Exploring the Ingot Wavefront Sensor for Sodium Laser Guide Stars in the laboratory

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Abstract

The combination of larger apertures and advanced Adaptive Optics systems promises to revolutionise ground-based astronomical observations, making next-generation telescopes the most powerful and coveted instruments. These telescopes, including the Extremely Large Telescope (ELT), will rely on Sodium Laser Guide Stars (LGSs) to correct atmospheric distortions and achieve higher imaging resolutions with high sky coverages. They will implement traditional Shack-Hartmann wavefront sensors adapted for LGSs, which face challenges such as elongated spot patterns due to the sodium layer's thickness and hence are expected to work in suboptimal conditions.
The Ingot class of Wavefront Sensors (I-WFS) was developed to address these issues. Designed to overcome the limitations of LGSs, the I-WFS enable AO systems to fully exploit the LGS potential. Matching the LGS geometry, they sense the beacon cylindrical volume while adapting to variable light distributions and differential elongation.
Our research focuses on the design, implementation, and laboratory testing of the I-WFSs. We detail the optical configuration of the three-pupil I-WFS, which splits the beacon into three beams. To simulate the LGS beacon the I-WFS laboratory setup includes OLED technology. We present the main results on the sensitivity and robustness of the I-WFS alignment in the presence of simulated sodium profiles, based on real sodium concentration measurements. Finally, we showcase a revised optical design of the laboratory bench that more accurately replicates the ELT parameters and that allows the incorporation of a Deformable Mirror for closed-loop operations. With this new system, we are preparing for future on-sky testing.

Keywords: Elongated sources, LGS, WFS, ELT, AO, Ingot Wavefront Sensor, Sodium profiles, OLED

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