

# Developing Homodyne Interferometers for Space Applications

Miranda Bradshaw<sup>1\*</sup>, Clive Speake<sup>1</sup>, Christian Trenkel<sup>2</sup>

<sup>1</sup> University of Birmingham, Birmingham, UK, <sup>2</sup> EADS Astrium UK, Stevenage

\*mjb@star.sr.bham.ac.uk

**Abstract:** The EUCLID homodyne interferometer is a compact optical instrument capable of measuring displacement with a resolution better than a nanometre, with a tilt immunity of  $\pm 1^\circ$ . It was designed and manufactured at the University of Birmingham [1, 2]. With support from EADS Astrium, EUCLID is being developed for space applications.

## 1. What is a Homodyne Interferometer?

A homodyne interferometer is a device that causes two beams of light of the *same* frequency to interfere. It has two “arms”; the distance travelled by a particular beam from the centre of the system to a mirror (shown in Fig. 1). In polarisation-based interferometers, each arm contains one polarisation component of light. The length of one arm may be altered by moving the mirror in that arm by some distance,  $z$ .

The change in arm length means one beam travels further than the other, creating a difference in *optical path length* between the two beams. This difference is measured as a displacement via the interference pattern caused when the two beams are recombined (Fig. 1). The displacement of the mirror is proportional to the distance between the fringes.

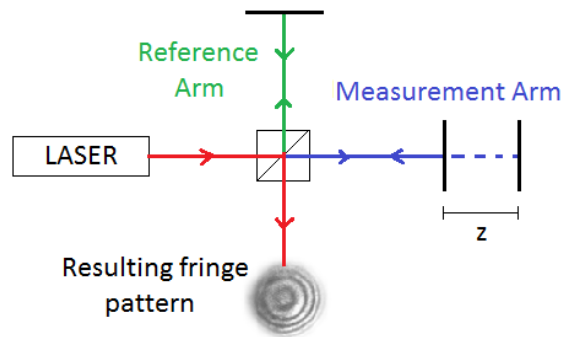


Figure 1: A simple homodyne interferometer, containing a beam-splitter and two mirrors

## 2. What is EUCLID?

The Easy to Use Compact Laser Interferometric Device (EUCLID) is a tilt-insensitive polarisation-based homodyne interferometer (Fig. 2). It can measure distances up to 12 mm, with a sensitivity of nanometres. It is 60 x 56 x 22.5 mm and weighs only 130 g, making it light-weight and compact; ideal for space applications.

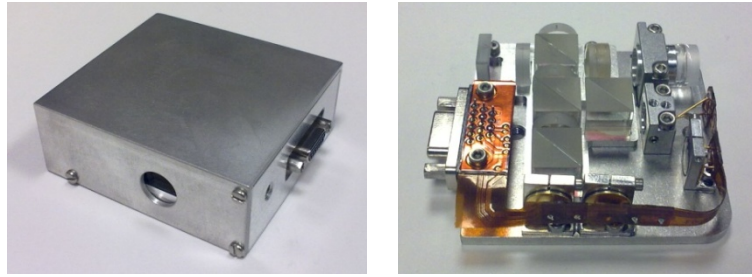


Figure 2: (a) EUCLID [3]; (b) EUCLID with cover removed [3]

### 3. Tilt Immunity from a Cat's Eye

Tilt immunity is provided by the *cat's eye* within the design. A *cat's eye* is a lens and a mirror (placed at the focal plane of the lens,  $f$ ). The system acts as a retro-reflector, thus any incoming beam is reflected back out of the system parallel to its entry axis (Fig.3). Using this concept within the design, EUCLID is tilt-immune to  $\pm 1^\circ$ .

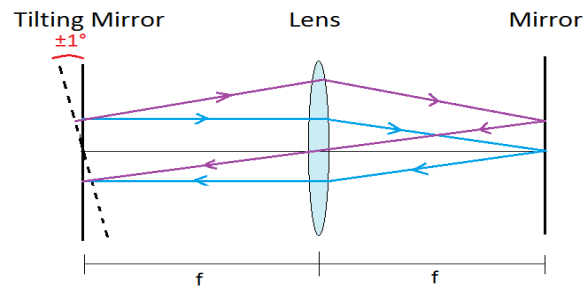


Figure 3: The cat's eye schematic

### Summary

With support from EADS Astrium, the EUCLID homodyne interferometer is being developed for space applications at the University of Birmingham. A new cats' eye design has been developed, allowing a longer target arm. A prototype has been successfully built in the laboratory in Birmingham, with a target arm of 1 m.

The new EUCLID design will provide accurate, long-range measurements for space missions without compromising mass or power budgets. It will enable greater precision in satellite structure metrology and spacecraft positioning.

### References

- [1] F Pena-Arellano, S Aston, C Speake, "Experimental realization of a mirror tilt immune interferometer", unpublished
- [2] C Speake, S Aston, F Pena-Arellano, T Copland, "Improved interferometer", International Patent Publication Number, WO 2009/010750(A1), 2009
- [3] Photographs courtesy of S M Aston, 2011