Effects on the Geodetic-VLBI Measurables Due to Polarization Leakage in the Receivers

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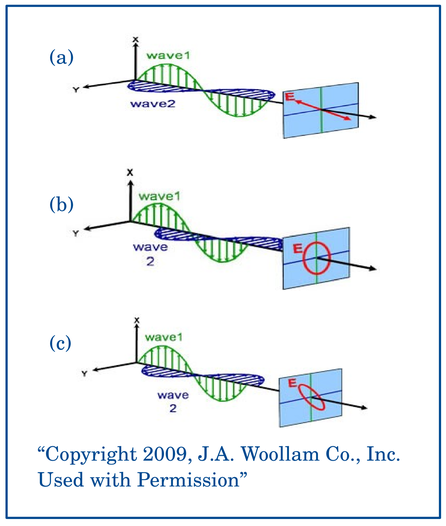
Polarization leakage:
- is an instrumental error that decreases the precision of the geodetic and astrometric measurements.
- can be corrected in the data provided the leakage characteristics are known.

1. Polarization Principle:

- Light is an electromagnetic field propagating in space.
- The ***E*** field for a wave of arbitrary polarization may be viewed as the vector sum of the fields oscillating in orthogonal planes.
- The motion of the tip of ***E*** gives the wave's polarization state.
- If the light emitter is incoherent => polarization is measured statistically.

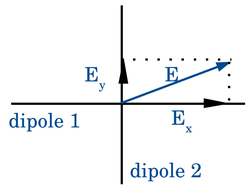


Let wave1 be the component of ***E*** along *xz* plane and wave 2 be the component of ***E*** along *yz* plane:

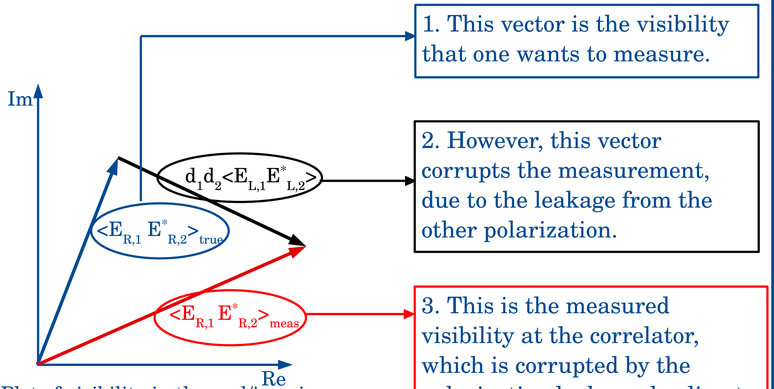
- If wave1 and wave2 are in phase => linear polarization [figure (a)]
- If wave1 and wave2 have a 90° phase shift => circular polarization [figure(b)]
- If wave1 and wave2 have an arbitrary phase shift => elliptical polarization [figure(c)]

2. Polarization in VLBI:

- To determine station & source position, VLBI uses the relative phase of the incoming electric field at the two stations.
- To receive the full electric field (***E***) of the incoming radiation one needs two dipoles.



- To maximize the SNR in the cross-correlation one wants to select the same polarization states at the two stations (geodetic VLBI uses only right circular polarization, acronym: RCP).
- A polarizer is required to select the two states.
- Polarizers do not separate the two polarization states with perfect purity => contamination occurs, which adds vectorially to the signal, corrupting the visibility (see below).
- The effects of leakage on visibility phases:

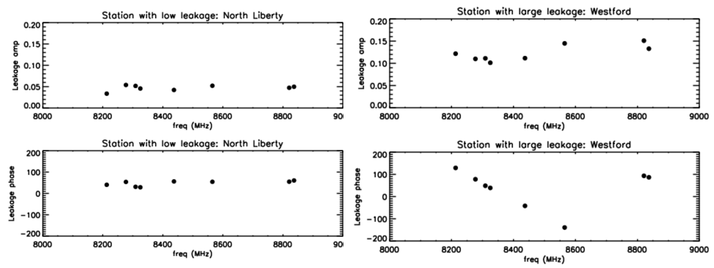


Plot of visibility in the real/imaginary plane for one scan. E_R = ***E*** of RCP arriving at each ant. E_L = ***E*** of LCP

3. Measuring the leakage characteristic:

In this project, we measured the polarization leakage at some geodetic VLBI stations and at the VLBA using the S/X receivers. The principle of the measurement is to observe an unpolarized source and ascribe any coherence found between nominally orthogonal polarization states to leakage.

Sample of the results:



How to estimate the effect on delay:

- Consider ideal visibility with 1 Jy source and 0° visibility phase and no leakage.
- Derive the visibility phase change due to the leakage and add this to the ideal visibility, corrupting the visibility with leakage. (Note that the phase change due to the leakage can vary from source to source and over time on a given source due to differential feed rotation angles => it cannot be easily absorbed in a baseline clock)
- FFT the corrupted visibility spectrum to MBD.
- Fit Gaussian to the MBD peak.
- The peak for the baseline North Liberty–Westford (Nl-Wf) was found to be shifted by 4.45e-12 s due to leakage.

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delay error (Nl – Wf) : 4.4 ps or 1.2 mm

(Note: this analysis was done considering 0° parallactic angle at both stations.

- Extra delay can be removed in software that will be developed.

The correction will yield better baseline-length repeatability