
Upgrades of FIRST at Subaru/SCEXAO for H α imaging of protoplanets using photonics

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Abstract

The Fiber Imager for a Single Telescope (FIRST) is a visible spectro-interferometer (600–850 nm, $R \sim 400$). FIRST couples light from sub-apertures into single-mode fibers that are interferometrically combined and spectrally dispersed, delivering high accuracy coherence measurements at high angular resolution. Indeed, it provides inner working angles as low as $0.5\lambda/D$, smaller than the typical inner working angles of a few λ/D of classical direct imaging techniques using current ExAO instruments, making it suitable for exoplanet detection and characterization.

Installed on the Subaru telescope's extreme adaptive optics platform SCEXAO, FIRST is regularly tested on sky. Its potential has already been demonstrated by measuring spectral features of tight binary systems at high angular resolution, below the diffraction limit of the telescope. At present, the contrast limit of FIRST is estimated at 0.01 with a magnitude limit of 6 in the R-band.

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In this presentation, we will report on the ongoing developments aiming at increasing its spectral resolution, sensitivity and dynamic range which will bring young exoplanets around nearby stars within reach. At their earliest stages of formation, exoplanets are accreting matter, a phenomenon inducing a bright emission in the H α line (656.3 nm) which strongly improves the companion-to-star contrast to 0.01 - 0.001 at this wavelength (e.g., PDS 70b&c). To this end, we are implementing several upgrades to enhance the sensitivity of FIRST: integration of a new spectrograph providing a higher spectral resolution ($R \sim 3600$ at 656 nm) to detect the H α signal, use of metrology sources to monitor instrumental phase variations, design and optimization of the visible photonic beam combiner to provide increased stability and accuracy.

In the longer term, FIRST on the ELT would offer unique capabilities. The interferometric phase as measured by FIRST would sense the wavefront and feed the AO system. In particular, we have shown that the low wind and petalling effects can be reconstructed thanks to the spectral phase measurement. Combining wavefront sensing and science measurement, FIRST would offer an integrated solution to perform high contrast at unprecedented high angular resolution ($0.5\lambda/D \sim 2$ mas on a 38m-telescope at 656 nm), opening up the avenue for potential new exoplanet populations to be probed.

Keywords: optical interferometry, pupil remapping, spectro, interferometry, high contrast, high angular resolution, visible photonic integrated circuit, Subaru Telescope, FIRST