) (400, 90, 20, 6, 3.5, 2, 1.3, 0.7 cm) | 6 | | | | |
| **(10)** Time requested (hours) | 8 | | | | |

**(11)** Type of observation: ○ continuum ⊗ spectroscopy ○ multichannel continuum ○ polarimetry ○ solar
(check all that apply) ○ pulsar ○ high-time resolution ○ Pie Town link ○ other:

**(12)** Suitable for dynamic scheduling? ⊗ Suitable ○ Unsuitable

**(13)** ABSTRACT (do not write outside this space)


There are six known Galactic $H_2CO$ masers. Our recent VLBA+Y27 observations of the $H_2CO$ masers in Sgr B2 have increased the number of masers detected using VLBI to three. In order to interpret quantitatively our VLBI observations of the Sgr B2 masers, measurements of the flux densities and line widths of the masers at a recent epoch using the VLA are needed. The masers were previously observed with the BnA configuration of the VLA in February 1993, but likely varied in flux density prior to the May 2003 VLBA+Y27 observations. Furthermore, the 1993 VLA observations employed a coarse (1.5 km $s^{-1}$) spectral resolution which did not resolve the spectral lines (observed using the VLBA to have a FWHM of 0.26 km $s^{-1}$). We have already made significant use of the VLA and VLBA to study the Sgr B2 $H_2CO$ masers (8 hours of the VLA for project AM0387 and 8 hours of VLBA+Y27 for project BH114). We request 8 hours of exploratory time during a configuration move of the VLA in order to obtain the flux density and line width at the current epoch measurements which will successfully complete the current VLBA+Y27 experiment.


NRAO use only
(10/04)

**(14)** Observer present for observations? ⊗ Yes ○ No Data analysis at? ⊗ Home ○ AOC or CV (2 weeks notice)

**(15)** Help required: ⊗ None ○ Consultation ○ Friend (extensive help)

| **(16)** Spectroscopy only | line 1 | line 2 | line 3 | line 4 |
|---|---|---|---|---|
| Transition (HI, OH, etc.) | $H_2CO$ | | | |
| Rest Frequency (MHz) | 4829.659 | | | |
| Velocity (km/s) | 74.64 | | | |
| Observing frequency (MHz) | 4830.860 | | | |
| Correlator mode | 2AC (BW8) | | | |
| IF bandwidth(s) (MHz) | 0.1953125 | | | |
| Hanning smoothing (y/n) | y | | | |
| Number of channels per IF | 64 | | | |
| Frequency Resolution (kHz/channel) | 3.052 | | | |
| Rms noise (mJy/bm, nat. weight., 1 hr) | 5 | | | |
| Rms noise (K, nat. weight., 1 hr) | 50 | | | |

| **(17)** Number of sources: | **2** |
|---|---|

(If more than 10 please attach list. If more than 30 give only selection criteria and LST range(s).)

| **(18)** NAME | Coordinates 1950 ○ 2000 ⊗ RA hh mm Dec. ± xx.x° | Conf. | $\lambda$ (cm) | Corr. mode | Band-width per IF (MHz) | Total Flux (Jy)* | LAS | Required rms (mJy/bm) | Required dynamic range | Time request (hr) |
|---|---|---|---|---|---|---|---|---|---|---|
| Sgr B2 A-D | 17 47, -28.4 | Any | 6 | 2AC | 0.195 | 0.3 | 1″ | 3 | 1000 | 8 |
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*For spectral line, this should be the total flux at the peak of the line

Notes to the table (if any): The maser sources have sub-arcsecond size but $H_2CO$ absorption in the region has larger angular scale.

**(19)** Restrictions to elevation (other than hardware limits) or HA range (give reason):

**(20)** Preferred range of dates for scheduling (give reason): Since imaging is not a priority for this experiment, scheduling during a mo
be sufficient.

**(21)** Dates which are not acceptable:

**(22)** Special hardware, software, or operating requirements:

**(23)** Please attach a self-contained Scientific Justification **not in excess of 1000 words.** (Preprints or reprints will be ignored.)

Please include the full addresses (postal and e-mail) for first-time users or for those that have moved (if not contact author).

When your proposal is scheduled, the contents of the cover sheets become public information (Any supporting pages are for refereeing only).

v4.3 10/04

# Introduction

The empirical knowledge of Galactic formaldehyde masers has increased significantly in the past few years. Araya et al. (2004, 2005) have discovered three new maser sources and Hoffman et al. (2003b) have made the first VLBI images of two masers sources. Most recently, Araya & Hoffman et al. have successfully proposed for MERLIN observations of one of the new maser sources and Hoffman et al. have detected a third maser source using VLBI: Sgr B2.

The history of the study of the Sgr B2 masers begins with the discovery in July 1982 by Whiteoak and Gardner (1983) using the BnA configuration of the VLA (with 6.1-km/s spectral resolution). The February 1993 VLA (BnA) observations by Mehringer et al. (1994) were the first comprehensive study of the region and resulted in the discovery of four new maser spots in the source. In May 2003, Hoffman et al. used the VLBA+Y27 to detect the brightest of the masers observed by Mehringer et al. With this proposal, we request additional VLA data necessary in order to interpret quantitatively the recent VLBA+Y27 observations.

# Scientific Justification

The Sgr B2 maser field is a complicated superposition of several HII regions. The 1993 VLA observations show two of the masers (their A and D regions) to be the most intense, having flux densities of approximately 300 mJy. Hoffman et al. observed the A and D masers using the VLBA+Y27, detecting the A maser (Fig. 1 & 2). In order to interpret the VLBI detection of the A maser and the non-detection of the D maser, two factors must be considered: (1) the D maser may have varied in intensity in the 10 years between the VLA and VLBA observations, decreasing below the detection threshold of the VLBI experiment, and (2) the D maser may be too large to be detected on the long VLBI baselines. Both of these explanations have precedents in the study of formaldehyde masers.

Hoffman et al. (2003b) confirmed the variability of one of the NGC 7538 masers and discovered variability in the second maser. Indeed, the formaldehyde masers have been observed to change in flux density by a factor of two in less than five years. Fortunately, this variability appears to be relatively slow and smooth with a timescale of several years. The proposed VLA observations would provide a flux at the modern epoch.

Also, Hoffman et al. (2003b), using the VLA, MERLIN, and the VLBA, made a comprehensive study of the two formaldehyde masers in NGC 7538. Based on the VLA determined flux density, we had expected to detect both masers with both MERLIN and the VLBA. However, one of the maser features was discovered to be extended and barely detected with MERLIN (and not detected with the VLBA), while the other maser is quite bright and easily detected with the VLBA. By using the proposed VLA observations, we can determine whether the Sgr B2 D maser is not detected due to an extended emission morphology or due to a decrease in the flux density from 1993 to 2003. Furthermore, we cannot estimate the flux density successfully observed in the VLBA+Y27 image of the Sgr B2 A maser (Fig. 1) without a recent VLA observing epoch.

In addition, we will obtain resolved spectra of the $H_2CO$ maser sources in Sgr B2 for the first time. Included in Figure 2 along with the VLBA spectrum of the Sgr B2 A maser are the channel widths from the 1993 VLA observations. The VLA observations showed emission in two adjacent 1.5-km/s channels. Without VLA data at finer spectral resolution, it is difficult to interpret the relationship between the VLBA spectral feature and the unresolved 1993 VLA feature(s). If the signal in the two VLA channels is indeed due to two different masers, one of them may simply be resolved out of the VLBA observations. On the other hand, it is well established that spectral lines observed using VLBI have narrower line widths than when observed with shorter-baseline interferometers, in which case a single maser line may be extend across two VLA channels. Palmer, Goss, and Devine (2003) apply this trend to constrain the physical models of 6-cm OH masers (see also Hoffman et al. 2003a for a discussion of 1720-MHz OH masers in supernova remnants). In the current proposal we plan to adequately sample the spectral lines in frequency in order to better constrain these possibilities.

In summary, the proposed observations will play a major role in the interpretation of the eight hours of VLBA+Y27 $H_2CO$ maser data from May 2003 (BH114).

# Proposal and Time Request

In order to achieve sufficient spectral resolution on both the A and D maser regions in Sgr B2, two IF's with different velocity centers will be employed. However, only one array pointing is needed to image both maser regions. The on-line Hanning-smoothed correlator configuration will result in 3-kHz (0.2-km/s) spectral channel width. In order to detect a 30-mJy maser in a 3-kHz channel with 20-$\sigma$ confidence, 6 hours of integration are required. The Galactic center is observable from the VLA for approximately 8 hours each day. In order to accommodate logistical overhead and in order to obtain maximally extended $u$-$v$ coverage, we request one 8-hour allocation on the VLA. This project is suitable for scheduling during a move between array configurations (for example, the upcoming moves from C to D or D to A).

# References

Araya, E., P. Hofner, H. Linz, M. Sewilo, C. Watson, E. Churchwell, L. Olmi, S. Kurtz, 2004 ApJS 154, 579

Araya, E., P. Hofner, S. Kurtz, H. Linz, L. Olmi, M. Sewilo, C. Watson, E. Churchwell, 2005 ApJ 618, 339

Hoffman, I. M., W. M. Goss, C. L. Brogan, M. J. Claussen, A. M. S. Richards, 2003a ApJ 583, 272

Hoffman, Ian M., W. M. Goss, Patrick Palmer, A. M. S. Richards, 2003b ApJ 598, 1061

Palmer, Patrick, W. M. Goss, K. E. Devine, 2003 ApJ 599, 324

Mehringer, David M., W. M. Goss, Patrick Palmer, 1994 ApJ 434, 237

Whiteoak, J. B. & F. F. Gardner, 1983 MNRAS 205, 27P