PHASE CONNECTION FOR GEODESY: RESULTS FROM A 245-KM BASELINE

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ABSTRACT. In an effort to greatly improve the measurement precision of VLBI observables used to determine geodetic baselines, the potential of utilizing fringe phase has been investigated. The 245-km baseline between Mojave and Owens Valley (in CA) has been most thoroughly studied for this purpose. In trying several different experimental designs it appears that source scheduling is not the critical factor in determining when phase connection can be established. Normally, instrumental instabilities are also not limiting (although nominal functioning of the instrumentation is essential). The most serious factor in limiting opportunities for phase connection seems to be atmospheric variability. However, when the observation SNR is made large (> 50) to give very precise group delays (and hence enhance the chance of resolving phase ambiguities), the improvement in baseline uncertainty obtained using phase delays is only marginal compared with the corresponding group delay solution. For this case, the baseline error budget is dominated by stochastic variations in clock and atmospheric delay contributions rather than by observation noise.

1. INTRODUCTION

Normally, geodetic VLBI measurements are made using bandwidth synthesis group delay observations of quasars, the fundamental precision of which is limited by the radio bandwidth that can be spanned. A large gain in measurement precision is possible if, instead, phase delay can be used as the observable. For the frequency sequences used by NASA's Crustal Dynamics Project (CDP), the improvement in measurement precision is roughly a factor of 50. The overwhelming obstacle to using phase delays is the resolution of the cycle (two-pi) ambiguities inherent in phase measurements. Effective utilization of fringe phase requires that those ambiguities be resolved to a common lobe for all observations of a given experiment session. Recent CDP research efforts to use the precise phase observable have concentrated on developing observing and analysis techniques that will enhance the probability for maintaining phase connection for one-day intervals over

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baseline lengths of 100 to 1000 km. The goal is to measure the lengths of such baselines to within a few millimeters (i.e., a precision of about 0.01 ppm or better). Potential applications include refined studies of tectonic activity in regions such as southern California. Recognizing that phase connection over baselines of such lengths may not be a routine occurrence, a secondary interest is the identification of those processes which set the limit for phase stability. In particular, the characterization of instrumental variations has played a significant role in the effort.

2. METHODS & RESULTS

The baseline most intensively investigated for this study is the 245-km baseline between the 12-m Mojave Base Station antenna (in the Goldstone complex near Barstow, CA) and the 40-m dish at the Owens Valley Radio Observatory (OVRO). Several different observing strategies have been attempted, including scheduling observations of sources within a few tight clusters and more conventional geodetic schedules with longer slews between scans. Each approach has yielded successful phase connections at least once, indicating that schedule design need not be the critical factor in determining phase connectability. In addition, several analysis techniques have been applied to the problem of phase ambiguity resolution: shifting of the phases to the lobe nearest to the corresponding group delay (after dual-band correction for ionospheric dispersion); comparison to refined theoretical delays formed by parameter adjustments using the group delays. Both weighted least-squares and Kalman filtering have been used for the parameter estimation. Experience indicates that the most powerful approach for ambiguity resolution is the use of Kalman filtering of group delays made with SNR values of 50 or greater.

The CDP experiment most successful in its phase resolution was run on 1986 October 18 and, in addition to Mojave and OVRO, involved the 26-m antenna at Hat Creek, a 5-m mobile station located at Quincy, and a 4-m mobile at Monument Peak (all in CA). Kalman filter analysis of the group delays from all the stations except Hat Creek was used to generate refined theoretical delay values which in turn were used to produce phase residuals. The phases for the Mojave-OVRO baseline were found to be readily and reliably resolvable, whereas those from the remaining baselines were not. The ambiguity resolution was performed independently for both the X- and S-band data, ionospheric correction values were recalculated from the phases, and a Kalman solution was run for the Mojave-OVRO baseline. Comparison of the phase delay baseline solution with that using the group delays shows, at best, only marginal improvement in the determination of the baseline length and the three-dimensional station coordinates. The reason for this is that estimation of the stochastic clock and atmospheric variations, rather than measurement noise, dominates the error budget for the baseline results. Nonetheless, the effort has proven useful in revealing subtle instrumental variations in the Mark III system that had not previously been detected.

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