SCExAO/GLINT: Exoplanet detection at small angular separation with photonic nulling

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IN DEVELOPMENT

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OVERVIEW

The GLINT (Guided-Light Interferometric Nulling Technology) instrument is a **Near-IR** (J and H bands) **nulling interferometer** optimized for **observation of planets, protoplanets and disks at small angular separation** (~0.01 to 0.1 "), where traditional coronagraphs become inefficient. GLINT provides R~200 spectroscopy.

The GLINT instrument development is co-led by NAOJ/Subaru Telescope (Co-PI Guyon) and University of Sydney Australia (Co-PI Peter Tuthill).

SCIENCE GOALS AND CAPABILITIES

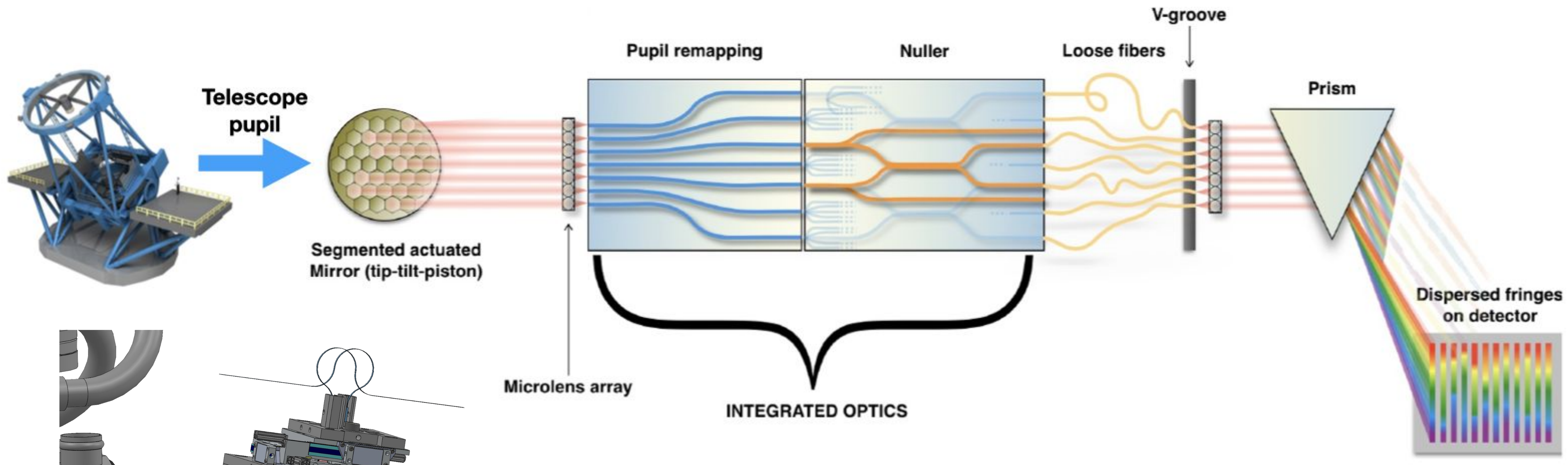
Directly imaging and measuring the spectra of exoplanets in the habitable zone is a major goal in current exoplanet science. But the small star-planet separation of habitable zone objects — of order 10 milli-arcseconds in the best cases — requires planets to be resolved at the absolute diffraction limit of the telescope, and the high star-planet contrasts requires the contaminating starlight to be removed, but this is challenging for current coronagraphs.

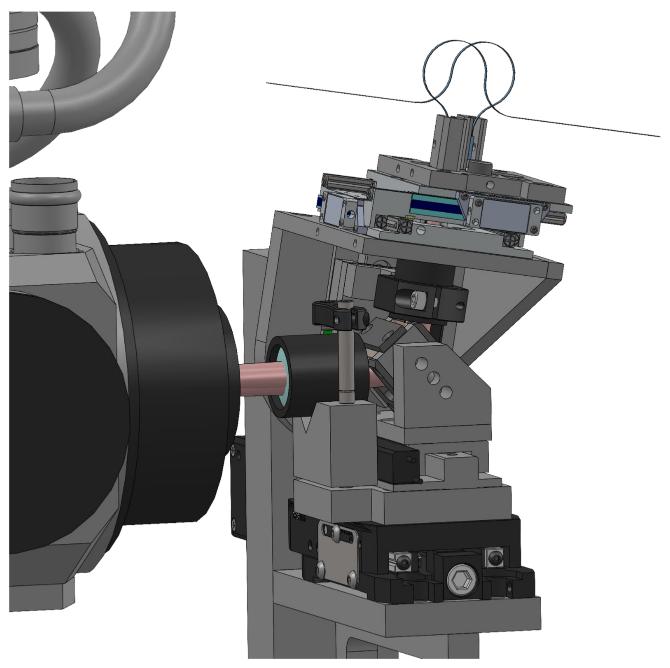
The GLINT photonic nulling interferometer transforms the Subaru telescope into an interferometer, by segmenting the pupil into a series of subapertures and injecting them into a photonic chip. Interferometry is performed within the chip, producing super-diffraction-limited imaging which is robust against seeing. Most importantly, destructive interference is used such that the direct starlight is removed (nulled), and the planet light remains. Following the successful demonstration of the pathfinder instrument, GLINT is now undergoing major development to upgrade it to a high performance exoplanet science instrument which will enable high contrast, spectrally resolved imaging for these close-separation, high-contrast science cases.

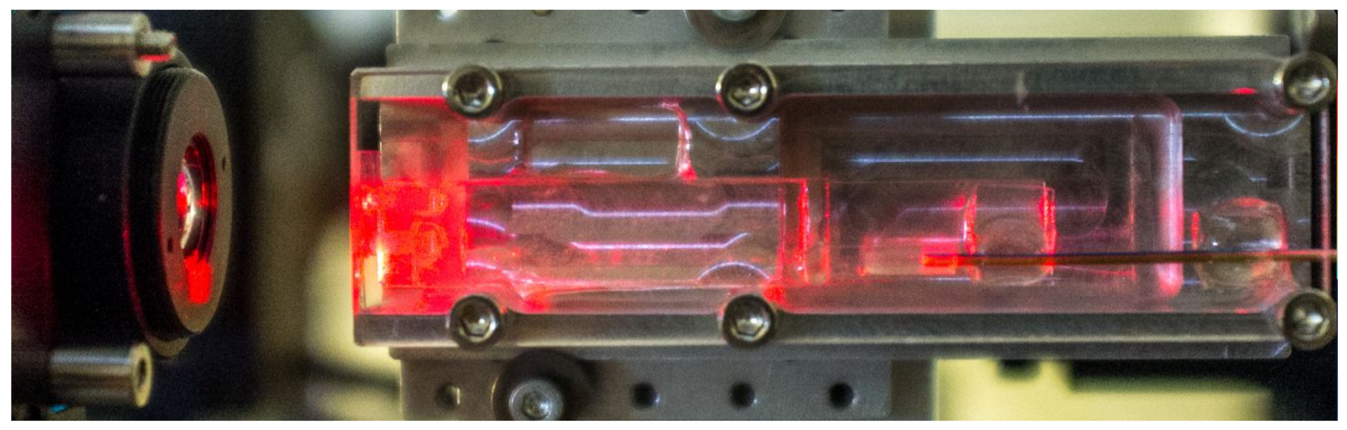
TECHNICAL OVERVIEW

The Subaru telescope pupil is relayed, via SCExAO, onto a segmented deformable mirror. This segments the pupil and optimally injects it into a series of waveguides within the GLINT photonic chip. Therein, a series of couplers and splitters provides the necessary interference to remove the contaminating starlight, measure the astronomical source image and measure the residual wavefront error to be used in real-time correction.

The outputs are spectrally dispersed and fed to the high speed, low noise C-Red 1 detector, for offline data analysis and real-time feedback to the AO system.







Top right: A conceptual diagram of the GLINT instrument

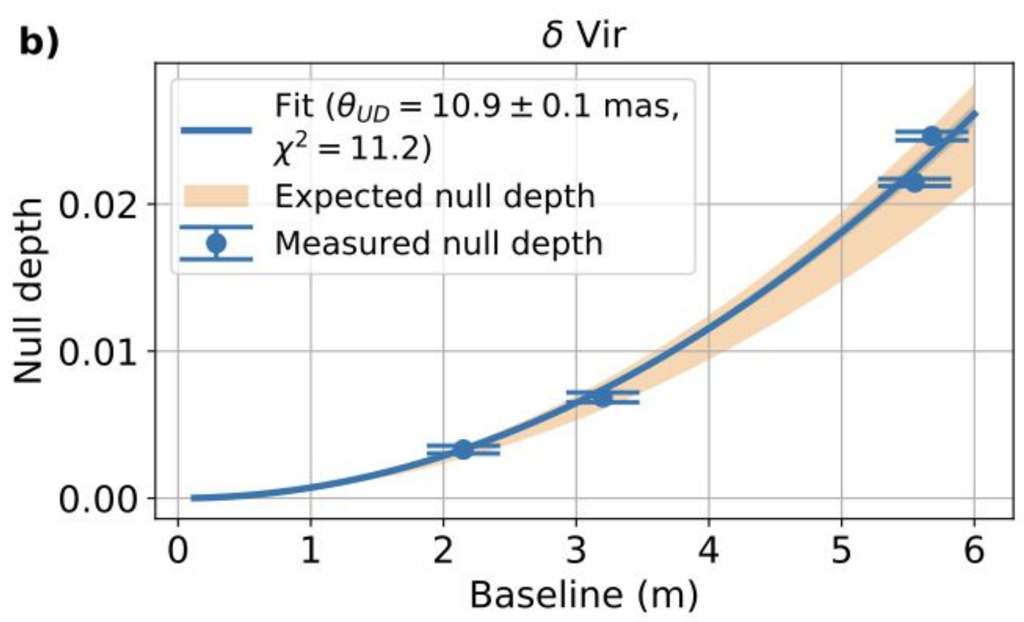
Bottom left: CAD model of the SM-fibre spectrograph that is fed by the GLINT chip outputs, and uses the C-Red 1 detector

Bottom right: An image of the GLINT chip, here with red light injected to help make the chip's structure visible

RECENT HIGHLIGHTS

On-sky angular resolution demonstration

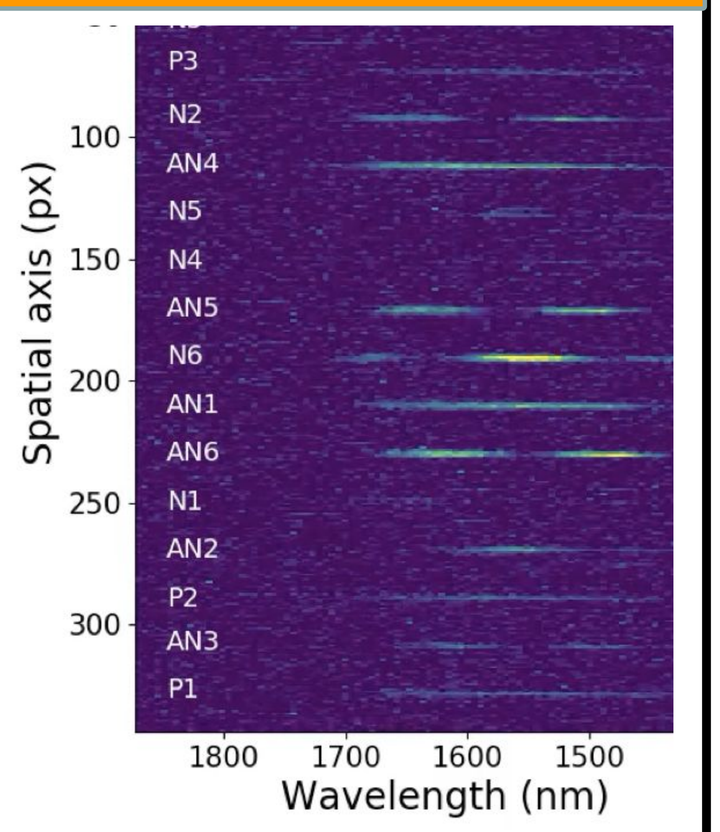
In on-sky tests, the prototype GLINT used nulling interferometry to measure the angular diameter of stars, to evaluate spatial resolving power.



Here, the diameter of δ *Virginis* was **measured to be 10.9 ± 0.1 milliarcseconds**, despite the fact that the **telescope diffraction limit is 40 milliarcseconds**

TECHNICAL EXAMPLE

An example raw data frame (~1 ms exposure) showing the spectrally dispersed outputs. Here, channels labelled N1 and N4 are nulled, with starlight redirected to other outputs and only off-axis light remaining..



FUTURE PLANS

Following the current upgrade project, GLINT will have the following capabilities:

- 9 input waveguides, resulting in 36 baseines (Fourier spatial components), each having R~200 spectral resolution
- Interference on-chip performed using innovative *tri-coupler* devices, which allow real-time phase-error measurement in addition to science measurements, in turn providing fringe-tracking capability for sustained deep nulls
- Broadband operation over entire H band

Additional future plans include:

- Integration with MKIDS detectors to enable zero-noise, high-spectral resolution measurements
- Nulled, science-light outputs sent to facility high-R spectrographs

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