DRAFT

VLB ARRAY MEMO No. 435

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To: VLBA

From: Alan E.E. Rogers

Subject: Proposed Pulsar Support Modes - Draft for comments -

Introduction

Various VLBA memos discuss pulsar observations with special emphasis on astrometry. See the following:

Memo	Series	Author	Title
351	main	Backer	Pulsar VLBI Specifications
361	main	Gwinn	Pulsar Astrometry-Ionospheric Corr.
367	main	Bartel	Pulsar Dedispersion Mode
380	main	Shapiro	Pulsar Astrometry-Iono. Correct.

The need for dedispersion and ionospheric correction is clear.

Proposed observing pulsar astrometry observing mode:

# Video bands	32*	(16 USB + 16 LSB pairs)
Video bandwidth	1	MHz
# bits/sample	2	
# tracks/pass	32	
Record speed	135	IPS
Data rate	128	M/bits/sec

*When sensitivity is not of prime importance only 16 USB would be used

With DM = 100 pc cm^{-3}

Sweep time (=pulse smearing) over 1 MHz at 1.4 GHz = 230 usec

detection sensitivity (SNR ~ 6) ~ 5 mJ (without pulse gate enhancement)

~ 1 mJ (with pulse gate enhancement)

assuming VLA to 1 VLBA element (T_s ~ 30°K, efficiency ~ 60%, t = 300 sec)

Comments:

a) Dedispersion

With each individual band only 1 MHz wide gating should provide adequate dedispersion for L-band observations. The phase of the pulsar gate should be set individually for each frequency channel. (Dedispersion of 1.5 ms pulsar, 1937+21 is a difficult case but even in this care the SNR will be within about $\sqrt{2}$ of optimum).

b) Ionospheric Correction

The VLBA has sufficient bandwidth at L-band to provide an ionospheric correction using the data itself. To make an approximate evaluation of the performance consider the following frequency sequence:

1300.99 MHz
1305.99 MHz
1320.99 MHz
1350.99 MHz
1405.99 MHz
1445.99 MHz
1470.99 MHz
1480.99 MHz

1619.99 MHz
1624.99 MHz
1639.99 MHz
1669.99 MHz
1724.99 MHz
1764.99 MHz
1789.99 MHz
1799.99 MHz

This sequence provides 2 minimum redundancy sub-arrays each with spanned bandwidth of 180 MHz and ambiguity of 200 nanoseconds. With an SNR of 20+ (within each sub-array) the group delay can be measured with one sigma error of 110 picoseconds for each sub-array and the difference between the group delays for each sub-array can be use to estimate the ionospheric path and to develop an observable which is completely free from ionospheric effects. With one sigma error of 410 picoseconds.

+Can be achieved with pulsar of 4% duty cycle and average flux of 5 mJ.

c) Correlator Support

Minimum requirements

1) Pulsar gating capability with separately programmable gating function+ for each baseband channel.

Gating with precision better than one microsecond and with pulse periods from 100 microseconds to 100 seconds. (The gating could be accomplished in the DPS with some loss of generality - the ability to suport multiple gating functions on each frequency channel without reducing the number of frequency channels).

Other requirements

1) Ability to support the Erickson method (by multiple pass processing if necessary) which requires software to allow processing with harmonics of the fringe rate.

2) Ability to suport multiple gates (by multiple pass processing if necessaray) to be able to measure the interferometric amplitude and phase across the pulse profile.

+simple gate function with one phase and duty cycle is not quite sufficient as some pulsars have multiple pulses. A more general gating function with at least three separately programmable phases and three separately programmable duty cycles is needed.