# VSOP PROPOSAL COVER SHEETS

ID :

TR :

SR :

DEADLINE : 17 November, 1995
SEND TO : VSOP SOG, ISAS, 3-1-1 Yoshinodai, Sagamihara, Kanagawa 229, JAPAN

Please read Appendix C of Announcement of Opportunity for details on how to fill in this Cover Sheet.

**(1)** Date prepared : 6 October 1995

**(2)** Proposal title : Non-scattered OH and $H_2O$ masers

| **(3)** | INVESTIGATORS | INSTITUTION |
|---|---|---|
| P.I. | V.I.Slysh | Astro Space Center, Moscow, Russia |
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**(4)** Principal Investigator (or contact person) details...

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**(5)** Proposal Abstract :

Proposed observations consist of four experiments: simultaneous dual band observations of OH and $H_2O$ masers in G34.26+0.15, G35.20-1.73, NGC6334N and Cepheus A. All the sources are situated in star forming regions that exibit also maser emission in methanol lines, but the latter 2 sources are characterized by strong circular polarization and very short time-scale variability ($<$ 1 year). The sizes of maser spots on this sources, except NGC6334N, have been measured with VLBI techniques by Kemball et al. (1988) and Slysh et al. (1995). Their sizes were found to be about 10 times smaller than the expected scattering angle in the models of I.S. Scattering. It is possible the sources are seen through a "hole" in the scattering medium and were unresolved or partially resolved in those experiments. Therefore high angular resolution observations/images may reveal intrinsic OH and $H_2O$ maser spots, not broadened by interstellar scattering.

**(6)** Proposal Category (indicate all that apply):

Object type:

☐ AGN, ☑ Masers, ☐ Stellar, ☐ Other :

Experiment type:

☑ Single-observation, ☐ Monitoring, ☐ Polarization,
☐ Time-critical, ☐ Target of Opportunity, ☐ Other :

**(7)** VSOP spacecraft observing mode (see Section 3 and Table 5 of the VSOP Proposer's Guide):

☑ 2 channel x 16 MHz, 2-bit (Standard mode),
☐ 2 channel x 32 MHz, 1-bit,
☐ 1 channel x 32 MHz, 2-bit

Phase calibration tones:

☐ On (Standard continuum mode),
☑ Off (Standard spectral line mode)

(Include justification of any non-standard choice at (14) below)

**(8)** Ground radio telescope setup

Polarization :

☑ VSOP Standard (IEEE LCP), ☐ Non-standard :

Recording mode :

☑ As for VSOP spacecraft (Standard), ☐ Other :

**(9)** Investigator participation in scheduling

☑ PI (or co-I) wishes to participate in scheduling ground radio telescopes
☑ PI (or co-I) wishes to participate in scheduling the space radio telescope

**(10)** Preferred correlator (see Sections 9.11 and 12 of VSOP Proposer's Guide):

☐ No preference, ☑ Mitaka, ☐ Socorro, ☐ Other :

**(11)** Preferred post-correlation data analysis location:

☑ Home Institution, ☐ Mitaka, ☐ NRAO AOC, ☐ JIVE, ☐ Other

**(12)** Post-correlation data analysis assistance required:

☐ None, ☑ Consultation, ☐ Extensive help

**(13)** Details of proposed experiments

In this proposal we shall exploit VSOP's dual-band simultaneous observing capability. Since we do not require large BW we shall observe simultaneously with L and K bands, 1 band per VSOP channel. Hence we do require that ground antennas/arrays can switch rapidly (at least every 15-20 min) between both bands if they do not support the simultaneous option.

Number of experiments in this proposal: 4

| | Experiment 1 | Experiment 2 | Experiment 3 | Experiment 4 |
|---|---|---|---|---|
| Source name | G34.26+0.15 | NGC6334N | W48 | Cepheus A |
| RA (hh mm ss.s) | 18 50 46.33 | 17 17 32.1 | 18 59 13.6 | 22 54 19.2 |
| Dec (dd mm ss) | +01 11 14.6 | -35 44 22.0 | +01 09 11.8 | +61 45 47.8 |
| J2000 or B1950? | B1950 | B1950 | B1950 | B1950 |
| Observing frequency band (GHz) | 1.6/22 | 1.6/22 | 1.6/22 | 1.6/22 |
| *Continuum observations:* | | | | |
| Standard VSOP freq. channels? | ☐ | ☐ | ☐ | ☐ |
| Channel A range (MHz) | | | | |
| Channel B range (MHz) | | | | |
| *Spectral line observations:* | | | | |
| Ch.A spectral line rest freq. (MHz) | 1665.4018 | 1665.4018 | 1665.4018 | 1665.4018 |
| Ch.A LSR velocity (km/s) | 55.9 | -10.0 | 59.0 | -13.8 |
| Ch.B spectral line rest freq. (MHz) | 22235.077 | 22235.077 | 22235.077 | 22235.077 |
| Ch.B LSR velocity (km/s) | 60.3 | -10.0 | 62.6 | -10.8 |
| Min. spectral channels per IF channel | 1024 | 1024 | 1024 | 1024 |
| Correlator averaging time (sec) | 0.5 | 0.5 | 0.5 | 0.5 |
| FWHM of field of view required (mas) | 1000 | 50 | 1000 | 1000 |
| No. of correlating passes (if >1) | 2 | 2 | 2 | 2 |
| Measured total flux density (Jy) | 50/600 | 100/65 | 40/30 | 20/4700 |
| Measured correlated flux density on > 5000 km baseline (Jy) | 34/500 | 50/75 | 29/10 | 10/500 |
| Image RMS needed (mJy/beam) | 100/500 | 100/500 | 100/500 | 100/500 |
| *Ground Radio Telescopes:* | | | | |
| *Preferred choice:* | | | | |
| Number of medium telescopes | | | | |
| Number of large telescopes | 3 | 3 | 3 | 3 |
| Suggested array given at Item (14) | ☑ | ☑ | ☑ | ☑ |
| *Minimum acceptable:* | | | | |
| Number of medium telescopes | | | | |
| Number of large telescopes | 2 | 2 | 2 | 2 |
| Suggested array given at Item (14) | ☑ | ☑ | ☑ | ☑ |
| *Length of observation:* | | | | |
| Preferred length (orbits) | 4 | 4 | 4 | 4 |
| Minimum acceptable length (orbits) | 2 | 2 | 2 | 2 |
| *Scheduling constraints*: | | | | |
| Preferred P.A. of beam *major* axis (deg) | | | | |
| 'No holes' ($u$,$v$) coverage? | ☐ | ☐ | ☐ | ☐ |
| *Or* maximum resolution ($u$,$v$) coverage? | ☑ | ☑ | ☑ | ☑ |
| Preferred range of dates for scheduling (for monitoring experiments give range for 1st observation only) | 98-07-20 to | 97-02-20 to | 98-07-20 to | 97-02-20 to |
| *For monitoring programs*: | | | | |
| Number of observations | | | | |
| Mean interval (days) | | | | |
| Acceptable variance from mean (days) | | | | |

**(14)** Additional notes to the scheduler :

Prefered choice: Arrays that can either observe simultaneously L/K band or which can switch quickly, hence, VLBA, Narrabri + 3 DSN 70m antennas, Cambridge and Usuda.
Minimum choice: Antennas must be capable or simultaneous observing of L/K bands or switching quickly between them, hence, VLBA, Narrabri, DSN antennas, Cambridge and Usuda.

**(15)** Attach a scientific and technical justification, not in excess of 2 pages of text and 2 pages of figures. Up to one page of $(u,v)$ plots per source may optionally be included.
(Refer to the VSOP Announcement of Opportunity for detailed instructions.)
Preprints and reprints will not be forwarded to the Scientific Review Committee.

Send two paper copies of the complete proposal to:

VSOP Observing Proposals
VSOP Science Operations Group
Institute of Space and Astronautical Science
3-1-1 Yoshinodai, Sagamihara
Kanagawa 229 JAPAN

In addition, e-mail the completed LaTeX file to submit@vsopgw.isaslan1.isas.ac.jp

Cover Sheets of accepted proposals will be made available to the astronomical community.

**Proposals must be received at ISAS by 17 November 1995**

**Scientific and Technical Justification**

The sources G34.26+0.15 and G35.20-1.73 were observed in 1665 MHz OH maser line with a single-baseline (baseline ~40 M$\lambda$ = 7200 km) interferometer involving Medicina (Bologna) and Hartebeesthoek (Johannesburg) by Kemball, Diamond and Mantovani (1988) among 16 other OH masers. They obtained three positive detections - G34.26+0.15, G35.20-1.73 and G45.47+0.13. All the detected sources are at galactic longitudes $l \geq 34^o$. The first two sources have greater correlated flux density(>30Jy) and their likely distances do not exceed 4 kpc. These OH masers were also observed in the 3-station VLBI experiment in 1993 with Ussuriisk 70-m telescope (Russia), Parkes 64-m telescope (Australia), and Hobart 26-m telescope (Australia, Hobart) using the S-2 recording systems (baseline ~ 9000 kms). The (unpublished) results are similar to those of Kemball et al. NGC6334N and Cepheus A have been observed with VLBI by Kent and Mutel (1982) and Migenes et al. (1995), respectively, in both bands, and both seem to exhibit correlated flux above the VSOP threshold.

The expected scattering angle of a plane wave source in a uniform Kolmogorov medium given by Cordes, Ananthakrishnan and Dennison (1984) for these sources at an observing frequecy of 1.6 GHz is about 20 milliarcseconds, as shown in Kemball et al. The measured diameters for G34.26+0.15, G35.20-1.73 and Cepheus A are about 1.4, 0.8 and 3.0 mas, respectively, which is about 10 times smaller than expected. But this is consistent with a highly clumped small-scale distribution of free electron density turbulence at low galactic latitudes (Cordes et al. 1985). So one can suppose that these sources are observed through a hole in the free electron plasma distribution along the lines of sight with low turbulence in the Galaxy. In the case of NGC6334N the size of the maser spots was estimated to be about 12 mas (Kent and Mutel) but with much lower spatial resolution observations. The source is scattered but there is evidence for finer and smaller structure. Therefore high angular resolution observations of these sources may give the intrinsic sizes of maser spots not broadened by interstellar scattering.

We propose to observe the $H_20$ masers, simultaneously, in order to study the frequency dependence of the scattered size (if any) and to obtain the distribution of $H_20$ maser spots relative to OH masers. The strong (~600Jy) water maser in G34.26+0.15 was first detected by Genzel and Downes (1977) at a radial velocity 58.0 km/s which is shifted by 2.1 km/s from the center of OH maser line. It was not observed with VLBI, so the correlated flux density given in the cover sheet table is an estimate obtained with formula (8) of VSOP proposer's guide, assuming interferometer baseline length of 5000 km. The other 3 sources have all been observed at 22 GHz and show sufficient maser emission as to be detected with VSOP baselines. Technically, the fringe search at L band will also help the search at 22 GHz at the correlator.

The interferometer fringe separation in the Kemball et al. (1988) experiment was ~5mas. An apparent angular size of a maser spot was then estimated assuming a circularly symmetric Gaussian brihgtness distribution model. The estimates may be in error due to the poor uv-coverage; also the sources may have a more complicated structure, and maser spots may be unresolved. Though the size estimates from Slysh et al. (1995) arise from slightly larger baselines our uv coverage was also poor. Thus observations with higher angular resolution may give important knowledge of internal structure of masers. The possible results will be interesting for the physics of maser emission, and for the investigation of star formation processes and interstellar scattering distribution. The prototypical OH maser W3(OH) well studied with VLBI has OH and $H_20$ masers distribution of about 1 arcsecond in diameter, see for example Reid and Moran (1988). So we propose to cover a field of view of 1 arcsecond. To resolve different maser spots in radial velocity it is important to have maximum number of spectral channels per IF channel. A typical image of OH maser consists of many maser spots with diameters of about 1 mas or less distributed in a region of about 1 arcsecond in diameter. So (u,v) coverage must be chosen to provide maximum angular resolution, but one needs not to fill all holes in the (u,v) plane. The preferred choice of ground based radio telescopes is three large telescopes: Madrid, Goldstone and Tidbinbilla, the VLBA and ATCA since they are capable of switching quickly between L and K band. Hence, while VSOP observes simultaneously at L and K band the ground antennas will switch bands every 15 minutes. The preferred observation period for sources 1 and 3 are: 1998 July 20 - 1998 Oct 25, and for sources 2 and 4 is 1997 Feb 20 - 1997 May 10, since they will provide the best uv coverage possible.