Intensity Interferometry at Lowell Observatory

WORKING TOWARD THE INTERFEROMETER IN A SUITCASE

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Origins of Stellar Interferometry

• 1920’s: Albert Michelson builds first stellar interferometer by using two sub-apertures of Mt. Wilson 100-inch telescopes.

• Measured several stellar diameters.

• Tried to extend the baseline, but mechanical issues prevented progress.
How Optical Interferometry is Done Today...

Light is made to interfere prior to detection. (Michelson Interferometry).

Higher signal-to-noise, but expensive. Certainly NOT portable.

~300 m baselines. Much Larger? Hmmm...
Intensity Interferometry

- There is a weak correlation in the arrival times of photons when viewed by two different detectors. “Wave Noise.”
- Related to beat frequencies, in the most extreme case.
- This effect was used in astronomy in the 1970’s to measure diameters of bright stars.
- One configuration of the two telescopes yields one Fourier component of the image
- (well, $|\gamma|^2$).
- But, huge collectors were needed to detect this weak signal on the photomultiplier tubes of the day.

P.S.: Only two stations, So no imaging!

Sydney University Stellar Interferometer

Photo: J. Davis
“Wave Noise”
A lot has changed since 1974!

- S/N in Intensity Interferometry depends on telescope size AND speed of electronics.
- Timing capabilities today are about 1000x what they were in the 70’s.
- Can achieve the same result today with a much smaller telescope! (Portable Instrument!)

\[
\frac{S}{N} = 2.512^{-m} F_0 A \eta |\gamma_{12}(B)| \sqrt{\frac{\Delta f T_0}{2}}
\]
Intensity Interferometry Revisited

Picoquant Picoharp 300 timing module.

Two SPAD detectors

Issues: Small size, dead time.
SPAD Arrays

- Deadtime and small size can be mitigated if you have many SPADs all looking at the same source.
- Development of SPAD arrays is being started, e.g. the SPADlab at Everyphotoncounts.com
Simulation Data

Random Correlations

Data “Frames” $\sim 0.4 \, \mu s$ long (8192 elements)
Big Glass is getting cheap!
Three-Station Wireless Interferometer at SCSU

GPS
Computer Cards:
~0.5μs synchronization
Dirty Beam Simulation

FWHM ~ 0.1 mas

uv-plane coverage
6-hour observation
Truly Portable

Anderson Mesa
(Lowell Observatory)

53-m baseline

Two runs: Dec 2011 & June 2012
Kitt Peak: Another Possibility?

Mayall + WIYN
(3.8m + 3.5m)
~700m baseline
Observation Time

![Graph showing observation time vs. magnitude for SCSU, Lowell, and KPNO.]
Conclusions

• Intensity Interferometry Opportunity Today
  • We’ve got great instrumentation for intensity interferometry: SPADs, Picoharp
  • Large Dobsonian Telescopes are affordable for on-campus observing.
  • Need to explore GPS Technology For wireless operation.
  • Take timing correlator and the SPAD detectors to larger telescopes. “Interferometer in a suitcase.”
    • Lowell: Already doing this.
    • Kitt Peak: A possibility for the future.

• Science:
  • Imaging close binaries, stellar surfaces
  • Imaging an exoplanet transit? (One fine day...)

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