Location of the Non-thermal Optical Emission from Jets in AGN

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ABSTRACT

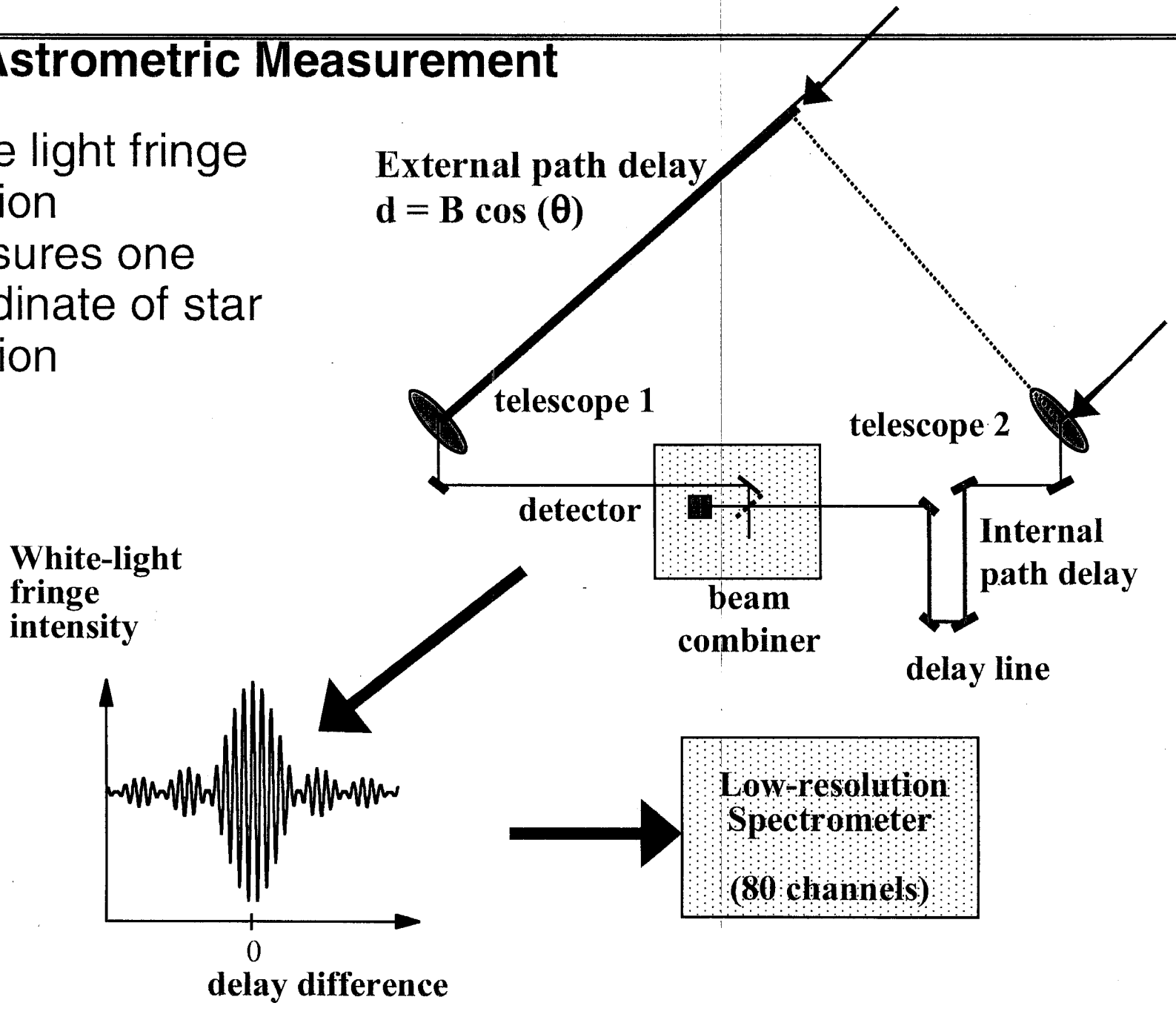
As part of an approved key science project for the Space Interferometry Mission, we plan to measure the position offsets between red and blue optical emission from a sample of active galactic nuclei. By using differential measurements of the fringe phase between different color bands, we expect to be able to detect color-dependent astrometric offsets of several micro-arcseconds. The blue optical continuum is expected to be dominated by thermal emission from the inner accretion disk (the source of the Big Blue Bump) in many quasar spectra. The red optical continuum is expected to be dominated by power-law nonthermal emission from the relativistic jet or from a hot corona surrounding the inner accretion disk. Our measurements of position offsets between blue and red light will allow us to determine the location of nonthermal optical emission with respect to the thermal emission from the inner accretion disk. We will also be able to monitor the astrometric stability of the optical emission centroids.
This research was carried out at the Jet Propulsion Laboratory, California Institute of Technology, under contract with the U.S. National Aeronautics and Space Administration.

What physical effects might we see with SIM ?

- **Accretion disk** radiates thermal emission with peak in optical-near-UV
  - size: 0.012 pc (=2 lightweeks)
  - ~160 μas diameter at distance of M87
  - *brighter in blue than in red*
- **Corona** or wind radiates non-thermal emission
  - *brighter in red than in blue*
  - *both red and blue photocenters centered on BH*
- **Relativistic jet** also radiates non-thermal emission.
  - Base of the jets is offset from the core by hundreds of times the diameter of the accretion disk
  - *brighter in red than in blue*
  - *red photocenter offset from blue photocenter in jet direction*

SIM Astrometric Measurement

- White light fringe position measures one coordinate of star position



Color Dependent Differential Astrometry

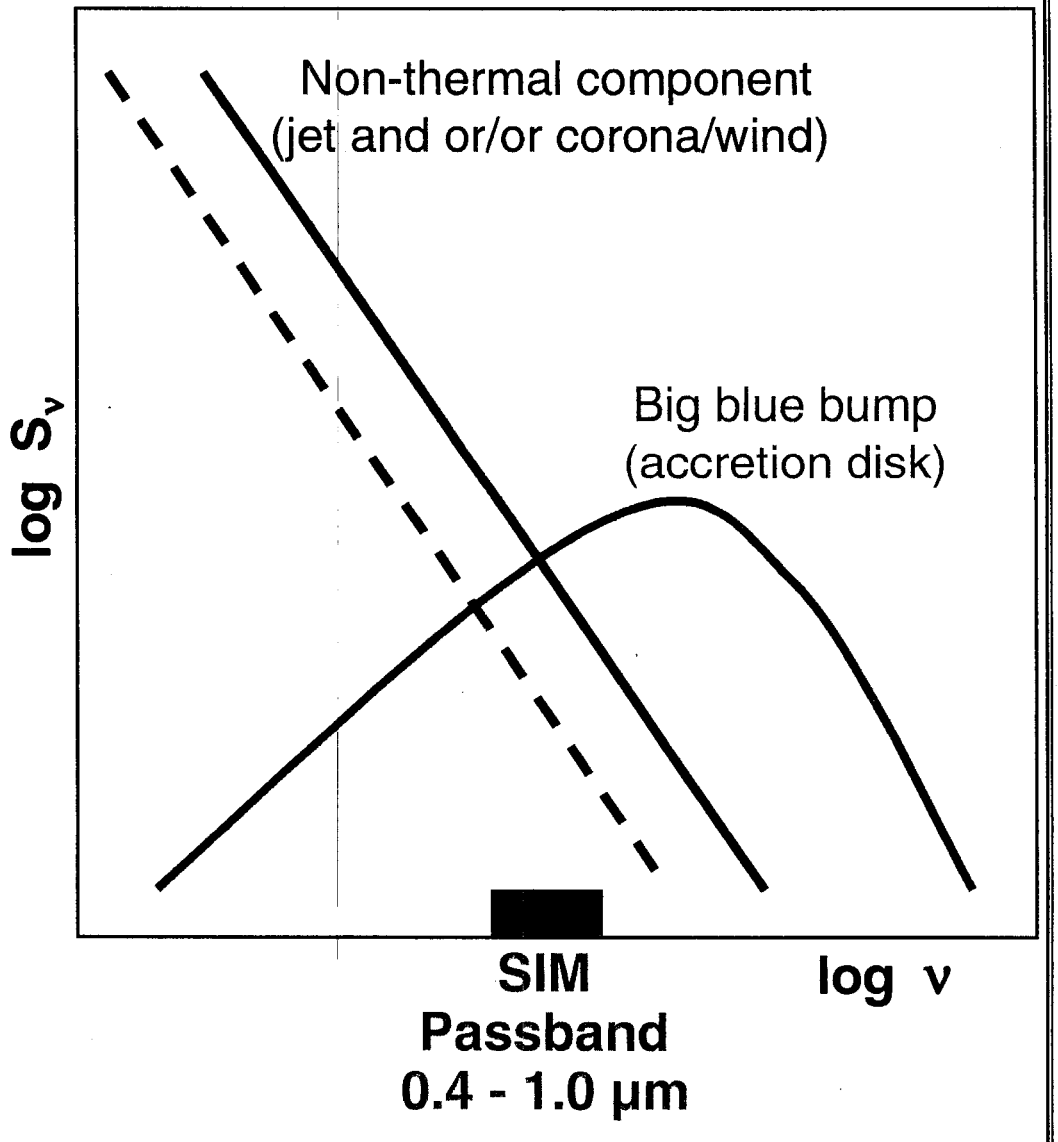
- Measure differential group delay
  - Should be a robust measurement, since it involves only a single target, and does not depend on the absolute value of the group delay
  - Hence, more powerful than group delay itself
  - Same as Keck Interferometer plans for detecting "hot Jupiters"

- Simple experiment: divide the 80 SIM spectral channels into "red" and "blue" groups
  - Average over red and blue groups, find offset from difference in averaged phases
  - Astrometric accuracy reduced by only ~ 4 due to half the photon count and doubling length of white light fringe envelope

- Should be 'easy' to detect a shift of 20 μas in a single measurement
  - Shift of 30-100 μas are expected for quasar targets such as 3C 345

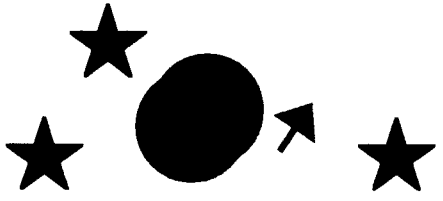
Representative quasar spectrum

- SIM observes in the optical
- Strongly 'concave' spectrum indicates transition between components



Where does the compact non-thermal emission come from?

Expect no color shift,
(or small shift ~1-5 μas)
with no preferred axis;
no preferred variability direction

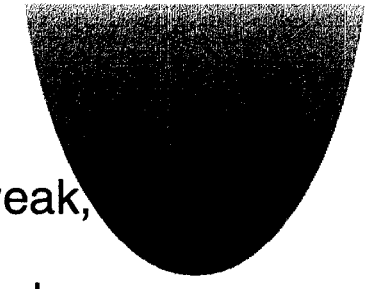


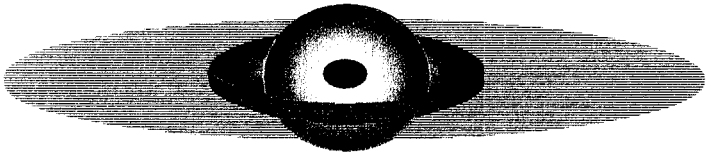
Up to
~100 μas

Expected
variability
direction:
along jet

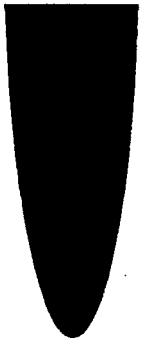
Radio-quiet AGN

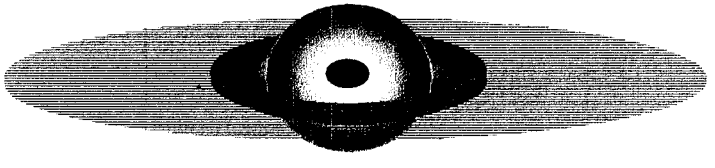
(Jet is weak,
poorly
collimated, or
absent)





Radio-loud AGN





SUMMARY

We plan to use SIM's ability to precisely determine changes in position between red and blue light from a single source to test two general models for the optical structure of AGN.

In one model, power law (red) light comes from synchrotron emission along the relativistic jet. In the second model, red light comes from synchrotron or inverse Compton emission from a hot, magnetized corona or wind above the accretion disk. In both model, blue light is thermal emission from the optically thick part of the jet. This is the source of the "big blue bump" in many quasars and AGN.

If red light comes from the jet, its photocenter will be offset (along the position angle of the jet) from the blue photo-center associated with the accretion disk. If red light comes from a disk corona or wind, the red and blue photocenters should be coincident.

We can measure the offset between red and blue photo-centers, and monitor any changes in the separation, by measuring the phase shift of the white light fringe between the red and blue halves of the SIM detector. This is a differential measurement, and is largely independent of the absolute delay accuracy or precise knowledge of baseline orientation. It depends only on the available SNR of the detected fringes.