# On-chip nulling interferometry for the detection of young exoplanetary systems

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## ABSTRACT

*Context.* Nulling interferometry allows to obtain both high angular resolution and high contrast imaging of an object (planet, dust belt...) orbiting a much brighter object (star). The principle is as follows: a given number of telescopes (here, 4) collect the flux coming from a system star + planet, and, through the right recombination, the on-axis stellar light is cancelled (nulled) by destructively interfering with itself, while the off-axis planetary signal will still be retrieved. In the case of young planetary systems, the thermal infrared is an interesting working spot, as the maximum emission of a young planet is shifted in the IR compared to its host star's flux: the flux ratio between the star and the planet diminishes, allowing to alleviate the constraint on the required contrast for the detection of young giant planets (a nulling of $10^{-5}$ after post-processing). The development of astrophotonic chips (using integrated optics for astrophysical applications) allow for more compact instruments, easing their integration on ground telescopes (GRAVITY recombination chip) or, even more so, space based projects (LIFE, Large Interferometer for Exoplanets, exploiting the idea of a space based nulling interferometer).
*Aims.* We aim to develop an integrated nulling chip in the context of the NOTT instrument. NOTT is an L'-band (3,5-4,0 μm) nulling interferometer, part of Asgard, an instrument suite in preparation for the VLTI visitor focus. NOTT will focus primarily on young planetary systems near the snow line, as well as detecting exozodiacal dust that could obscure Earth like planets.
*Methods.* In order to obtain a high contrast ratio, nulling interferometry requires modal filtering as well as a precise control of the wavefront splitters and couplers, and integrated optics is a way to do both at the same time. We designed 4-Telescope recombination nulling chips made in Lithium Niobate ($LiNbO_3$) using Titane Diffusion. The electro-optic properties of Lithium Niobate allow to locally change the refractive index of the material by applying an electric field ramp modulation, allowing to finely tune the fringes, thus increasing the contrast.
*Results.* We obtained very good transmission of the waveguides in LiNbO3 in the mid-IR, and we report on the splitting ratio and interferometric recombination of the photonic functions, as well as the obtention of interferometric fringes using electro-optic modulation.

**Key words.** astrophotonics – high angular resolution – high contrast imaging – nulling interferometry – L'-band – young giant planets