Title of the Project: Characterization of the instrumental residual astigmatism and distortions for weak and strong lensing observations, from the Vera C. Rubin Observatory to the new generation of Extremely Large Telescopes

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Outline of the project:

The control and minimization of the instrumental residual aberrations is a key capability for any high-resolution and wide-field telescope. Instruments like MICADO at the Extremely Large Telescope (ELT), thanks to the Adaptive Optics (AO) correction provided by MORFEO, the multi-conjugate AO system for ELT, shall be capable of delivering ultra-precise relative astrometry (50 μas). To achieve such precision, the optical distortions shall be controlled to 1 part in 10^5. A comparable challenge comes from the mapping and study of the dark matter and dark energy in the Universe using strong and weak lensing observations with the Vera C. Rubin Observatory. Rubin is a US-led infrastructure to deploy an 8.4m telescope with a 3.5° field of view to map the southern sky with a dedicated decadal survey between 320 nm and 1080 nm. The lensing observations require excellent control of the residual instrumental astigmatism down at 1 part in 10,000 (Schechter & Levinson 2011). The dominant systematic error in weak lensing observations comes from the spatial correction of the telescope Point Spread Function (PSF) generated by small misalignments of the telescope optics (Jee & Tyson 2011). A precise characterization of the PSF and the image geometrical distortion is also crucial for image reconstruction in strong lensing, especially for small-scale dark matter detection. The optical design of ELT and Rubin telescopes have an interesting analogy based on a three-mirror anastigmat system. In this framework, the candidate shall measure and assess the Rubin telescope aberration residual content and the stability of the system alignment over time as a benchmark for the upcoming ELT-MORFEO project.
The work conducted on the telescope telemetry data collected during the alignment and commissioning will be complemented with optical ray tracing simulations to model and interpret the empirical results for dedicated scientific cases. The output product of this work should help verify the strong and weak lensing science requirements for the Rubin telescope in synergy with other ongoing and planned wide-field surveys, like the ESA-Euclid mission. The proposed research subject is predominantly instrumental (~70%), with a scientific part dedicated to the weak and strong lensing science case (~30%). The scientific part of the work is oriented to estimate the PSF shape (shear) and position stability (distortion) over the telescope to enable high-quality gravitational lensing observations and tackle the problem both on the observational and simulation sides. The skills mastered will provide the candidate with knowledge of modern integration, verification, and data analysis techniques. The project will place the student in an international scientific environment, and collaborations will help him/her/them continue the work after completing the Ph.D. program.
The position requires availability to travel and work for periodic shifts in Chile.