National Aeronautics and Space Administration
Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

Experimental Progress in Deep and Broadband Infrared Nulling for TPF-I

J. Kent Wallace, R. Gappinger, R. Bartos, J. Negron, S. Moser, F. Loya

Project Objective:

The achromatic nulling testbed will demonstrate two-beam mid-infrared nulling to a level of 10-6 and develop optical components needed to achieve this performance level. The testbed will also demonstrate simple detectability of a faint off-axis source while nulling a bright on-axis source.

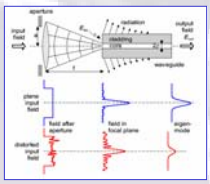
- Deep and broad dual-polarization two-beam mid-infrared nulling
- Comparison of field-flip vs. phase delay architectures
- Validation of symmetric beam injection and planet injection approaches.
- Design and testing of intensity control devices
- Beamsplitter design
- Mid-infrared source evaluation and selection
- Mid-infrared detector selection
- Alignment algorithm development
- Simple null-control algorithm development

Implementation

- Will begin with a flexible, room-temperature, in-air nulling testbed, based on the reciprocal-beamsplitter beam-combiner concept.
- The initial emphasis will be on the development and definition of the optical components and alignment algorithms needed to achieve the desired mid-infrared null levels.
- The second generation nuller will be a cold (LN2) nuller to achieve ultimate performance.
- The basic detection of off-axis sources will be demonstrated with a single baseline.

Technology Development Areas

Single-mode Spatial Filters



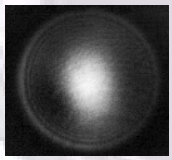
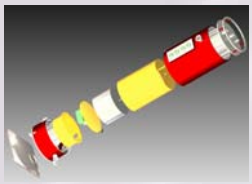


Image of the pupil illuminated with a SM 10 μm fiber.

Objective
- Insure spatial coherence of source
- "Clean-up" of output beam

Component Development
- Hollow metal waveguides
  - University of Arizona
- Silver Halide single-mode fibers
  - Tel-Aviv University
- Chalcogenide single-mode fibers
  - Naval Research Lab

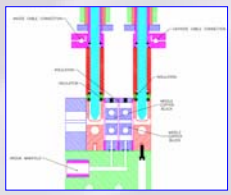
MidIR Camera

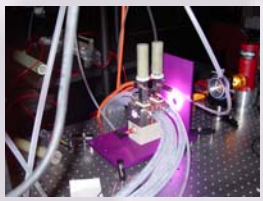


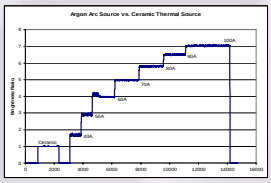
Objective
- Improve IR detector
- Array enables greater characterization
  - Dispersion measurements

Component Development
- Detector: Si:As BIB Array from DRS, Technologies
- Electronics from Astronomical Research Assoc. (Leach)
- Dewar contract with IR Labs

Argon Arc Source





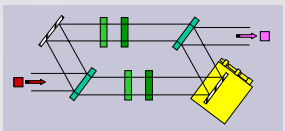


Objective
- Increase the photon flux at 10um

Component Development
- Argon Arc Source
- Effective Temperature is ~10,000K
- Based upon previous NIST design

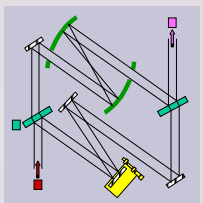
Nulling Architectures

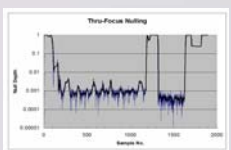
Phase Plate



Key Aspects
- Most mature nulling architecture
  - Keck Interferometer
  - Laser Null of 10^{-6}
  - White light: 10^{-4} with 30% bandpass
- Intrinsically limited in wavelength
  - Glass properties define operating bandpass
- Enables non-p phase changes
  - Critical to some beam combining architectures
- Status
  - Single glass plates for laser and white light
  - Ready for dual-glass upgrade

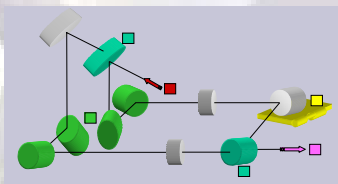
Through Focus





Key Aspects
- Intrinsically broadband
  - Beamsplitters are band-limiting elements
  - All other optics are reflective
- Compact
  - All optics are co-planar
- Polarization effects vary across the pupil
- Pupil inversion
  - Necessitates a single-mode spatial filter
  - Mirrors the planet light
- Status
  - Preliminary build is done
  - Preliminary results in hand

Nulling Periscope



Key Aspects
- Intrinsically broadband
  - Reflectors are all un-powered
  - Beamsplitters limit the optical bandpass
- Architecture is non-planar
- Status
  - Initial build complete
  - Searching for white light fringe

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