

Ground and space based interferometry

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Abstract: Ground and space based interferometry are complementary. While, in the longer term, space missions promise to break the limitations imposed by our atmosphere, the technologies that will enable this are validated on ground based facilities.

1 Introduction

A. Couder's statement that "The air is the worst part of an instrument" applies in full vigor to stellar interferometry. Not only does the air restrict the available transparency windows, but the performance of a stellar interferometer is intimately connected to the intensity and the temporal behavior of the atmospheric turbulence, and the number of photons available in the coherence volume $r_0 c \tau_0$ that will determine the ultimate sensitivity of on-axis cophasing systems. The turbulence (via its isoplanetic angle θ_0) also drives the fraction of the sky available for off-axis cophasing.

Moving interferometers to space, therefore, comes as a natural idea and this was first explored in the early eighties, with several workshops dedicated to the topic from 1984 to 1992 (1984 Cargèse: ESA colloquium on Kilometric Optical Arrays in Space; 1987 Granada: ESA workshop on optical interferometry in space; 1987 Cambridge: Workshop on imaging interferometry; 1989: LOUISA workshop; 1990 New York: Astrophysics from the Moon; 1991: NASA workshop on Science Objectives and Architectures for Optical Interferometry in space; 1992 Beaulieu: Targets for Space-based interferometry). In addition to the potential for full-sky coherent observations of faint sources across the whole spectrum (including the UV and the far infrared), proponents of space interferometry pointed out the low radiation environment (with permanent sun shielding possible and thermal background limited by zodiacal lights at long wavelengths), unlimited real estate for baseline deployment and a broader choice of configurations than from the ground (linear arrays, 2D arrays, free-floating interferometers), most of them alleviating the need for a delay line. For these reasons, space interferometry was perceived as "easier" than ground-based interferometry.

Overall, this was a fairly euphoric period which was characterized by a multiplicity of projects, which were defined by instrumental concepts rather than by science objectives. Proposed baselines were on a modest scale (10–100 m at most) but still provided very high resolution due to the short operating wavelengths, and most projects put the emphasis on image reconstruction. Moon-based concepts were also introduced (Burke et al. 1989) with the expectation that the cost of human presence would be covered by a lunar base program. With the promise of routine shuttle flights (up to 50 per year), access to space was expected to become cheap to the point that the main issue would be the cost of the payload. All of these projects were considered for a 15 to 20 year time frame, i.e. planned to be completed by now.

2 The current situation

Twenty years later, while ground based interferometry has evolved from single-team experiments into mature large scale, community-open facilities such as the VLTI, space interferometry is still in its infancy. There are currently no space interferometry missions that are beyond the preliminary development phase. The global astrometric mission GAIA, originally planned to be carried out by a space interferometer, will fly around 2012 but its instrumental concept no longer involves an interferometer. Quite ironically, the first scientific results based on space interferometry data were obtained with an instrument never designed for that purpose – the Fine Guidance Sensor of the Hubble Space Telescope (see for example Lattanzi 1994).

Contrary to the early concepts, interferometric missions currently under study have a much more focused application, and their design is driven by their science cases (all linked to exoplanetary studies): either narrow angle astrometric detection in the visible (SIM, Laskin 2004), or detection of telluric exoplanets in the habitable zone of nearby stars, with spectroscopic characterization (in the search for biological markers in their atmosphere) using interferometric nulling in the far infrared (DARWIN, TPF-I, Fridlund 2004). These are going to be major missions, whose development time is expected to take 10 to 20 years.

3 Conclusion

The future is certainly bright for space interferometry: it has found a compelling science case (the remote sensing of life on other worlds) and it is currently the only known technique (with the possible exception of coronagraphy in the visible on large space telescopes) to achieve this goal. But space missions are best built from technology with a history of experience, and therefore their future lies in the long term. Until then, ground based interferometry is needed to prove the technology readiness and prepare the science programs. As the fundamental limits set by the atmosphere have not yet been reached, the full potential from the ground should also be exploited with the implementation of new technologies (MCAO, laser guide stars, fine fringe tracking, dual field), and operation from the sites most appropriate for interferometry.

References

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