Laboratory Demonstration of a Focal Plane Coronagraphic Interferometer

Nicole M. Putnam

Steward Observatory, University of Arizona, Tucson, AZ, USA

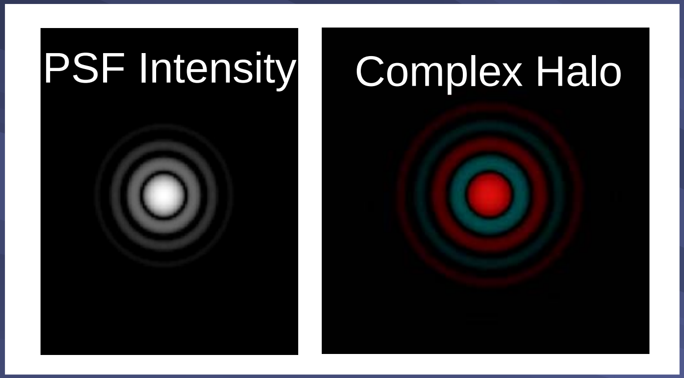
Advisors: Dr. J. Roger P. Angel and Dr. John Codona

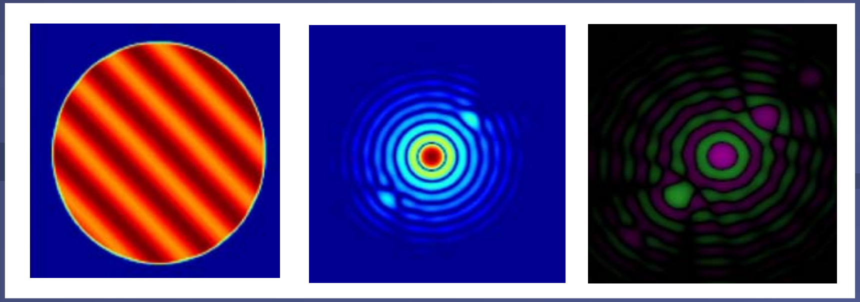
Concept

- Build a focal plane interferometer to measure the complex amplitude (phase and amplitude) of the star halo
  - We use the light normally thrown away in a coronagraph
  - Fast and direct method
- Pupil DM modulated to null speckles at a point and over a region
  - Suitable for ground based AO as well as TPF
  - Closed loop operation

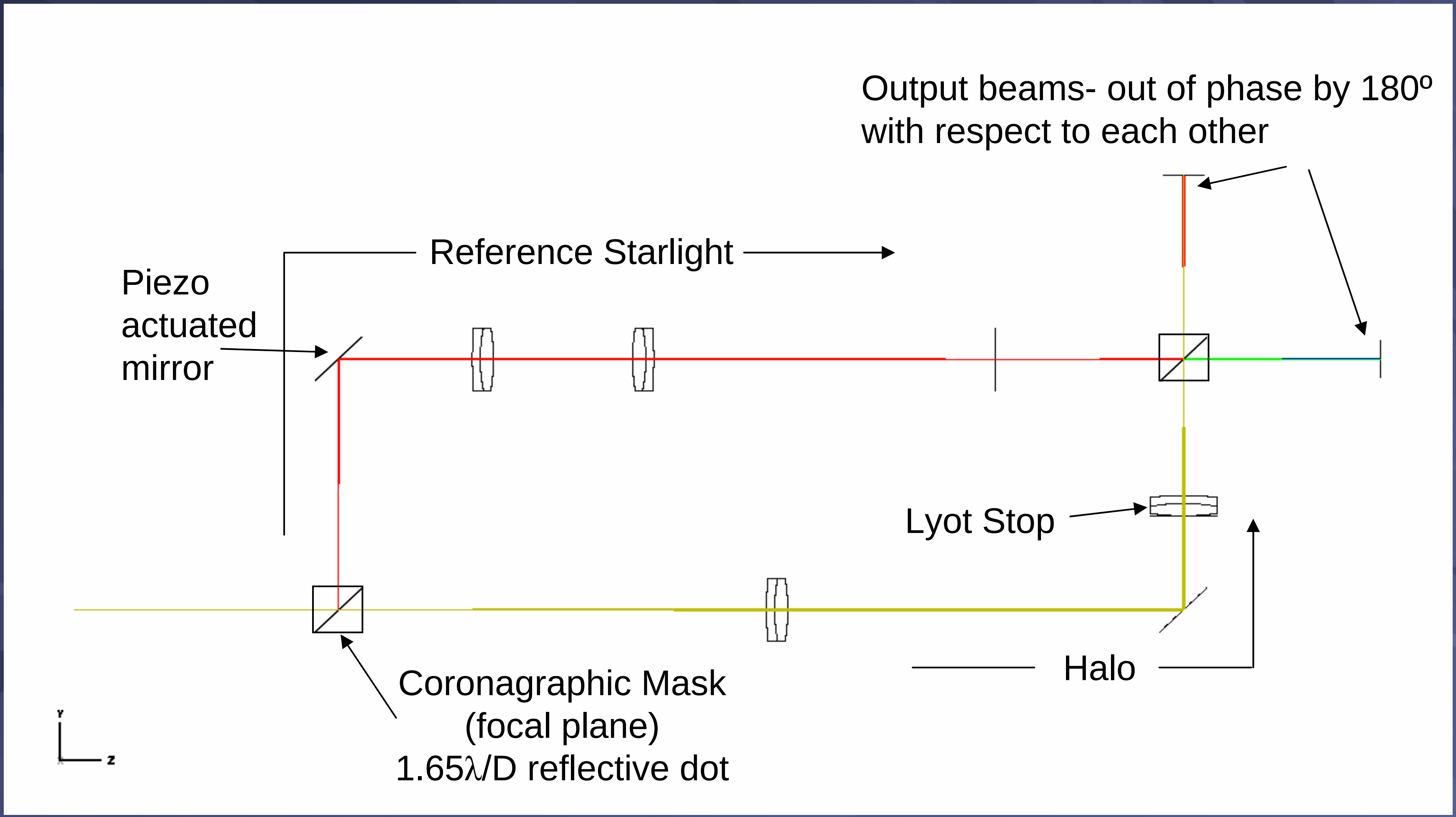
Motivation

- The halo is made up of diffraction effects and speckles that change, making correction at very low photon noise levels important, whether on the ground or in space

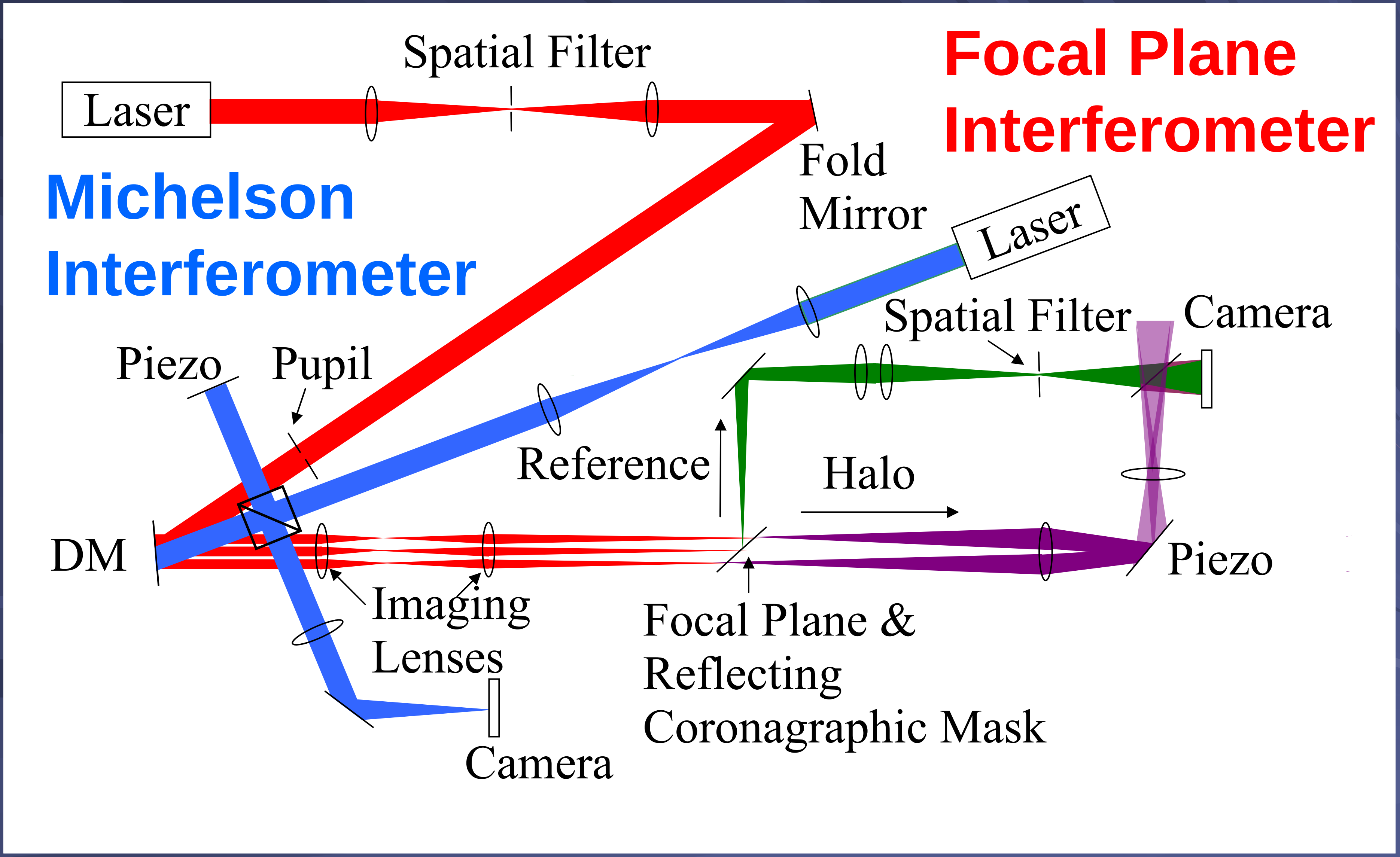




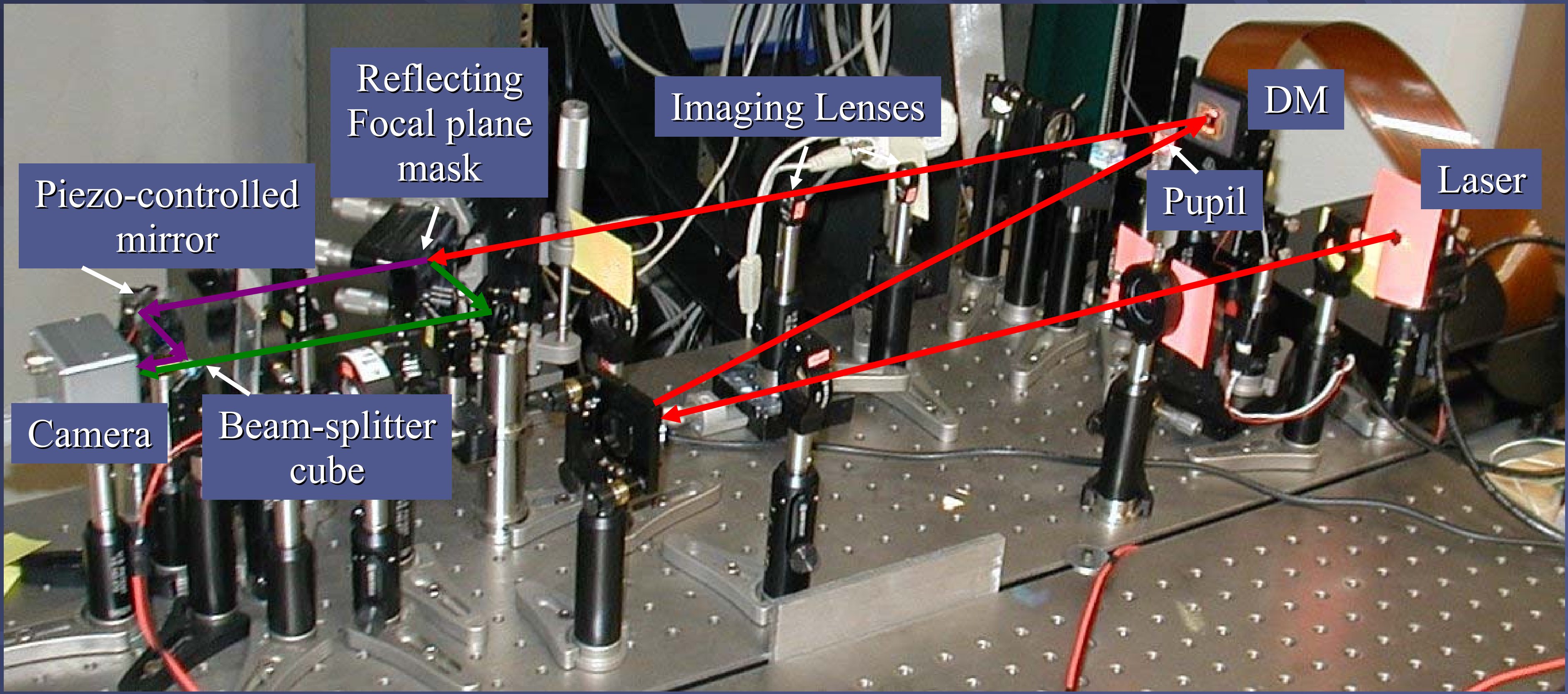
The Focal Plane Interferometric Coronagraph Concept



Lab Prototype I designed and built

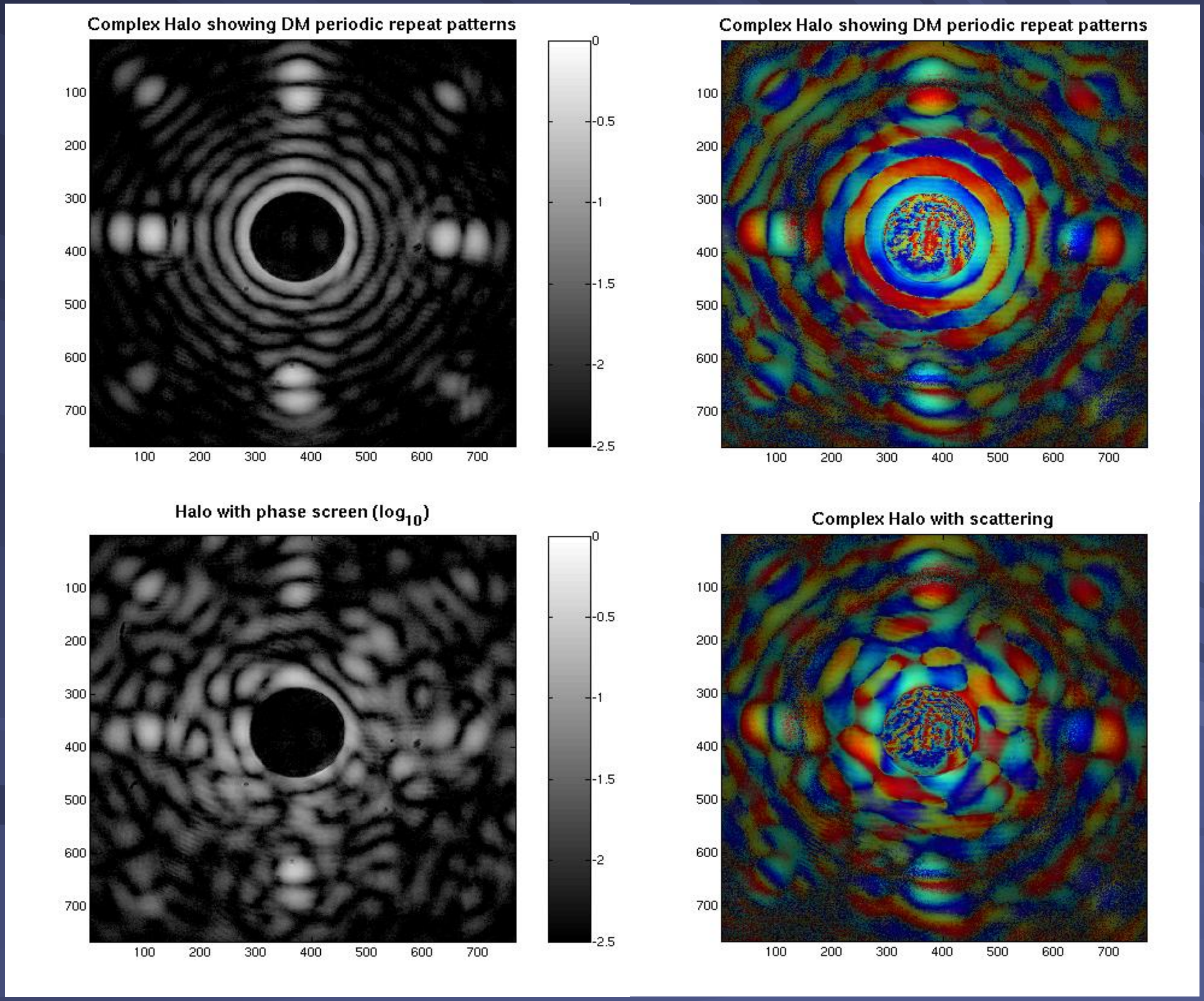


Photograph of Lab Prototype



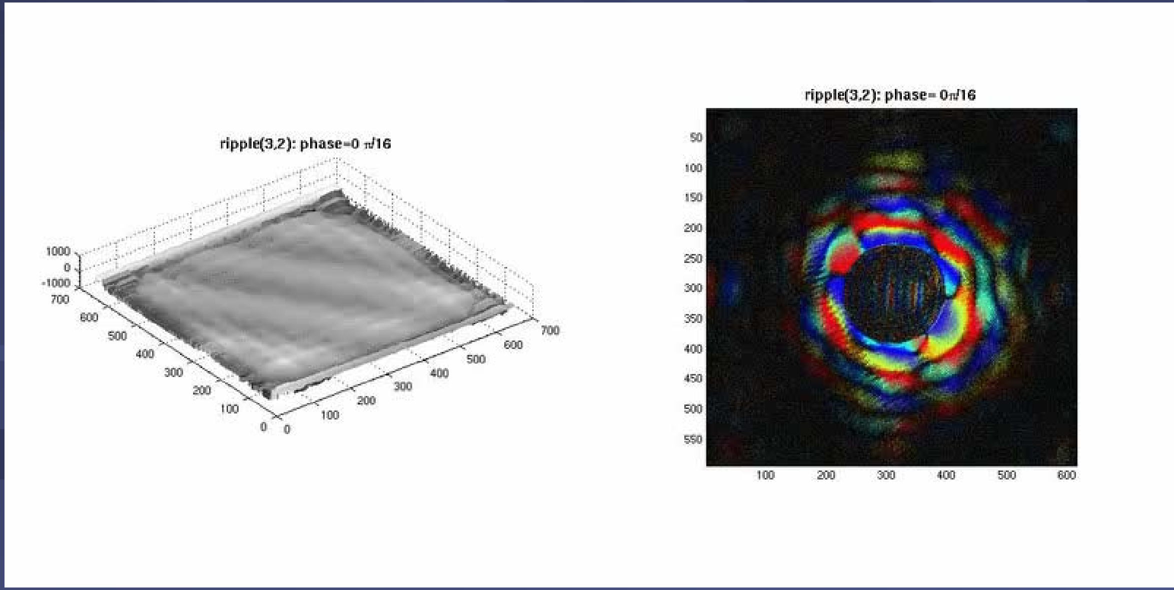
- The prototype is currently on a 12”x36” breadboard with vibration isolation pads.

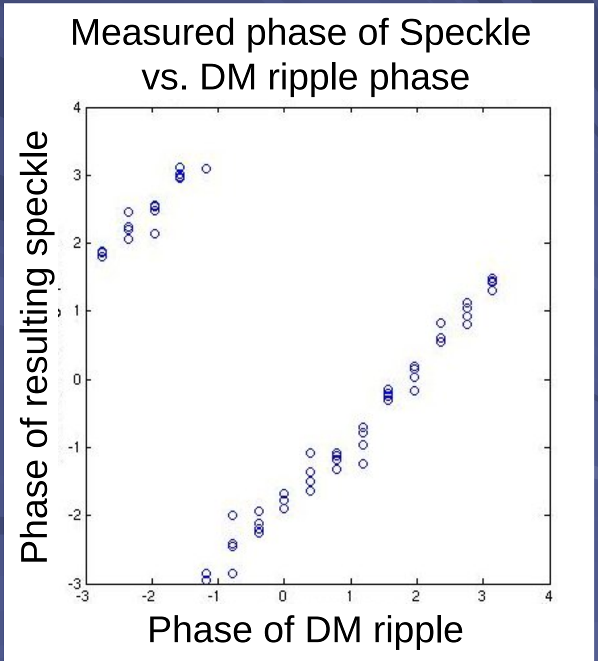
Focal Plane Interferometer Output



Nulling at a single point

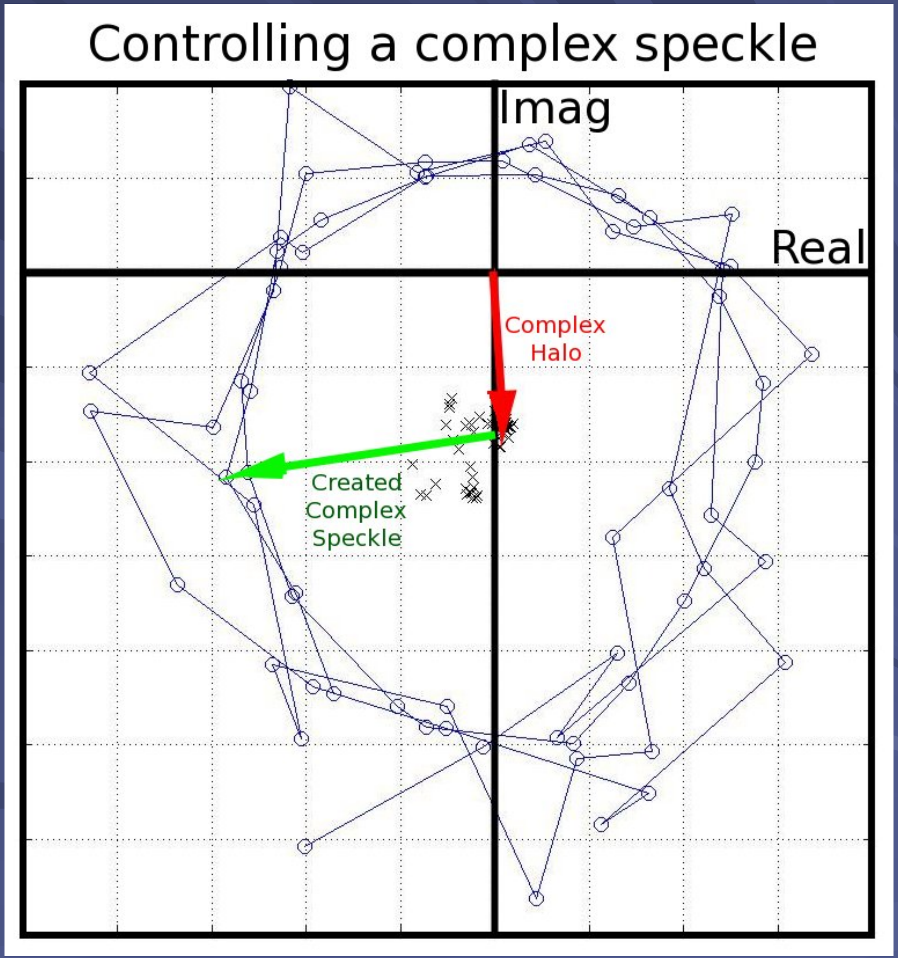
- The Michelson Interferometer reveals the test ripple applied to the DM (left).
- Holding the wave vector constant and varying the ripple phase (i.e. its position), the phase of the resulting speckle can be controlled (right).





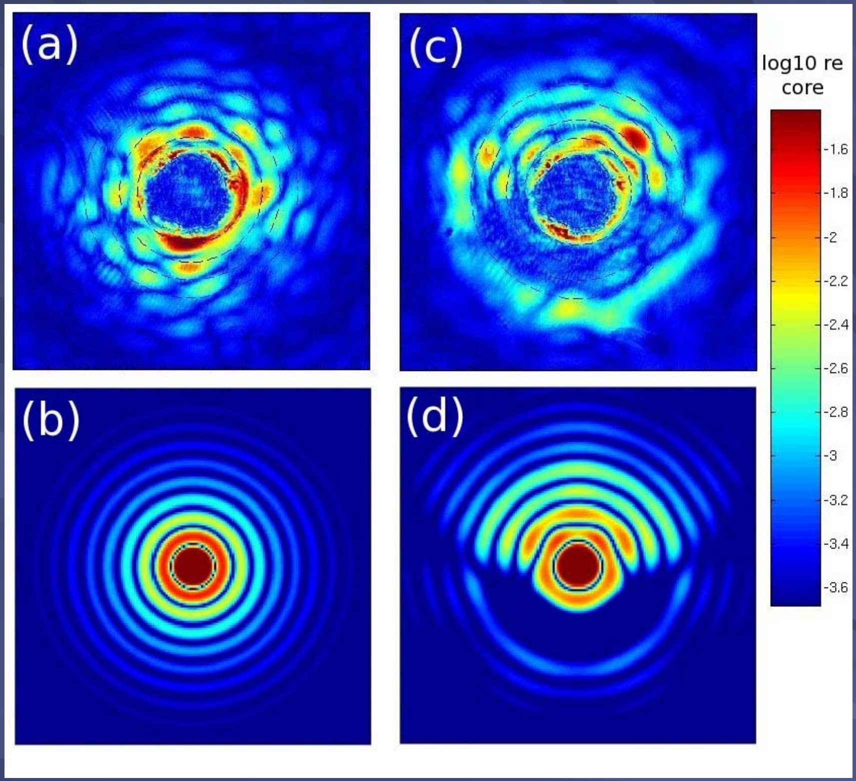
Nulling Speckles

- The resulting halo field is the complex sum of the original halo and created speckle.
- Since the amplitude of the speckle is proportional to the amplitude of the ripple, the ripple phase and amplitude can be selected so as to make the resultant nearly zero. The resulting halo intensity is proportional to the magnitude-squared of this sum.

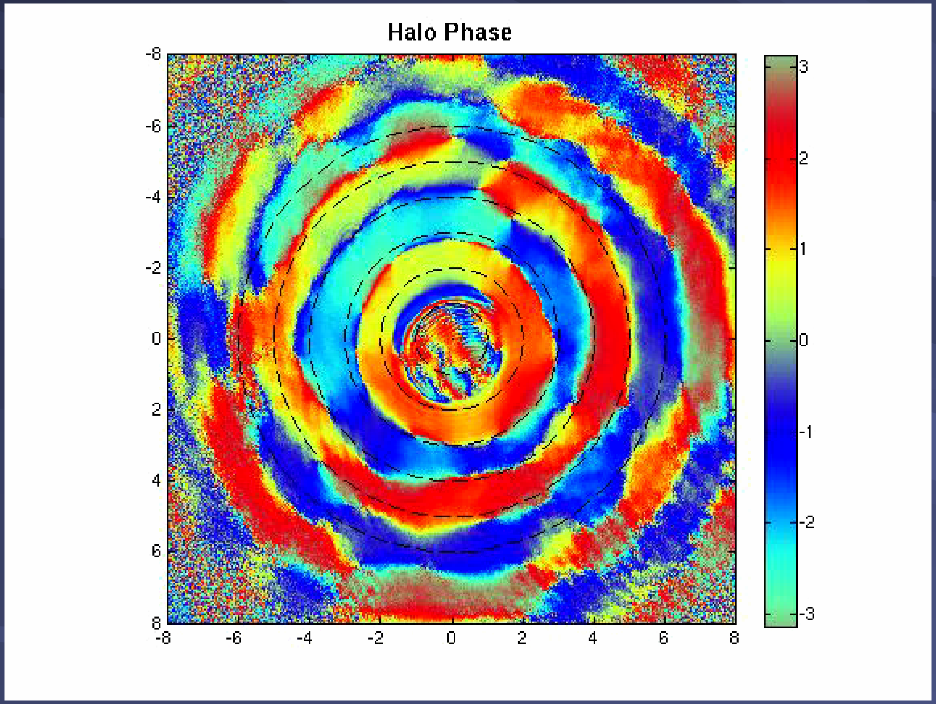


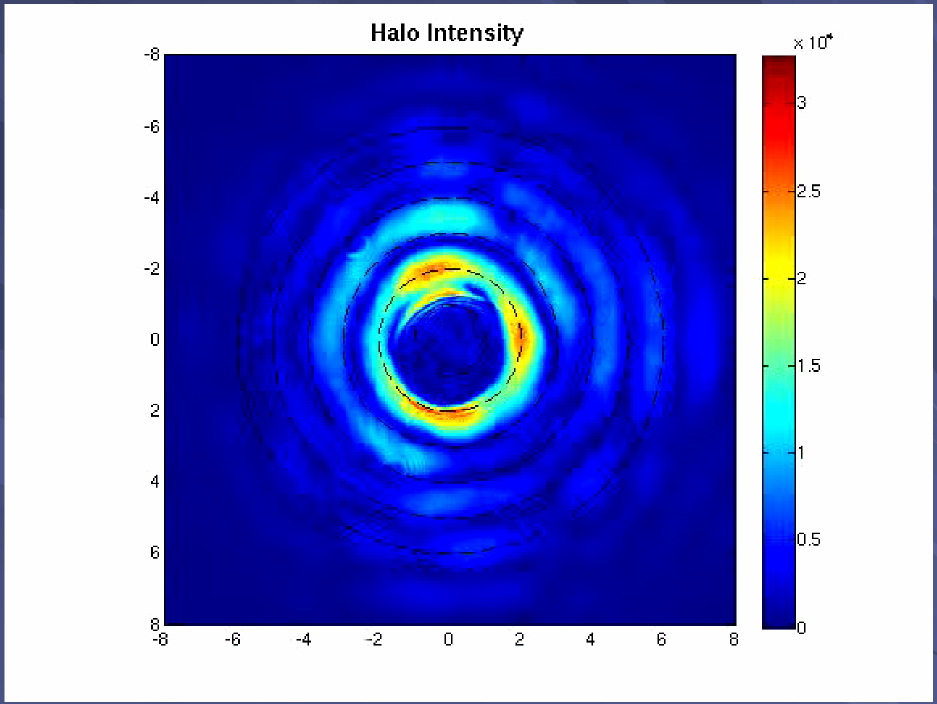
Comparison of Theory with Laboratory Results

- The complex halo before and after correction
  - (a) Lab results showing the complex phase of the halo from the output of the focal plane interferometric coronagraph before correction. Data was intentionally perturbed to simulate a residual halo in a real system
  - (b) Theoretical simulation of the star halo before correction
  - (c) Lab demonstration of the nulled halo after correction
  - (d) Theoretical simulation of the nulled complex halo
- Using a smaller focal plane mask, we were able to suppress well into the first Airy ring

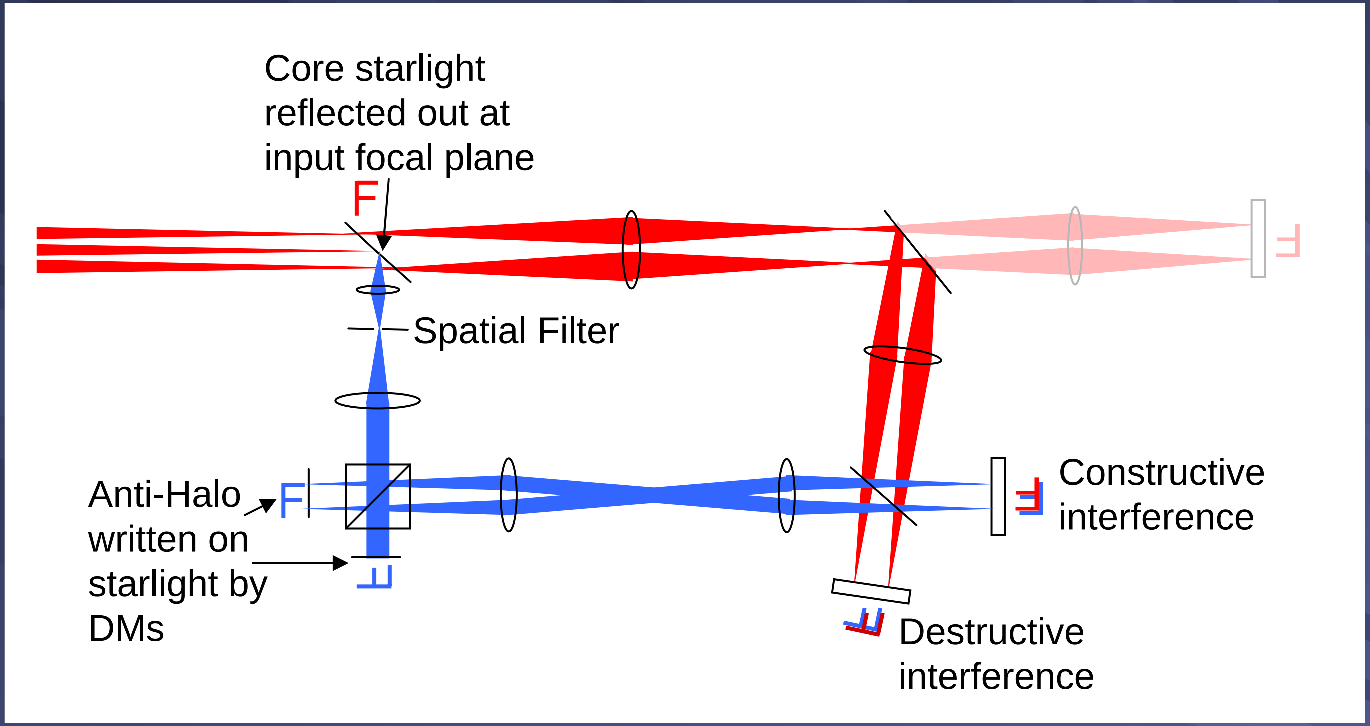


Animation of Speckle Suppression





Anti-halo apodization for 360 degree suppression - AHA



- Measure four phases simultaneously to determine complex amplitude
  - Insensitive to vibration
  - Can get useful information from a single photon
- Use focal plane spatial light modulator to directly generate a detailed "anti-halo" to interfere destructively with the star halo

Conclusions

- New technique to drive the suppression has been demonstrated in the lab
- Technique used for getting really close to the star (first Airy ring)
- We will continue development by using a full coronagraph and focal plane suppression techniques driven by the interferometric data