The ESO Very Large Telescope Interferometer GRAVITY instrument: an overview

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1. Introduction

At the centre of the Milky Way galaxy, the Galactic Centre, there exists a super-massive black-hole with over four million solar masses. Near infrared flares are observed at the position of the supermassive black-hole. The GRAVITY instrument was designed to be able to astronometrically monitor the flares to probe how and if they move around the super-massive black hole. This requires an astrometric precision of the order of the angular size of the Schwarzschild radius, for this super-massive black-hole: 10 micro arc-seconds. This precision would allow us to probe origin of these flares, the space-time around the supermassive black hole and testing stellar dynamics in the strong field gravity (Eisenhauer et al. 2011).

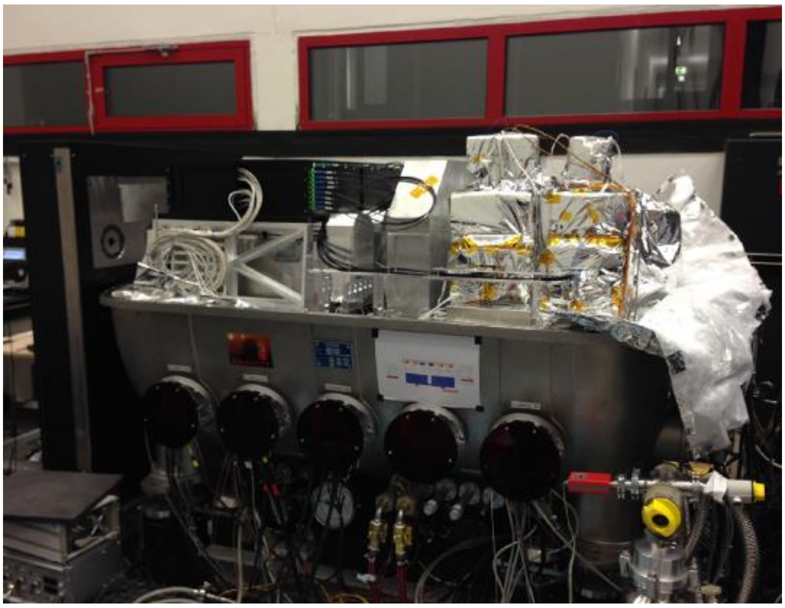

Figure 1. Left panel: Building the GRAVITY instrument. It can be seen that sub instruments of GRAVITY are installed inside the GRAVITY cryostat.

2. Materials and Methods

GRAVITY (Eisenhauer et al. 2011) is a beam combiner instrument operating in the astronomical K-band (2.2 micrometres), cf. Figure 1. It combines the four 8m telescopes beams of the Very Large Telescope Interferometer. The GRAVITY subsystems include: a) wavefront sensors; b) acquisition camera and beam stabilization system (Gordo et al. 2014; Pfuhl et al. 2014); c) fringe tracker; d) metrology system and e) a novel fibre-fed integrated optics; d) a spectrograph with a resolution of up to 4.000.

Atmospheric wavefront errors are measured by imaging a reference star using four infrared wave front sensors. The errors are corrected by using VLT multi-applications curvature adaptive optics deformable mirrors (MACAO). The infrared wavefront sensors are extending the usability of adaptive optics to the regions of high visible obscuration like the Galactic Centre. During observations, telescope beams are stabilized using laser guiding systems and the near infrared acquisition camera (Gordo et al. 2014).The acquisition camera operates in the astronomical H-band (1.65 micrometres). The telescope pupil and tip-tilt perturbations are measured by injecting laser beams from the telescope spider. The perturbations are corrected by actuating and steering mirrors. These corrections are mandatory to achieve the required astrometric accuracy and to stabilize the light injection into the fibres.

The polarization and the differential optical path between the science and fringe-tracking reference are adjusted by the fibre control unit using fibred differential delay lines and polarization rotators. The acquisition camera plays a critical role in injecting science and phase reference stars light into the fibres that deliver the beams to the integrated beam combiner chip. Four phase-shift fringe sampling is imprinted on chip which provides instantaneous phase and visibility information for all interferometric baselines. In astrometric mode both science and phase reference stars are used to drive the fringe tracker detector and the science spectrometer. Phase differences that occur between the beam combiner and the telescopes along the optical train are compensated by measuring the interference patterns of laser light back-propagated from the beam combiner instrument to the telescope spiders.

3. Discussion

Presently all systems are integrated and tested within the cryostat. GRAVITY will be shipped to the European Southern Observatory at Paranal in June 2015.

References

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