Programmable Phase Nulling Interferometer for Giant Mirrors

Phase I SBIR

Mirror Tech Days 2018
Nov 6, 2018 – El Segundo, CA

Janelle Shane (PI)
Steve Serati (Founder and CTO)
Doug McKnight (VP of R&D)
Ron Eng (TPOC - MSFC)

Boulder Nonlinear Systems, Inc.
450 Courtney Way
Lafayette, CO 80026
www.bnonlinear.com
Motivation: mirror characterization
LCoS Spatial Light Modulators

Liquid Crystal on Silicon (LCoS) Spatial Light Modulators (SLMs)

Reflected Wavefront

Coverglass
Coverglass Electrode
Liquid Crystal Layer
Dielectric Mirror
Aluminum Pixel Electrodes

ΔV_y
ΔV_x
Δy
Δx
SLM nulling range

Phase I 512x512 SLM
- Binary range: < 256 waves
- 15 µm pixels

Phase II 1536x1536 SLM
- Binary range: < 768 waves
- 25 µm pixels
SLM nulling range

Phase I 512x512 SLM
Binary range: < 256 waves
15 µm pixels

Phase II 1536x1536 SLM
Binary range: < 768 waves
25 µm pixels
Use of SLMs to extend CGH range

SLM: 100 wave range

Phase I 512x512 SLM
Binary range: < 256 waves
15 µm pixels

Phase II 1536x1536 SLM
Binary range: < 768 waves
25 µm pixels

Temperature, gravity, similar segments
Optical setup

1. PSI measurement
2. Invert measured phase
3. Apply with SLM to null
PSI Measurement: planar mirror

SLM piston applied (4-step PSI):

0  \pi/2  \pi  3\pi/2

Correction phase: Null

Retrieved phase:
Nulling results: planar mirror w/ tilt

Interferogram before nulling

Retrieved phase

System nulled
Nulling results: adaptive null

Moving optic in the test arm
Nulling time: 0.9s
SLM rate: 400 Hz
Camera rate: 15 Hz
w/ triggered fast camera &
GPU accelerated calculation,
100 Hz nulling is possible
Nulling results: Custom SLM-applied phase

Interferogram before nulling

PSI retrieved phase

System nulled

X tilt: 0.5
Y tilt: 0.25
Oblique astigmatism: 0.25
Defocus: 1
Horizontal coma: 1
Future work

Speed
- Speed limited by 15fps camera rate
- SLM speed: 400fps; 500fps w/next-gen
- >100 Hz nulling

Commercial-grade hardware
- Vibration management
- Quality of optics
- Integration w/ commercial interferometer

Characterization
- Accuracy, range
- Results w/ known optics & CGH
- Regional SLM calibration
  - Accounts for nonuniform SLM surface
Future work – expanded range

SLM: 100 wave range

Phase I 512x512 SLM
Binary range: < 256 waves
15 um pixels

Phase II 1536x1536 SLM
Binary range: < 768 waves
25 um pixels
Conclusions

- LCoS can apply arbitrary phase, incl. piston for PSI
- Can extend the range of a CGH
- 1 Hz nulling shown; 100 Hz nulling likely
- Phase 2: larger SLM, commercial interferometer

Contact me:
Janelle Shane
jshane@bnonlinear.com
303-604-0077