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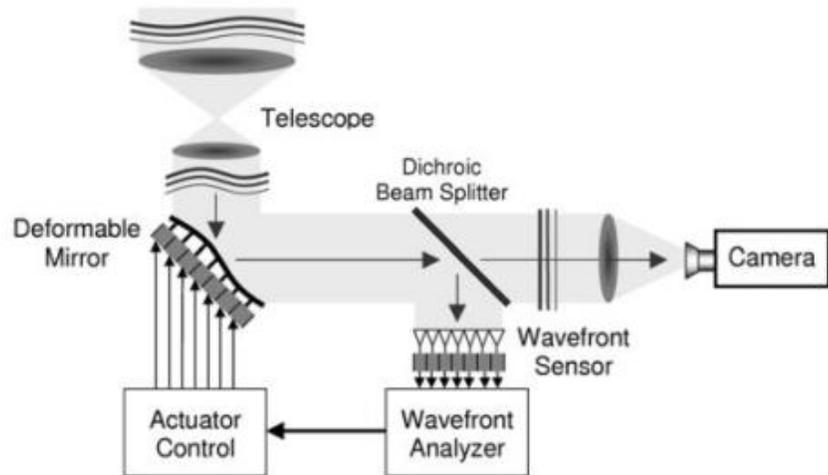
Advanced control systems for adaptive optics for laser communications

Diego Gilioli - 41st Cycle

Supervisor: Dr. Stefano Bonora

1° year admission - 12/11/2025

Study case

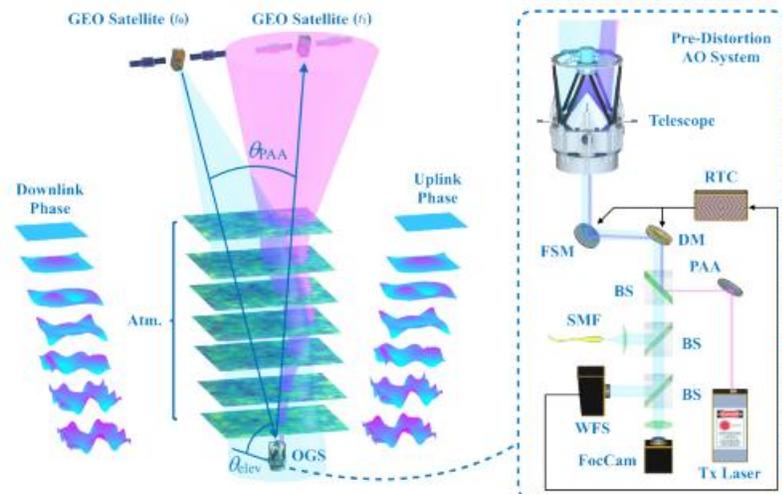


Credits: Guchuan Zhu et al. 2006

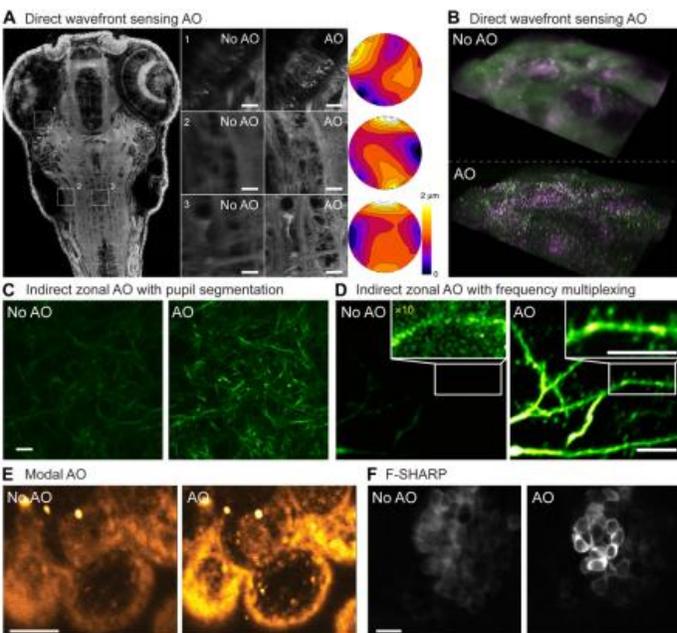


Credits: ESO/P. Weilbacher (AIP)

- The atmospheric turbulence introduces aberrations to the PSF of a light source in optical band → lower intensity, incorrect position, increase Bit Error Rate (BER) for Free-Space Optic Communication (FSOC)
- Adaptive Optics (AO) is a technology aimed for the compensation of the turbulence and the mitigation of its effect, both in uplink and downlink
- AO system is made of: 1 Wavefront Sensor (WFS) → detection of the aberrations; 1 Real-Time Computer (RTC) → brain of the system; 1 Deformable Mirror (DM) → wavefront correction



Credits: HRISTOVSKI et al. 2024



Credits: ZHANG et al. 2023

- AO for FSOC: “reverse” process than astronomical AO → pre-distortion of the laser using DM or Deformable Lens (DL) → atmosphere itself changes the wavefront of the laser
- Issues: high power laser and integration in the optical setup; design and developing of custom components
- Microscopy: correction of the observation across semi-transparent mediums in difficult environment
- Issues: wide range of distorting mediums, integration of the reference beam in the optical system



My role



Workplan

- 1st year: design and development of prototype AO components (using apposite software and machines)
- 2nd year: measurement and refinement of the prototypes
- 3rd year: performance testing and real-world case of study implementation

Methods

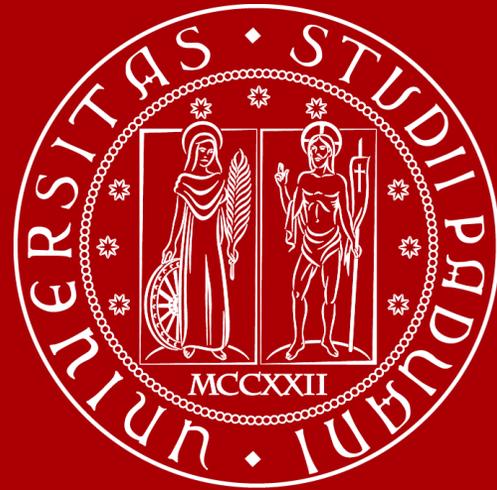
- Design SW (Zemax, CAD, ...)
- Machines (3D printers, laser incision, ...)
- Advanced optical lab design and setup for different purposes
- Transversal skills between material science, engineering and optics

Expectation



- Upgrade of the AO systems for FSOC, guaranteeing better control on the aberrations and more accurate pointing on the receiver → accurate and stable optical communication from ground-station to satellite
- Update of AO systems and eventually Multi-Conjugate AO (MCAO) for microscopy purposes → simplification of histological observations
- Design and production of integrated AO instrumentation adaptable for custom necessity

Thank you for the attention



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