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VSOP PROPOSAL COVER SHEETS

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 : November 17, 1995

(2) Proposal title : The Intraday Variable Source PKS 0405-385

(3)	INVESTIGATORS	INSTITUTION
P.I.	L. Kedziora-Chudczer	RCfTA/Sydney Uni.
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co-I.	P. McCulloch, J. Lovell, M. Costa	University of Tasmania
co-I.	E. Valtaoja, M. Tornikoski	Metsahovi Radio Observatory
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(5) Proposal Abstract :

We propose to monitor at 1.6 GHz, over the period of two days (eight spacecraft orbits) and with a global array of radio telescopes in conjunction with VSOP, PKS 0405-385, a high amplitude and short time-scale variable radio source.
We specifically wish to coordinate the VSOP observation with our ground-based monitoring of the total flux in many wavelength bands and the radio polarisation.
A comparison between variations in the source structure, brightness temperature, total radio flux and polaristion will be possible, constraining the Doppler factor for the radiating material and models which seek to explain the variability.

(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

An 'experiment' is one or more observations of one source in one wavelength band.
A request to observe the same source in all 3 wavelength bands requires 3 columns to be filled in.
To observe the same source at the same frequency multiple times – a 'monitoring experiment' – requires only one column to be filled in.
Number of experiments in this proposal: 1

	Experiment 1	Experiment 2	Experiment 3	Experiment 4
Source name	PKS 0405-385			
RA (hh mm ss.s)	04 05 12.00			
Dec (dd mm ss)	-38 34 26			
J2000 or B1950?	B1950			
Observing frequency band (GHz)	1.6			
Continuum observations:				
Standard VSOP freq. channels?	☑	☐	☐	☐
Channel A range (MHz)				
Channel B range (MHz)				
Spectral line observations:				
Ch.A spectral line rest freq. (MHz)				
Ch.A LSR velocity (km/s)				
Ch.B spectral line rest freq. (MHz)				
Ch.B LSR velocity (km/s)				
Min. spectral channels per IF channel				
Correlator averaging time (sec)				
FWHM of field of view required (mas)				
No. of correlating passes (if >1)				
Measured total flux density (Jy)	1 - 2 Jy			
Measured correlated flux density on > 5000 km baseline (Jy)	0.42 Jy			
Image RMS needed (mJy/beam)	∼10			
Ground Radio Telescopes:				
Preferred choice:				
Number of medium telescopes	14			
Number of large telescopes	3			
Suggested array given at Item (14)	☑	☐	☐	☐
Minimum acceptable:				
Number of medium telescopes	3			
Number of large telescopes	3			
Suggested array given at Item (14)	☑	☐	☐	☐
Length of observation:				
Preferred length (orbits)	8			
Minimum acceptable length (orbits)	4			
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)	97-02-01 to 97-02-30	to	to	to
For monitoring programs:				
Number of observations				
Mean interval (days)				
Acceptable variance from mean (days)				

(14) Additional notes to the scheduler :

Suggested preferred array: VLBA, Tidbinbilla, Noto, Mopra, Madrid, Hobart, Hartebeestoek, Goldstone, VSOP

Suggested minimum array: Tidbinbilla, Madrid, Hobart, Hartebeesthoek, Goldstone, Greenbank, VSOP

(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

The intraday variable source PKS 0405-385

Introduction The flux variability of flat spectrum, compact radio sources on time scales of months and years has been observed and discussed extensively. Recently, it has been found that radio sources can vary on much shorter time scales. Variations on the scale of days were first reported by Witzel et al. in 1986. A sample of 16 sources was monitored at wavelenghts between 2cm and 20cm (Quirrenbach et al. 1989). The fluxes of some of the sources observed varied by more than 20% within 24 hours. The variations seem to be most regular and strongest at a wavelength of 11cm. About 70% of the sample has also shown changes in polarization. The highest variability in amplitude, accompanied by changes of polarized flux density by a factor of ~ 3, has been observed for the quasar $0917 + 624$.

The variations at low radio frequencies (< 1GHz) are believed to be due to scattering in the interstellar and intergalactic medium. However, variations observed at higher frequencies are difficult to explain in this way, because the propagation effects responsible for low frequency variability decrease rapidly with increasing frequency. The alternative explanation, viz. the rapid variations are intrinsic to the source, requires the introduction of relativistic motion if the synchrotron hypothesis is maintained.

The possible explanations of intraday variability, therefore, include processes intrinsic and extrinsic to the sources. The two interpretations of the intraday variability in terms of propagations effects suggested so far are: refractive interstellar scattering (Heeschen et al, 1987) and microlensing by massive stars (Quirrenbach, 1991). The first hypothesis has difficulties accounting for the observed wavelength dependence and changes in polarization. On the other hand, in order to explain short time scale variations by microlensing, it is necessary to assume very high apparent transverse velocities ($> 40c$) between the lens and the source.

As intrinsic intraday flux variations are considered the coherent emission processes, Doppler boosting, and a shock propagating in a jet of the radio source (Qian et al. 1990) have been suggested. All these hypotheses avoid violating the inverse Compton limit for the brightness temperature. However, they pose other difficulties which cannot be easily solved. For instance, in order to apply the expanding synchrotron component model, used as an explanation for variations of compact radio sources, on the scale of days, very high Doppler factors ($D > 100$) are necessary.

We have undertaken a monitoring program of a sample of 120 compact, flat spectrum radio sources (Duncan et al. 1992) in search for intraday flux variations. The sources are observed at 3 cm, 6 cm, 13 cm and 20 cm to obtain broad spectral information on the variability (essential to distinguish between competing models). We also intend to look for changes in polarized flux. In order to link intraday variability with flux variations at longer time scales, we repeat the $3 - 4$ days observing sessions every a few months. The objective of the observing program is to detect flux variations stronger than $\pm 5\%$. The most spectacular intraday variable source found so far is PKS 0405-385 (Kedziora-Chudczer et el. in prep).

PKS 0405-385 The PKS 0405-385 is a quasar with optical magnitude m=18 and redshift z=1.285. It is a very compact, flat spectrum radio source detected also by EGRET in gamma-rays. The source varies rapidly at all frequencies observed in our program. Its total flux in the 3, 6 and 13 cm bands shows a continuous long term decrease combined with rapid short time variations. The strongest and fastest have been detected at 13 cm in May 94 (20% within 2 hours). At 6 cm the flux changes seem to persist over four epoch of monitoring with maximum 18% peak-to-peak change within 2 days in May 94 which is shown in figure . The at 3 cm flux variations have been strongest in November 93 (13%). Figure 1 shows the total flux density variablity at 3, 6 and 13 cm as measured with the ATCA.

The observations

We propose to use the high resolution capabilities of the VSOP mission to monitor, over a 48 hour period, the intraday variable PKS 0405-385. We therefore request the global array in conjunction with the VSOP satellite operating at a frequency of 1.6 GHz to observe PKS 0405-385 over 8 consecutive orbits. We require several large ground radio telescopes for improved signal to noise, for the purposes of imaging the source at several separate time steps, for comparison with variability and polarisation data obtained concurrently from the ground.

Scientific Justification

By the nature of the object we are proposing to study, short time-scale observations are required.

The strongest variations in the total flux density of PKS 0405-385 have been observed over time-scales of a few hours to two days at cm wavelengths. Thus we have requested two days of contiguous observations with VSOP and an array of telescopes on the ground which will allow almost continuous monitoring with several ground telescopes plus VSOP over the two days at a frequency of 1.6 GHz, in the range of the strongest variations.

These observations will allow us to monitor the brightness temperature and mas structure of the radio source over a period in time during which we will also be monitoring the total flux denisty and polarisation of the source at several frequencies, including 1.6 GHz.

Moreover, over a two day period, the space to ground u-v tracks change very little. Consequently, it will be possible to compare directly the visibilities from day to day at essentially the same points in the u-v plane, and to compare this with the total flux density variations. This will, in principle, allow us to image the background, non-variable (over one day) component of the source, separating it from the component which varies on shorter time-scales.

To achieve both of these goals, high signal to noise data is essential, as is good u-v coverage. Hence we request observations at 1.6 GHz, where the variability is strongest.

The NASA 70m antennas are also available at this frequency, giving high sensitivity, as well as world-wide coverage. The VLBA provides extensive u-v tracks. Interplanetary scintillations have little effect. At $>70^\circ$ from the sun (the solar avoidance limit) the scintillation index is less than 1% (Cohen, 1969, ARAA 7, 619).

An important outcome of this monitoring will be the detailed comparison of the Doppler factor inferred from variability arguements and the Doppler factor inferred from the VSOP measured brightness temperature. Any structural changes in the source over this short period in time will also be monitored. Thus we will be able to determine if the strong total flux density variability is due to variability in the unresolved core of the radio source, or components within a jet which is highly aligned with our line-of-sight.

References

Quirrenbach, A. 1991, *Variability of Active Galactic Nuclei* ed. Miller, H.R., Wiita, P.J. M. Cambridge University Press, p.165

Quirrenbach, A., Witzel, A., Krichbaum, T., Hummel, C.A., Alberti, A., & Schalinski, C., 1989 *Astron. Astrophys.* **226**, L1

Heeschen, D.S., Krichbaum, T. Schalinski, C.J., & Witzel, A., 1987 *Astron. J.* **94**, 1493

Qian, S.J.,Quirrenbach, A., Witzel, A., Krichbaum, T., Hummel, C.A., Zensus J.A., 1990, *Astron. Astrophys.* **241**, 15

Duncan, R.A., White, G.L., Wark, R., Reynolds, J.E., Jauncey, D.L., Norris, R.P., Taaffe, L., Savage, A., 1993 *Proc. ASA* **10**, 310

Figure 2. Ground radio telescope usage for monitoring observations of PKS 0405-385 during an eight orbit period in February 1997, using the suggested preferred array. Almost continuous tracking is possible with 4 or more ground radio telescopes

Figure 3. The uv coverage for the eight orbit observation of PKS 0405-385 during February 1997, using the suggested preferred array.