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HIGH-ANGULAR AND HIGH-CONTRAST VLTI OBSERVATIONS FROM Y TO L BAND WITH THE ASGARD INSTRUMENTAL SUITE

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Abstract. ESO's Very Large Telescope Interferometer (VLTI), Paranal, Chile, has a history of record-breaking discoveries in astrophysics and instrumentation. The next leap forward is its new visitor instrument: the Asgard instrumental suite. It comprises four natively collaborating instruments: HEIMDALLR, which performs fringe tracking, wavefront correction and stellar interferometry in the K band, with the same optics and simultaneously; Baldr, a Strehl optimizer using a Zernike wavefront sensor in the H band; BIFROST, a photonic combiner whose main science case is studying the formation processes and properties of stellar and planetary systems in the Y, J and H bands; and NOTT, a nulling interferometer dedicated to imaging young nearby planetary systems in the L band. The idea to make the instruments complementary arises from overlap between the different science cases across a range of spectral bands between Y and L. Asgard is to be set on the Visitor 2 table formerly used as the AMBER optical table. Its control architecture is a hybrid between custom and ESO-compliant developments which will allow Asgard to benefit from the flexibility offered to a visitor instrument while allowing for a deeper long-term integration into VLTI for an opening to the community. The suite is in its integration phase in Europe and should be shipped to Paranal in early 2025 after approval from ESO. We detail the current integration status of the project, the control software integration and the plans.

Keywords: long baseline interferometry, exoplanets, AGN, protoplanetary disk, spectroscopy, nulling interferometry, binaries

1 Introduction

The emphatic triumph of the Very Large Telescope Interferometer (VLTI) of the European Southern Observatory (ESO) and its second-generation instruments (namely General Relativity Analysis via Vlt InTerferometrY –GRAVITY– (Eisenhauer et al. 2011) and Multi AperTure mid-Infrared SpectroScopic Experiment –MATISSE– (Lopez et al. 2022)) in delivering unique science has set European astronomy apart. The Asgard instrument suite will extend the scientific capabilities of the VLTI following its priorities for the next decade (Mérand 2018). Asgard was approved during the first semester of 2023 for integration and commissioning from 2024 to mid-2026.

The Asgard suite (Martinod et al. 2023) mainly consists of four instruments which are:

- HEIMDALLR (High-Efficiency Multiaxial Do-it ALL Recombiner): a remapped interferometer + wavefront sensor operating in K band (Ireland et al. 2018);
- Baldr: an active injection controller (Zernike wavefront sensor) operating in H band;
- BIFROST (Beam-combination Instrument for studying the Formation and fundamental paRameters of Stars and planeTary systems): a stellar interferometer with high resolution spectroscopy operating in Y, J and H bands with spectral resolutions of R=50, 1000, 5000, 25000 (Kraus et al. 2022);

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- NOTT (Nulling Observations of dusT and planeTs): a photonic nuller operating in the L band (Defrère et al. 2022).

HEIMDALLR and Baldr are mostly dedicated to correcting atmospheric aberrations and atmospheric pistons; BIFROST and NOTT are mostly science-driven. Asgard will operate from Y to L bands (1 to 4 microns).

2 Science cases

Asgard science cases are diverse (Martinod et al. 2023; Kraus et al. 2022; Defrère et al. 2022), such as the formation process of binary systems, mass accretion and ejection, formation and evolution of exoplanetary systems and exoplanet atmospheres, protoplanetary and circumplanetary disks, exozodiacal dust.

BIFROST will remove the degeneracy between flux ratio and separation, raised in the GAIA DR3 catalog. It is then possible to derive dynamical masses and the ages for many systems across the HR diagram. Moreoever, the binary formation processes constrain the spin-orbit alignment of the system. Another BIFROST's key science os the exoplanet spectroscopy by performing differential visibility measurements in the Y and J bands, particularly in the Paschen β lines. The observation will yield information abouth surface gravity, cloupd article size, relative abundances, migration, complementary to the observations made in the K band by GRAVITY. BIFROST will have enough angular resolution to probe the area between the star and the inner rim of the accretion/rejection disks.

NOTT will image exoplanets within the snowline. This region is allegedly the birthplace of young hot giant planets. NOTT will also enable the determination of the age of the exoplanets and discriminate the formation process between hot or cold starts. Finally, NOTT will focus on the exozodiacal dust in the L-band. It complements the surveys done in the N and K bands. This dust is a marker of the formation of a planetary process and it is one of the main "natural" obstacle to the detection of exo-Earth.

3 Conclusions

Asgard is a new instrument suite proposed to ESO as a visitor instrument to open new unique scientific capabilities at the VLTI (YJH high-spectral resolution and L-band high-contrast nulling interferometry at milli-arcsecond angular separation). It consists of 4 different modules: BIFROST, Baldr, HEIMDALLR, and NOTT. The suite is currently in the design and preparation phases. Its science cases is broad and divserse with a particular focus on binary systems and exoplanetary observations.

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