Offset Decoding with A1 Sequences in Digitally Enhanced Interferometry

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Digitally enhanced interferometry (DI) finds its application across a broad range of optical interferometeric metrology including optical phased arrays, coherent LIDAR, fiber acoustic sensing, optical fiber frequency references and spectroscopy. This rapid and widespread development has been driven by DI's key premise: to leverage the correlation properties of pseudo-random noise (PRN) codes to independently measure optical time-of-flight and optical phase for each optical path within an interferometer. Using these PRN codes, DI enables channel isolation and multiplexed operation. By sharing much of the interferometer optics and using a single light source and photoreceiver, DI interferometers can therefore host many interferometer channels concurrently; using signal processing instead of optical complexity.

The typically used PRN code for DI is the maximal length sequence (m-sequence). These exhibit one significant limitation which is that crosstalk suppression between code delayed signals is limited to $1/L_M$ [1], where L_M is the PRN code length and the code gain upon zero relative decoding delay. This limits the optical phase noise rejection from delay mismatched interferometer signals, and where optical phase sensitivity approaching microradians is required, becomes dominant.

We have recently published a paper that provides a new approach called Offset decoding (OD), to eliminate the crosstalk-bandwidth limitation of standard m-sequence PRN codes [2]. Offset decoding preserves the convenient properties of m-sequence PRN codes while algebraically cancelling the $1/L_M$ residual response for delay mismatched signals and noise. In this talk, we introduce another PRN code, called A1 sequences [3], that is not only compatible with OD but provides additional advantages over m-sequences in removing the noise coupling effects arising from bandwidth limitations along the PRN signal chain.

[1] Daniel A. Shaddock, *Opt. Lett.* **32**, 3355–3357 (2007).

[2] A. Dey, Y. Zhang, J. Wong, P. G. Sibley, C. P. Bandutunga, M. B. Gray and J. H. Chow, *Opt. Lett.***46**, 5830-5833(2021).

[3] C. Nagasawa, M. Abo, H. Yamamoto and O. Uchino, *Appl. Opt.***10**, 1466–1470(1990).