GLOBAL FRINGE FITTING FOR POLARIZATION VLBI

L. F. Brown and D. H. Roberts
Department of Physics
Brandeis University
Waltham, MA 02254 USA

ABSTRACT. We present a global fringe fitting technique for the polarized fringes in VLBI. The standard search method imposes a signal-to-noise (*SNR*) limit on usable data. In our method the search procedure is circumvented and the *SNR* limitation removed.

1. INTRODUCTION

Standard VLBI data processing methods search a range of delays τ and delay rates $\dot{\tau}$ to "find the fringes;" this requires a large number of trials, typically $N=10^4$–10^5. The probability of false fringe detection depends on both N and the *SNR* of the fringe which is identified (Thompson *et al.* 1986). This places restrictions on the minimum *SNR* that can used if one wants to be confident of having found a true fringe; in Mark III VLBI this limit is 7. Compact radio sources are typically 1–10% linearly polarized, so the linearly polarized intensity (cross-hand, "XH") correlation coefficients are a tenth to a hundredth of the total intensity (parallel-hand, "PH") coefficients. The *SNR* restriction and reduced flux thus put a significant amount of VLBI polarization data at or below the limit of reliable detectability by the standard fringe search technique. Our technique, a simplified form of global fringe fitting (Schwab and Cotton 1983), was developed to circumvent the restrictions imposed by fringe searching and hence reclaim low *SNR* data.

2. THE R-L DELAY DIFFERENCE METHOD

Each VLBI station has different instrumental delays for right and left circular polarizations, so the PH (RR and LL) and XH (RL and LR) fringes are located at different residual delays. Our procedure predicts the location in $(\tau, \dot{\tau})$ space of the XH fringes by combining the observed τ and $\dot{\tau}$ of the PH fringes with the right-minus-left (R-L) station differences $\delta\tau$ and $\delta\dot{\tau}$. Using reliable ($SNR \geq 7$) PH and XH fringes, we determine $\delta\tau$ and $\delta\dot{\tau}$ for each station as a function of time throughout an experiment. For each baseline there are two independent estimates of the single- and multi-band $\delta\tau$ for each end of the baseline; for stations x and y on baseline xy,

$$\delta\tau_x \equiv \tau_x^R - \tau_x^L = (\tau_x^R - \tau_y^L) - (\tau_x^L - \tau_y^L) = \tau_{xy}^{RL} - \tau_{xy}^{LL} \,,$$

$$\delta\tau_y \equiv \tau_y^R - \tau_y^L = (\tau_x^R - \tau_y^L) - (\tau_x^R - \tau_y^R) = \tau_{xy}^{RL} - \tau_{xy}^{RR} \,,$$

plus two similar equations for reversed baseline order. The computation of $\delta\dot{\tau}$ mimicks that of $\delta\tau$. An example of the PH and XH multiband delays on one baseline is shown in

M. J. Reid and J. M. Moran (eds.), The Impact of VLBI on Astrophysics and Geophysics, 155–156.

https://doi.org/10.1017/S0074180900134345 Published online by Cambridge University Press

Figure 1. Figure 2 shows the results of determining the R-L delay differences for one station. The individual station R-L differences are found to be fairly stable over the duration of an experiment (typically 24 hours), so mean $\delta\tau$ is adopted for each station. The average $\delta\dot{\tau}$s were all found to be zero, so the delay-rates for the XH fringes on a given scan are taken to be the same as that of the associated parallel-hand fringes. We predict the XH τ from the PH τ using the R-L differences; take an RL scan as an example:

$$\tau_{xy}^{RL}|_{\mathrm{pred}} = \tau_{xy}^{LL}|_{\mathrm{obs}} + \overline{\delta\tau_x} \quad \text{or} \quad \tau_{xy}^{RL}|_{\mathrm{pred}} = \tau_{xy}^{RR}|_{\mathrm{obs}} + \overline{\delta\tau_y} \ .$$

This procedure is followed for both the single- and multi-band delays, and the results are passed to the Mark III fringe parameter estimation program, which finds the amplitude and phase of the cross fringes without having to search $(\tau, \dot{\tau})$ space. Since the number of trials is reduced to one, the *SNR* restriction is bypassed.

3. RESULTS

The results shown here were derived from data taken in March of 1984 in a run using six stations: Bonn, Haystack, NRAO, Ft. Davis, VLA, and OVRO. The refringed to standard ratios should behave in the following manner: in the *SNR* range 0-5 the ratios should be essentially random as the standard fringes below *SNR*=7 have a high probability of being false detections; in the range 6-9 the scans should agree fairly well in amplitude and phase. In the high *SNR* range (> 10) there should be little disagreement between the two methods. This behavior is seen in the fitted results; for example, Figure 3 shows the complex ratio of the the R-L delay difference refringed scans to the standard processing scans in the refringed *SNR* range 6-9. Preliminary applications show the R-L delay difference technique to work well. There is a significant increase in the amount of usable data for a not undue amount of additional computation time. There is, however, some evidence for short term $\delta\tau$ drifts at some stations. Present work involves applying the R-L differences on a scan-by-scan basis, which can be done if there is at least one good set of XH fringes to each station for each scan.

REFERENCES

Thompson, R. A., Moran, J. M., and Swenson, G. W. 1986, *Interferometry and Synthesis in Radio Astronomy*, (New York: Wiley), p. 264.

Schwab, F. R., and Cotton, W. D. 1983, *A.J.*, **88**, 688.

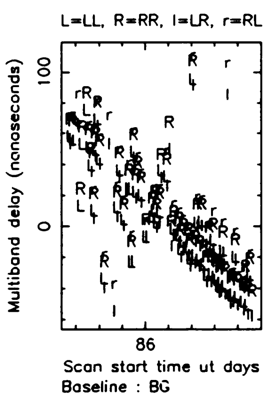

Figure 1

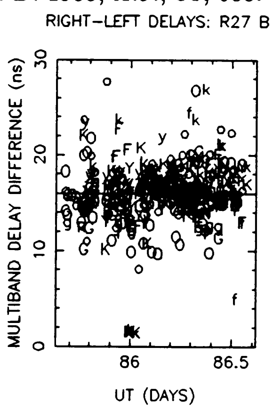

Figure 2

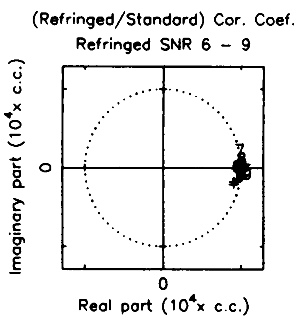

Figure 3

https://doi.org/10.1017/S0074180900134345 Published online by Cambridge University Press