“Adaptive Optics for Kilometer-Scale Free-Space Optical Links in Infrared Interferometry”

Proposant : Benoit Neichel (benoit.neichel@lam.fr)

Lieu : Laboratoire d'Astrophysique de Marseille (Aix-Marseille Université)

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Mots-clés : Instrumentation, Adpative Optics, Interferometry

Compétences nécessaires : The ideal candidate has a Master’s degree in optics, physics, engineering, or astronomy, with a strong interest in adaptive optics, atmospheric propagation, and scientific instrumentation. Experience in numerical simulation, Fourier optics, or real-time control is helpful, and familiarity with AO benches is an asset but not mandatory. Curiosity, autonomy, and motivation to work at the interface between theory, simulation, and experiment will be essential.

Sujet scientifique de la thèse :

This PhD aims to enable kilometer-scale optical/infrared interferometry by developing an adaptive optics (AO) system capable of stabilizing near-infrared stellar beams propagated horizontally over 1–2 km free-space links. Extending interferometric baselines to the kilometer scale would dramatically improve angular resolution, opening access to micro-arcsecond imaging of supermassive black holes, protoplanetary disks, and potentially atmospheric structures of nearby exoplanets. The main challenge lies in horizontal near-ground atmospheric propagation, which is dominated by strong and rapidly evolving turbulence. Over kilometer-scale paths, optical beams experience phase distortions, scintillation, beam wander, and wavefront degradation. Unlike laser communication systems, astronomical interferometry requires wavefront stability at the level of a few tens of nanometers, imposing extremely stringent correction requirements. The PhD will first focus on characterizing horizontal turbulence using theoretical models, meteorological data, and numerical tools developed at LAM and ONERA. The student will quantify key turbulence effects and derive system requirements for wavefront sensing and control. An end-to-end simulation platform will then be developed, incorporating Fresnel propagation, multi-layer turbulence, realistic wavefront sensor noise, deformable mirror models, pupil compression, and closed-loop control. This tool will allow performance evaluation and architecture optimization. A central component of the project is an on-sky pathfinder experiment at Paranal Observatory. Two small telescopes deployed along a horizontal baseline (~30 cm apertures) will be used to directly measure turbulence, test wavefront sensing strategies, and validate numerical models under real atmospheric conditions. This experiment will provide critical input for the design of a future kilometer-scale AO-assisted interferometric link. By the end of the PhD, the project will deliver validated simulation tools, a calibrated turbulence model for horizontal propagation at Paranal, and a consolidated AO architecture suitable for ultra-long-baseline infrared interferometry, paving the way for the next generation of high-angular-resolution astronomical facilities.

Informations complémentaires :

Contacts:

Benoit Neichel (LAM) – benoit.neichel@lam.fr

Thierry Fusco – thierry.fusco@onera.fr

Guillaume Bourdarot – bourdarot@mpe.mpg.de

Francois Glasser – fglasser@apical.fr