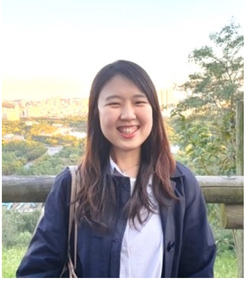

Spectroastrometry and Imaging Science with Photonic Lanterns on Extremely Large Telescopes

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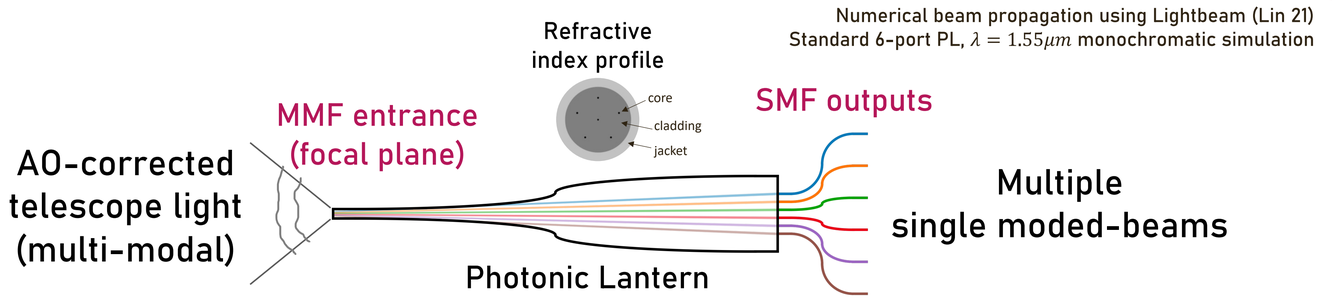
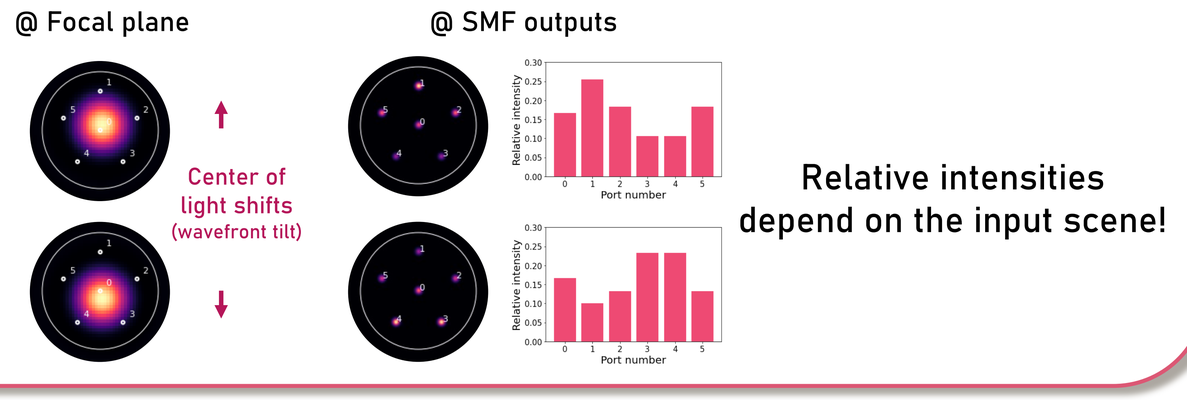
Photonic Lanterns are sensitive to small angular scales



A **photonic lantern (PL)** is a tapered waveguide that gradually transitions from a multimode fiber (MMF) geometry to a bundle of single mode fibers (SMFs), efficiently converting multimode light into multiple single-moded beams.

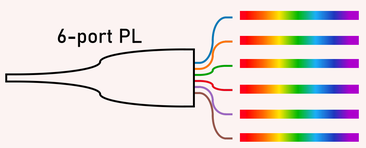
The outputs in SMFs have information on the input scene.



Relative intensities depend on the input scene!

Potential science cases of PLs on an ELT?

Application 1: Spectroastrometry



Outputs of a PL can be fed into a SMF-based spectrometer for a stable & high-throughput high-resolution spectroscopy.

Relative intensities in SMF outputs can be used to determine **2D** spectroastrometric signals.

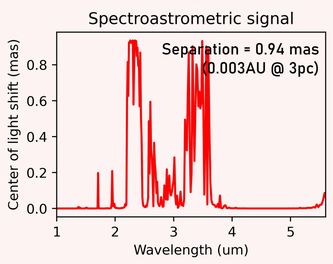
Spectroastrometry: measuring the center of light as a function of wavelength, a technique for studying objects whose morphology changes with wavelength, on scales smaller than the PSF size.

$$\text{Spectroastrometric S/N} \sim \sqrt{N_{phot}}\ \frac{\text{Center of light shift}}{\lambda/D} \propto D^2$$

Possible targets include:

1) Exomoons

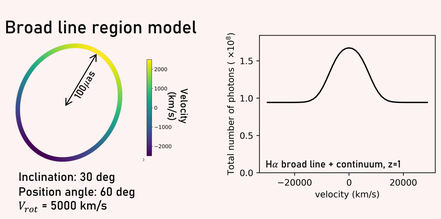
Tidally heated exomoons may be even brighter than the host planet at methane and water absorption bands

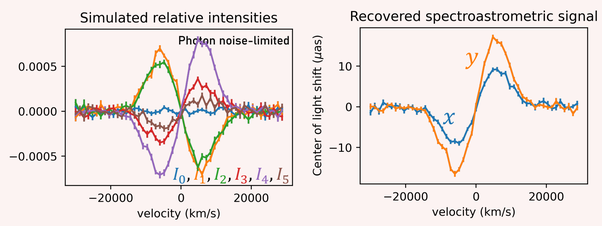


~ 1 mas spectro-astrometric signals are expected

Spectroastrometric signals from bright exomoons (tidally heated, large) around direct-imaged planets may be detected.

2) Broad line region of AGNs



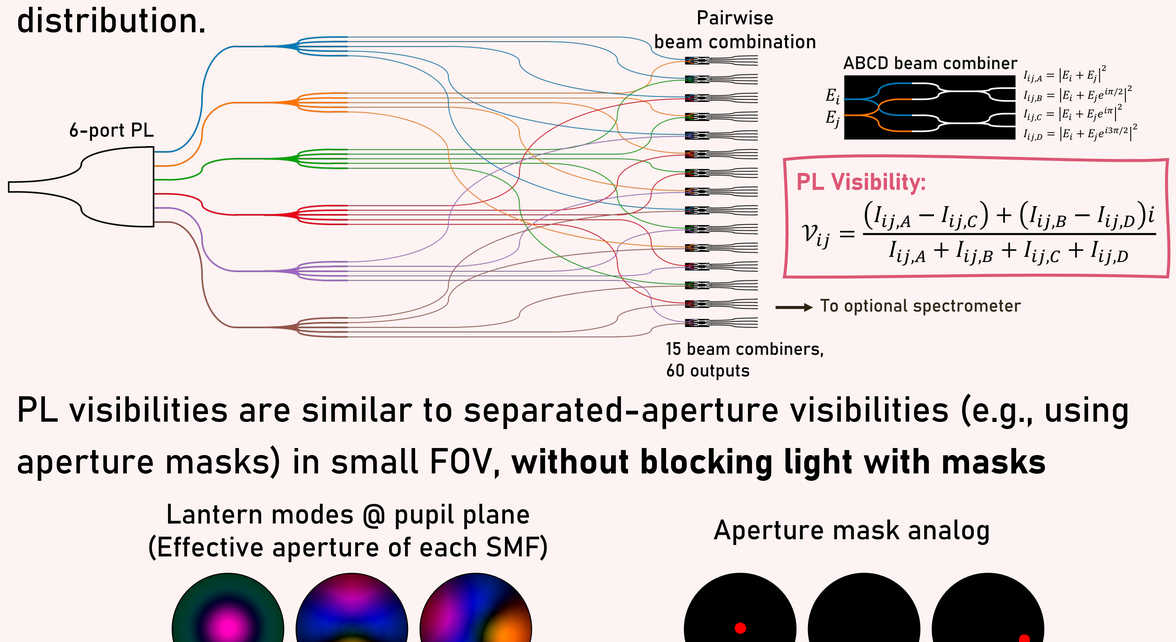


Broad line regions of AGNs can be spatially resolved using 2D spectroastrometric signals of PLs.

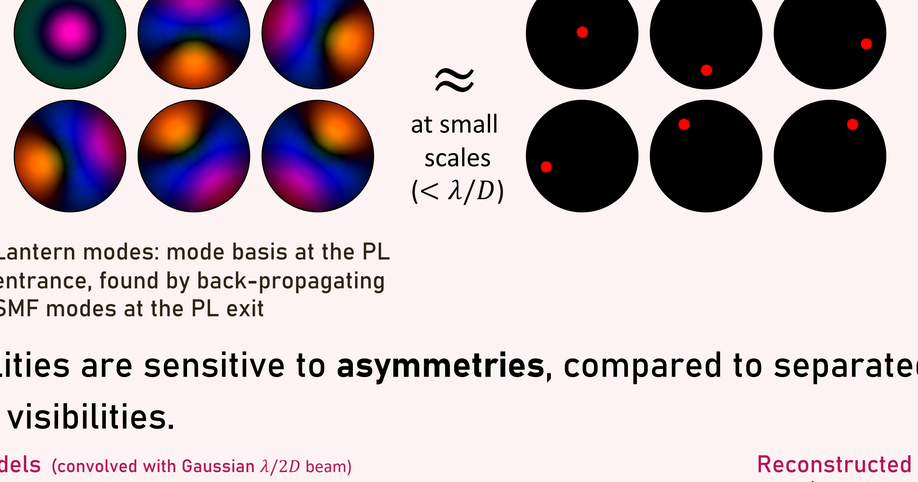
+ accreting protoplanets, high contrast binaries

Application 2: Interferometric Imaging

Outputs of a PL can be fed into a backend photonic integrated circuit beam combiner to learn about coherence properties of the source field distribution.

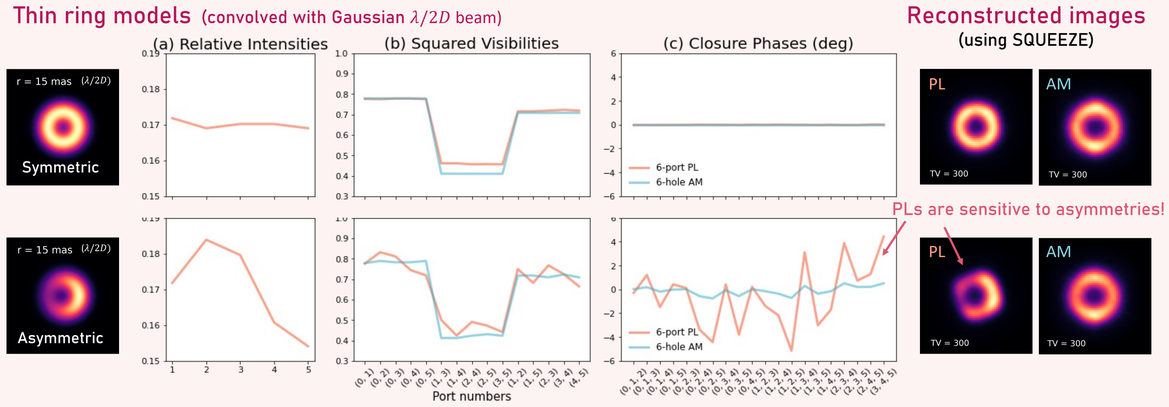


PL visibilities are similar to separated-aperture visibilities (e.g., using aperture masks) in small FOV, **without blocking light with masks**



Lantern modes: mode basis at the PL entrance, found by back-propagating SMF modes at the PL exit

PL visibilities are sensitive to **asymmetries**, compared to separated-aperture visibilities.



Possible science cases include: search for close-in orbit exoplanets, imaging inner region circumstellar disks

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