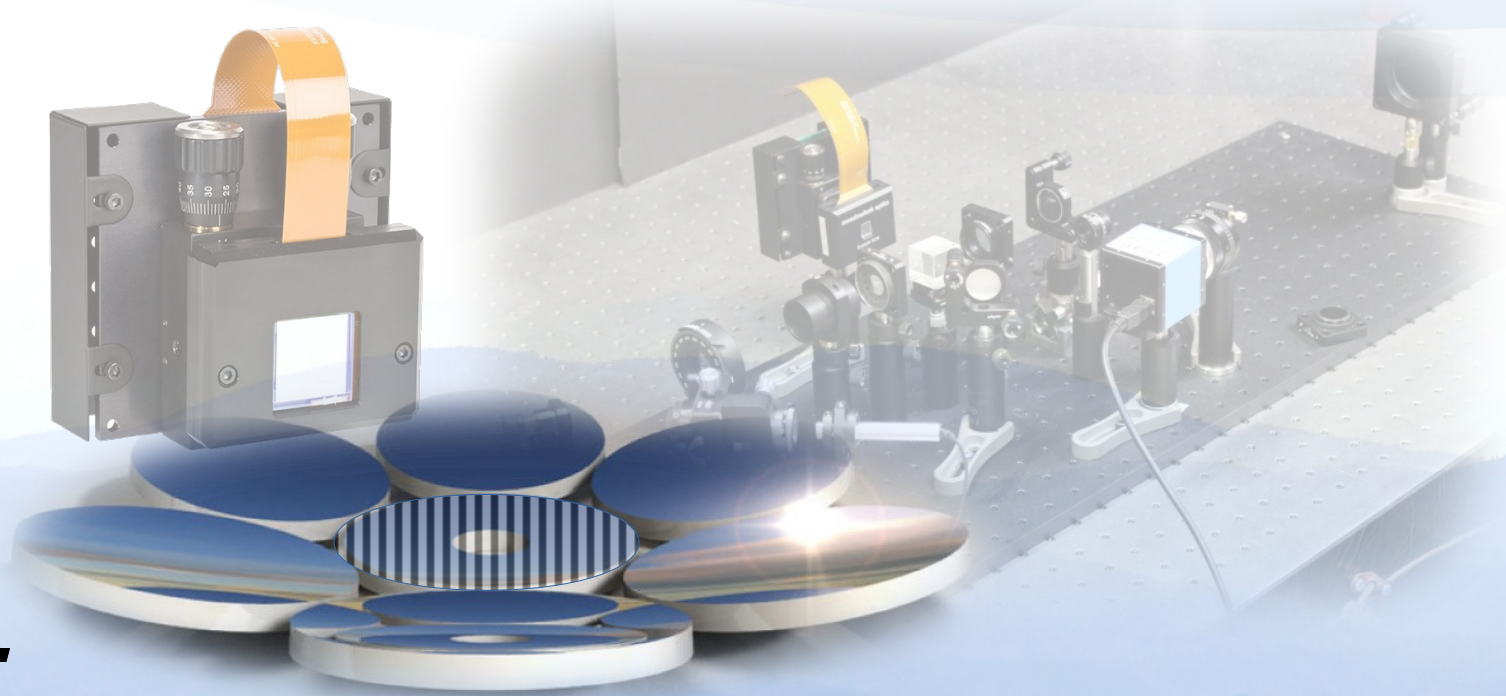
A PHASE RECONFIGURABLE NULLING INTERFEROMETER

Hugh J. Masterson - Boulder Nonlinear Systems, Inc



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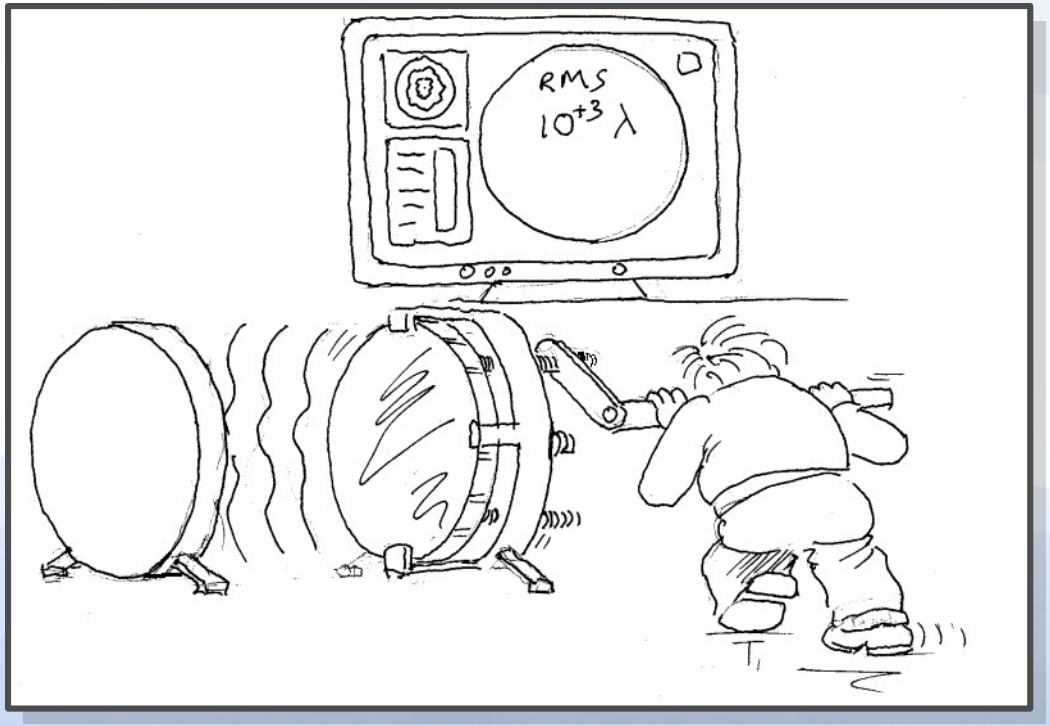
OUR TECH IS NON-MECHANICAL !



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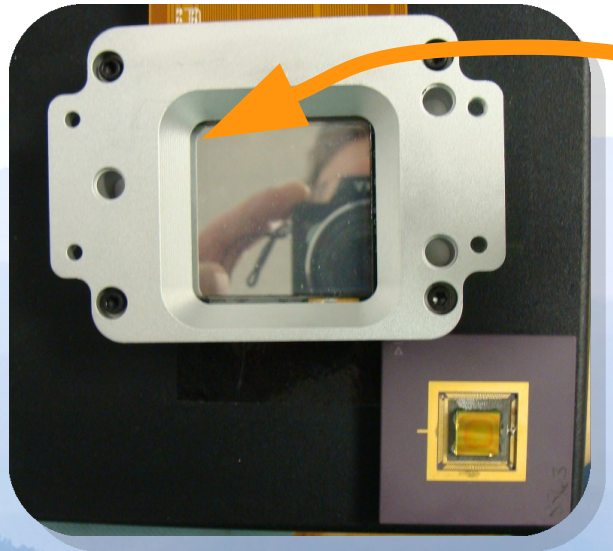
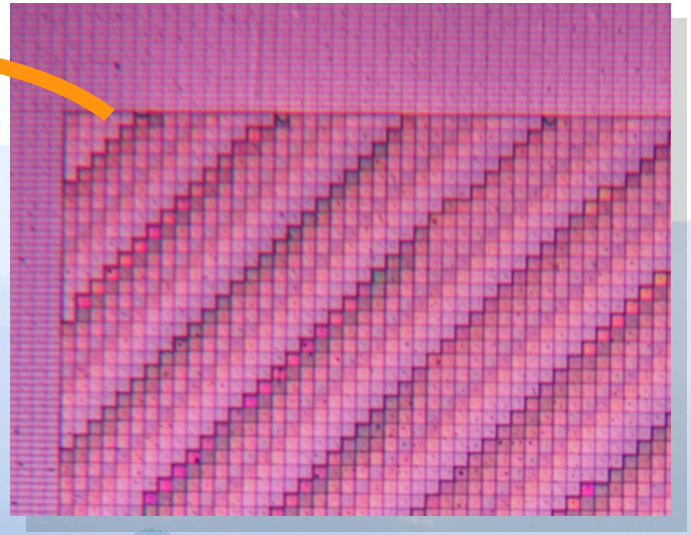
CORE TECHNOLOGY

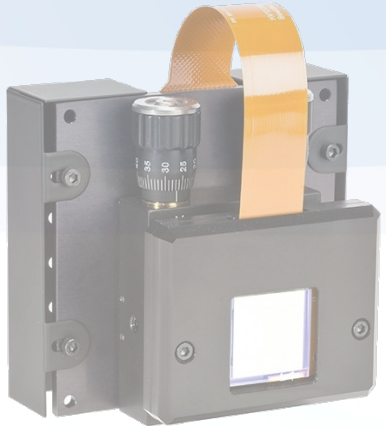
- Liquid Crystal on Silicon (LCoS) Spatial Light Modulator (SLM)
  - Pixelated devices with voltage controlled 2π phase per pixel
  - Standard Format 512x512 – 15μm pixels employe in this work
  - 1.5k x 1.5k 25μm pixel devices recently developed at BNS





WHY SLMs ?

Benefits



- Reconfigurability and sub-nm level phase control
- Non-mechanical and vibration free
- Possible cost savings over CGHs

Application Areas

- Nulling, phase shifting, and spatial carrier interferometry
- Substitution for a CGH or fine phase control with a general purpose CGH
- Compensation of moving air currents
- Crown jewel is to leverage the sub-nm phase control in metrology

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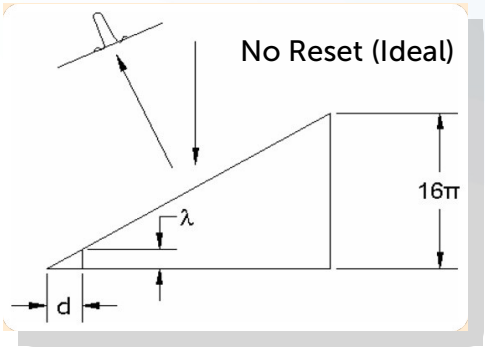
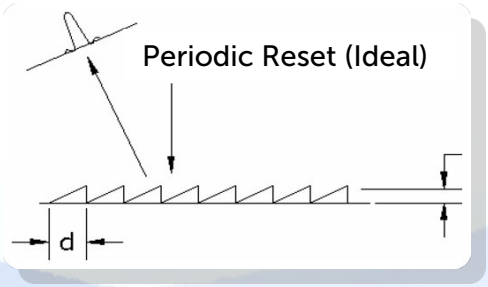
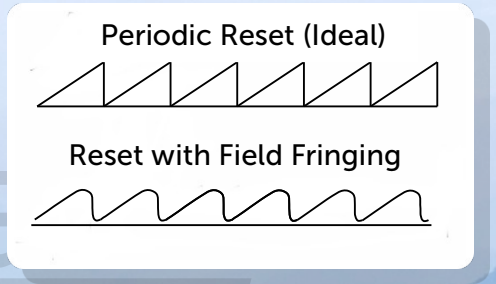
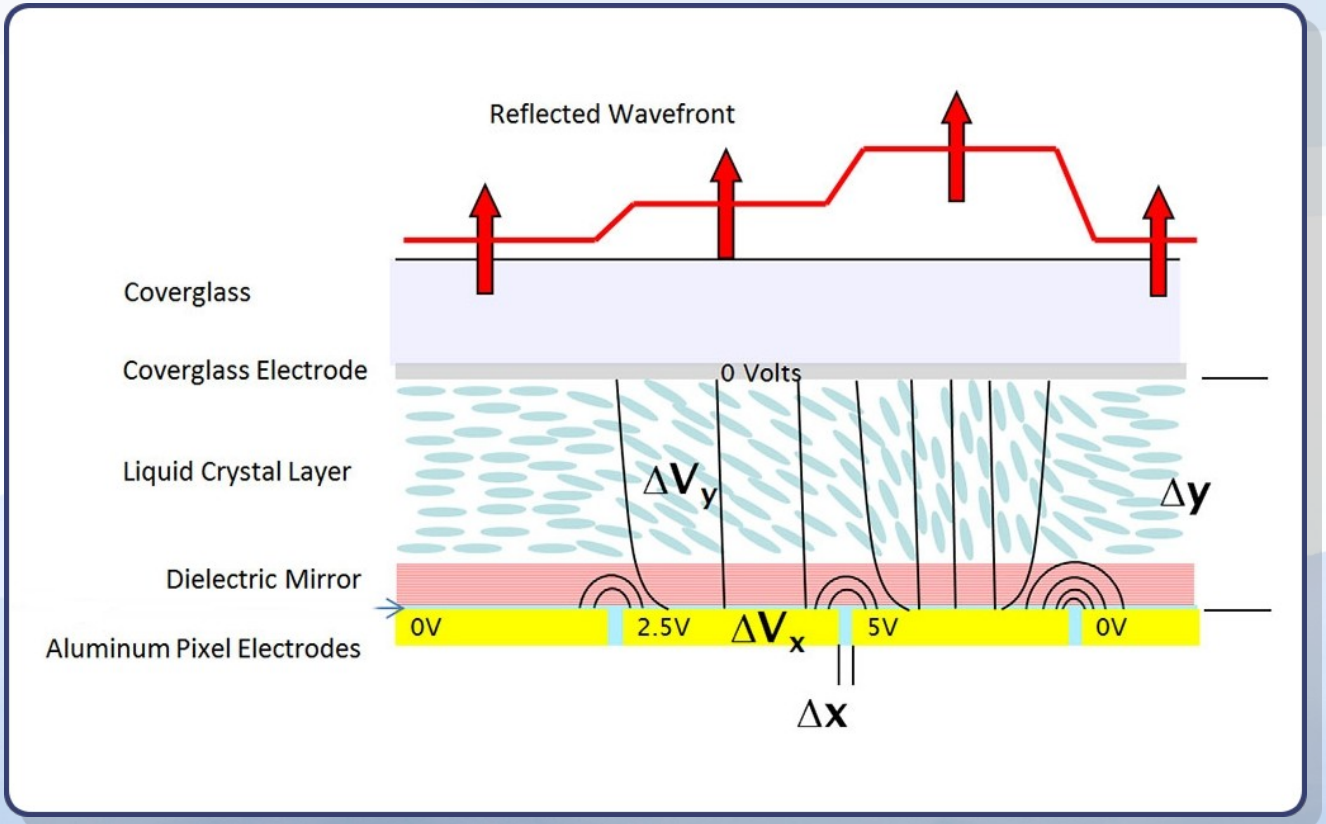
LCoS SLMS - HOW THEY WORK









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GOALS OF THIS WORK

- Reconfigurability demonstration – SLM applied to different optical wavefronts
- Preliminary examination of measurement precision
- Identify technical hurdles

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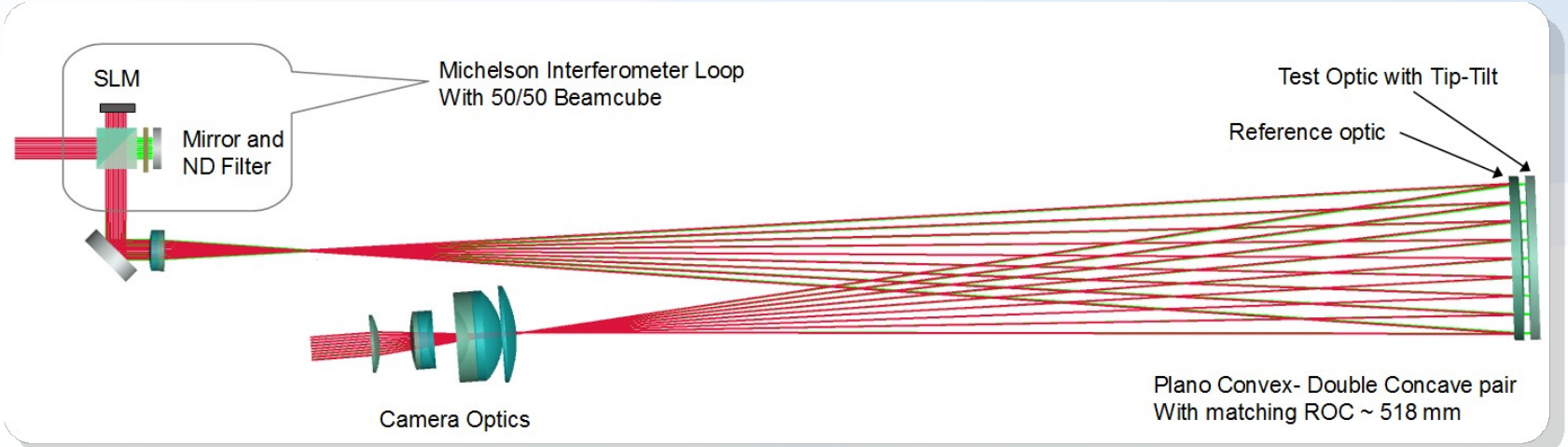
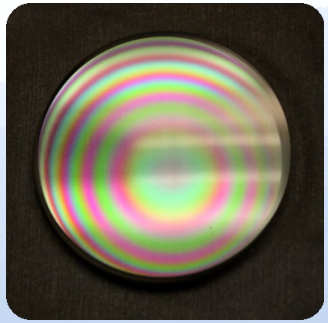
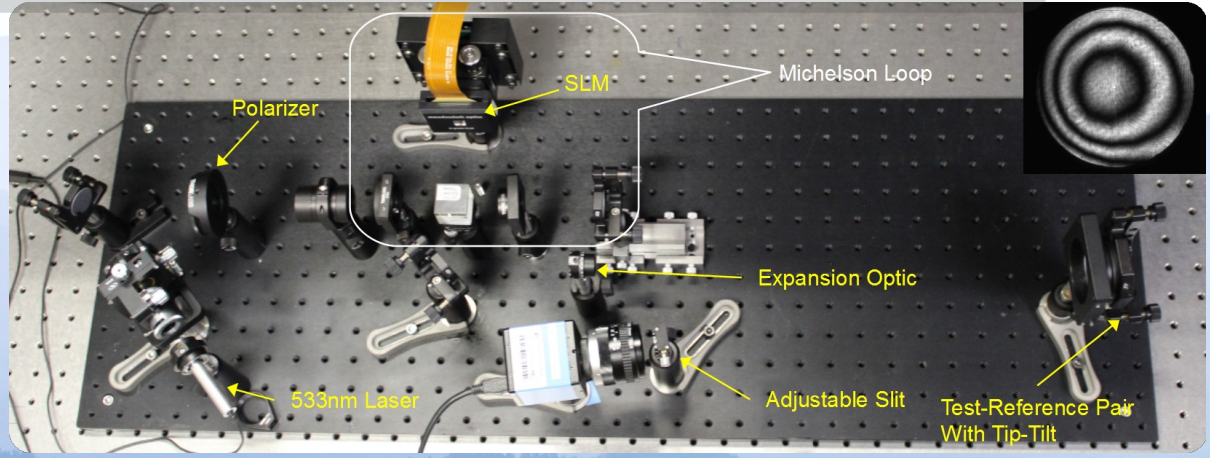
TEST SETUP – CONTROLLED THROUGH LABVIEW







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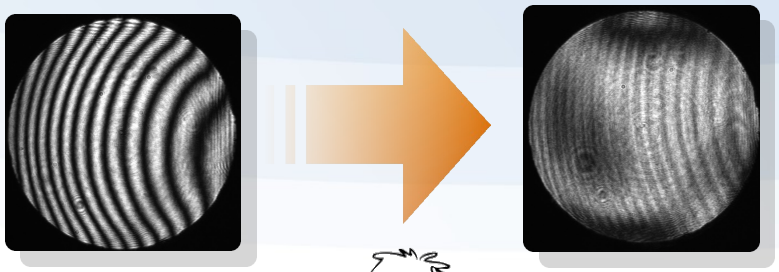
RESULTS - WHAT WE DISCOVERED

- First Light was a poor null



Problem - calculated wavefront not the same as corrective wavefront applied to SLM

  - Developed stochastic hill climber in LabVIEW to find the null

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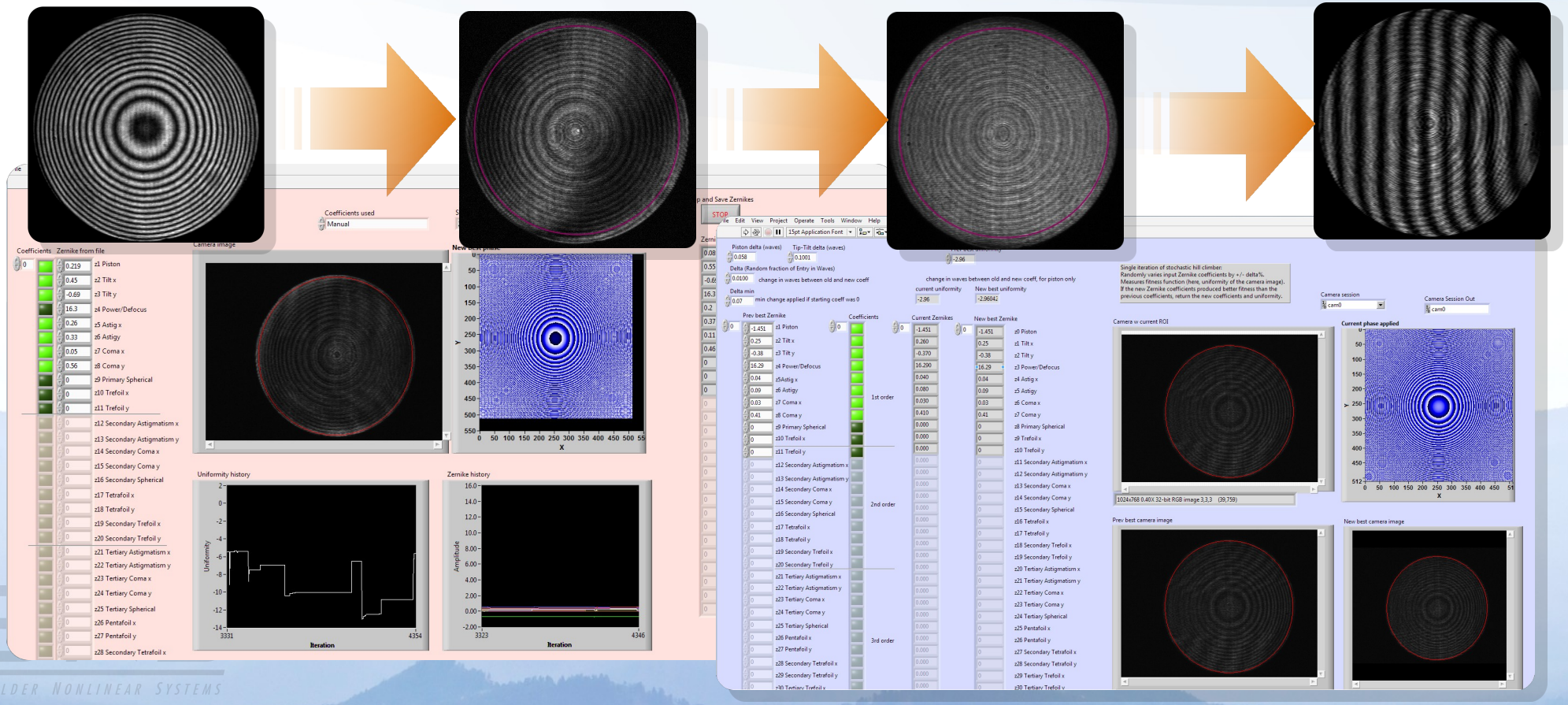
FINDING THE NULL ALGORITHMICALLY

SLM “OFF”

Good First Guess

Null

Null With Tilt



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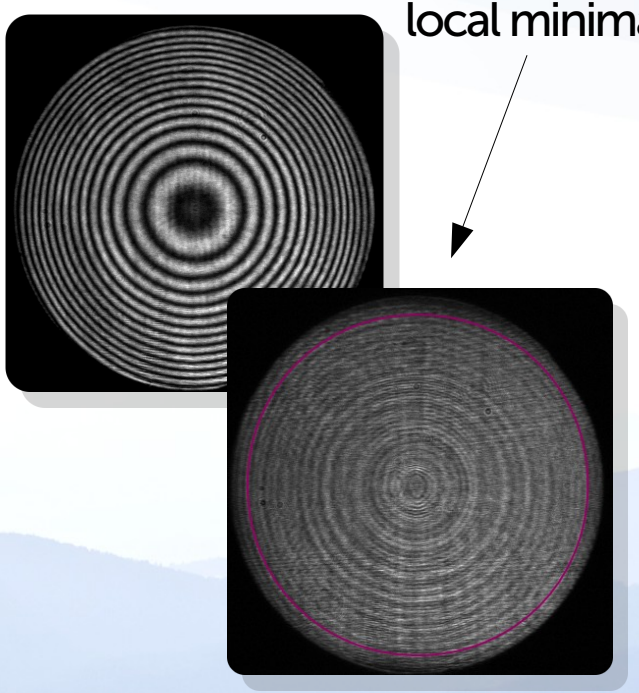
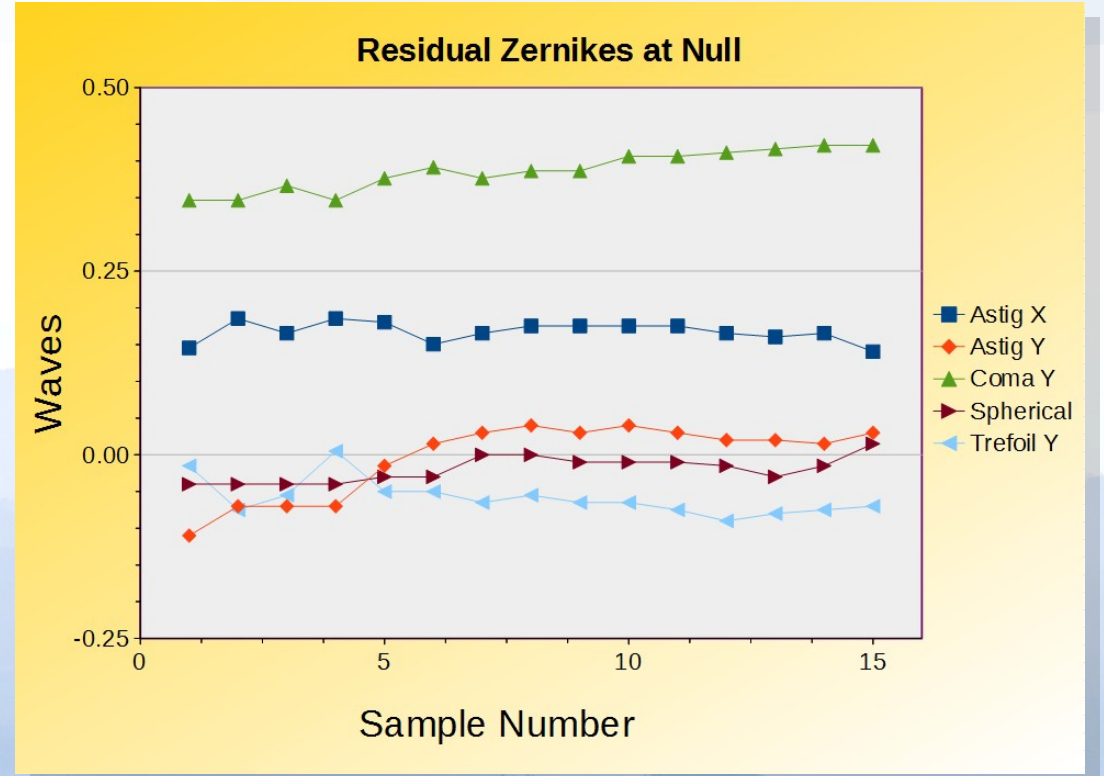
NULL REPEATABILITY MEASUREMENTS

Imprecision due to 2π phase wraps – equivalent local minima with different values for residuals





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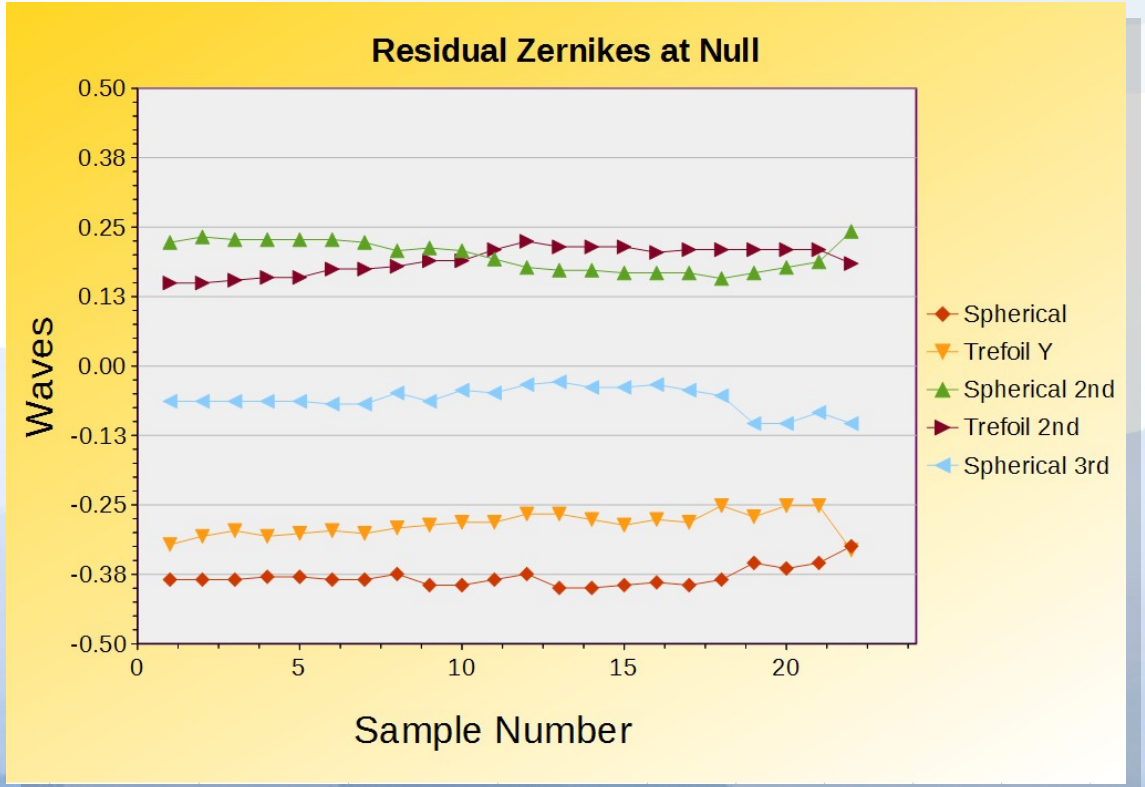
NULL REPEATABILITY ON STRESSED OPTIC

Severity of phase wraps varies according to required phase slope

Pronounced
2π wrap



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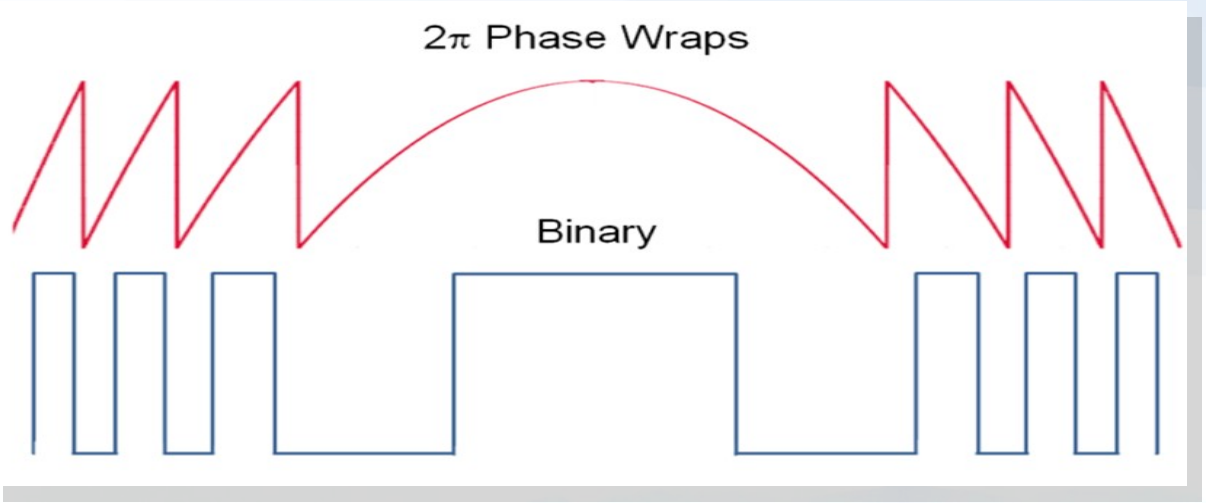
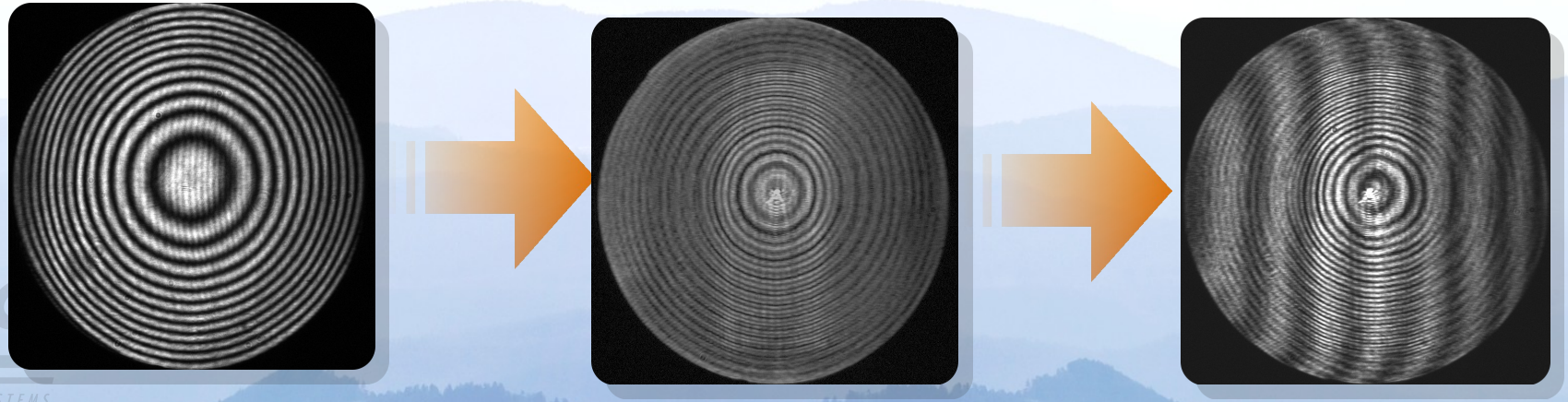
NULL BY CGH SIMULATION





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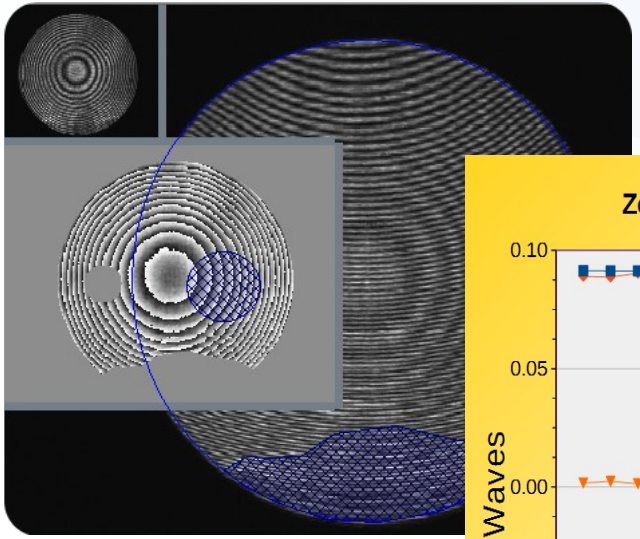
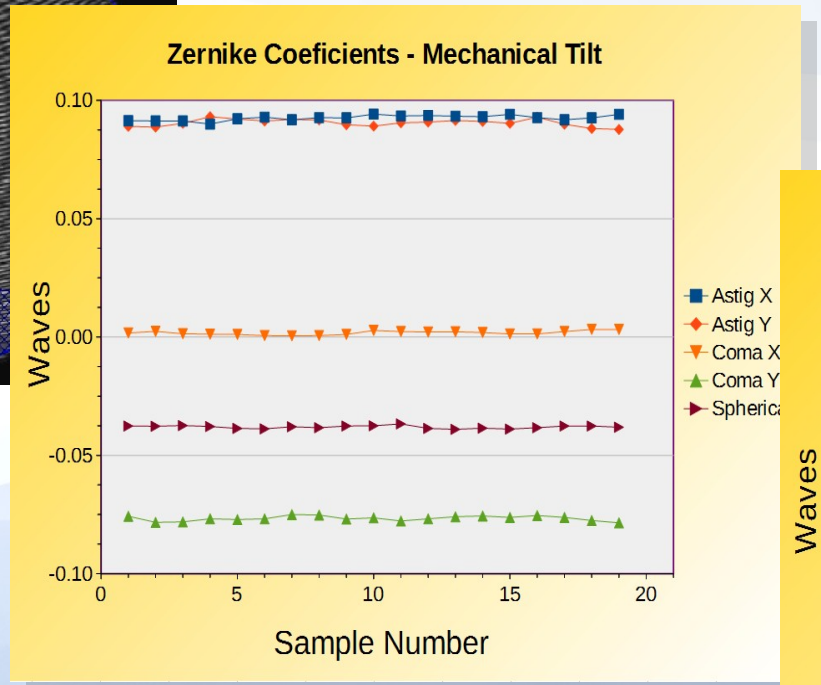
SPATIAL CARRIER FRINGE ANALYSIS



56 waves of tilt



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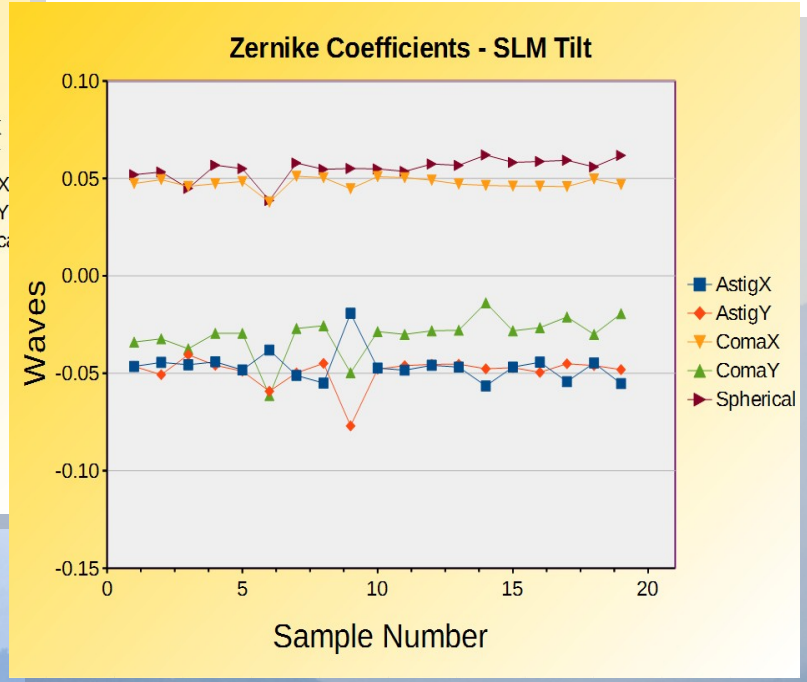

Intelliwave Software – Engineering Synthesis Design

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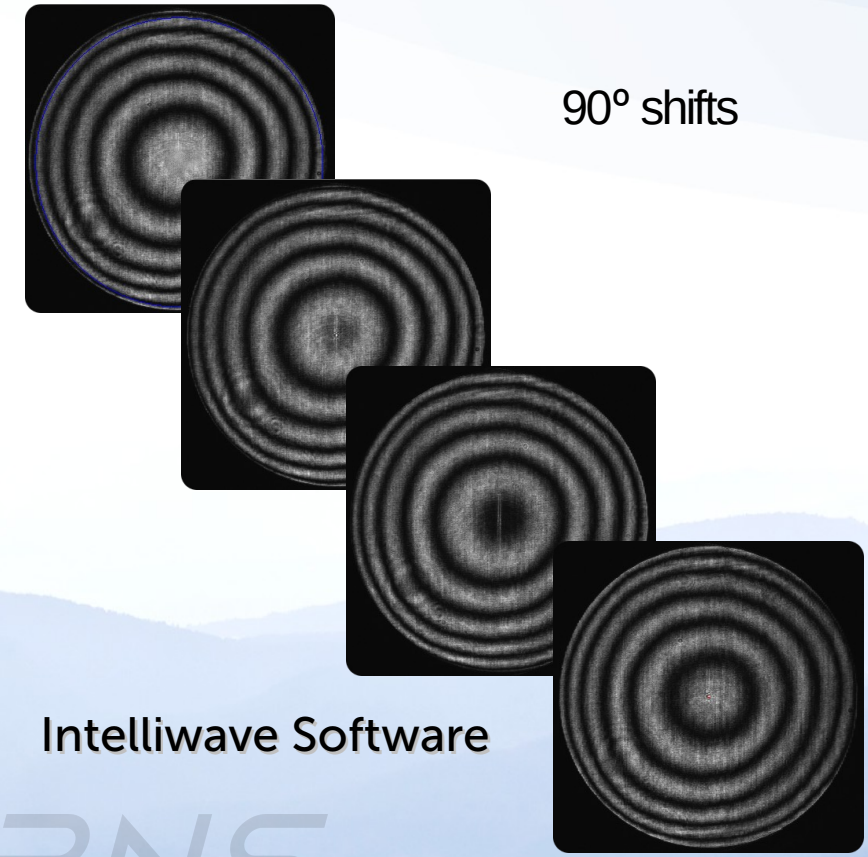
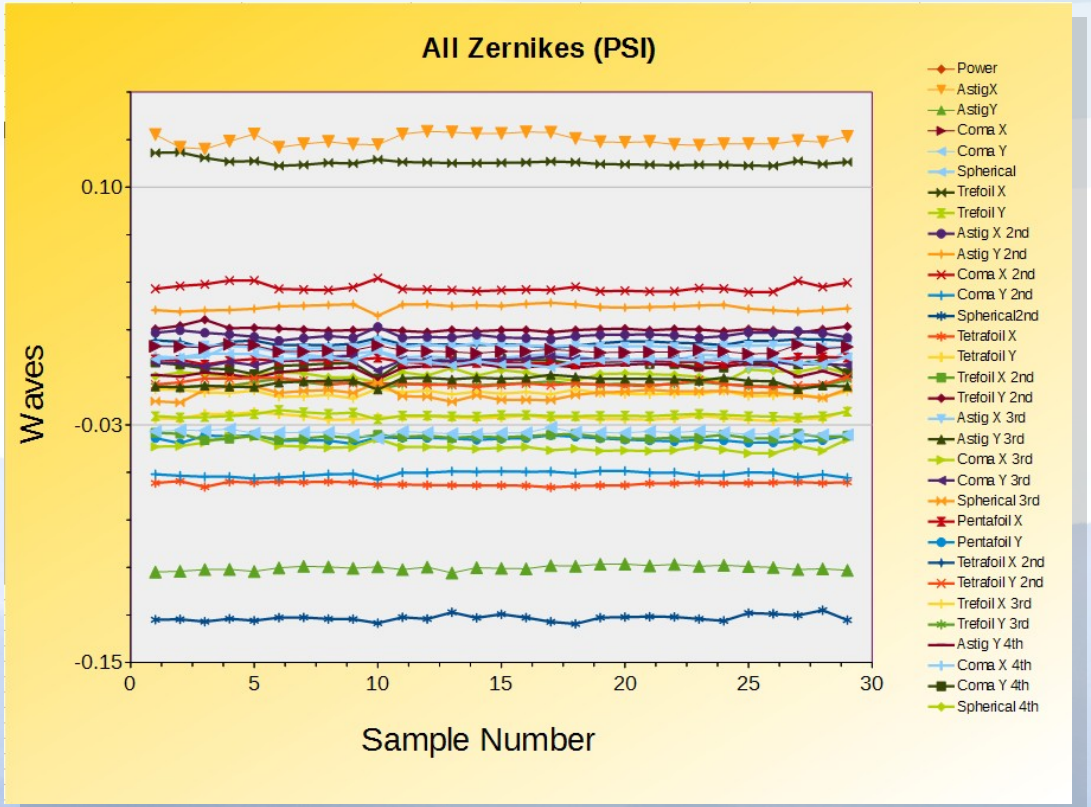
PHASE SHIFTING INTERFEROMETRY



90° shifts

Intelliwave Software



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CONCLUSIONS

- LCoS SLMs applicable to nulling, SCF, and PS interferometry.
- Presently the limiting factor stems from phase wrap error.
- Useable as CGH-like binary gratings, or pixelated phase ramps.

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FUTURE WORK

- Minimization of phase wraps by:
  - Removal of dielectric mirror. This will result in a significant improvement
  - Using thinner LC layers through testing at shorter wavelengths (e.g 405nm)
  - Increase in the pixel array size (space bandwidth product)
- Development of 1.5kx1.5k SLM prototype
  - Will employ a precision reference optic for quantitative analysis
  - Completion of a system error budget analysis
  - Identification of means to compensate for residual wrap artifacts
  - Identification of niche application areas
- Comparison with DMD technology if applicable

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