Thesis subject

Name of the laboratory: Laboratoire d'Astrophysique de Marseille LAM   (UMR7326)

Thesis advisor: **Raphael Gavazzi**
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HDR: yes   (2018, Sorbonne Universite)

Subject's title: Bridging the gap between weak and strong lensing regimes to shed light on the galaxy - dark matter halo relation

Subject description:

 The dark matter drives the cosmic evolution of structure in the universe and its distribution can reflect some of its fundamental properties but also it has a strong impact of the formation and evolution of galaxies and the visible baryonic matter therein. Gravitational lensing plays a key role in modern observational cosmology and wide field imaging surveys because of its ability to trace the mass. By combining the so-called strong and weak lensing regimes of distortions of faint background sources, we propose to uniquely investigate the light – matter relation and in particular the stellar to halo mass relation as a function of environment, by distinguishing sub-halos (ie treating differently central and satellite galaxies), and by relating the lensing signal within the large scale filamentary structure.

The project is perfectly timely with the start of the Euclid survey in which we occupy leading responsibilities. Much attention will be put on the details of the shape measurements in the inner parts of halos, where shear, convergence and magnification can be large (>0.1) and where the so-called flexion signal must be accounted for in order to propose a fully consistent modeling framework, also able to incorporate more local constraints like Einstein radii coming from the strong lensing regime.

The PhD student will incorporate the Euclid consortium (as well as CFIS/UNIONS for short term warm up studies) and explore some extensions of machine-learning and parametric model fitting methods which are proved to work efficiently in the regime of small distortions. Building on the large experience at LAM in strong and weak lensing signal extraction and modeling, the student will improve, test and incorporate those tools into the advanced newly refurbished SourceXtractor++ morphometry code.

Bibliography:
Kuemmel et al 2022 # Martinet et al. 2021 #   Euclid Preparation XXVI # Euclid Preparation IV # Great3 results

Please provide a brief justification of the scientific importance of the subject and/or its strategic interest for LAM:

With the upcoming launch of the Euclid satellite in which LAM has been putting a lot of expertise, resources, time and effort of the past decade, it is very now a critical time to warrant a maximal scientific return to LAM, by funding PhD subjects on a subject like strong and weak lensing, in which LAM has been playing a leading and recognized role. RG and Nicolas Martinet (NM, who will assist RG in some aspects of the thesis supervision) play leading lensing roles in the Euclid consortium, are eager to develop further this field at LAM in the context of Euclid.

Please provide a brief explanation about why the proposed subject is timely, and include an indication of the expected scientific landscape within 3 to 5 years after the defense:

The project is perfectly timely with the start if the Euclid Survey in which we occupy leading responsibilities. The first data release of Euclid is planned for 2025 but we already have in hand Science Verification and Early Release Observations program data. This guarantees a large visibility of the immediate applications of this thesis work but also asserts possible extensions and a secure working environment for the next 10 years or so.

Please provide a brief description of the work environment (resources, collaborations…) of the thesis:

We have at our disposal direct local access to servers at LAM and IAP and will also resort to the Euclid consortium computing resources in the Euclid Ground Segment for larger batches of calculations. We will also benefit from the support of CNES for the environment of the student. RG is co-lead of the strong lensing Science Working Group and NM is responsible of various work packages in the Weak Lensing SWG and OU-SHE (shear measurement organisation unit). This will naturally help the student find his/her way into this large collaboration and be active on the most promising and juicy aspects of the project.

Please indicate if other (co-) funding has been requested/accepted for this subject:

Additionally, we requested funding to the ANR for a PhD on this subject (PI de la Torre).

Please provide information about ongoing and past (over a 10 years period) supervision(s):

Raphael Gavazzi has co-supervised 4 theses in his former host institution (IAP) and none at LAM since his arrival in Sept 2021:
- Marko Shuntov (2019-2022) co-supervised with H McCracken
- Alexandre Barthelemy (2018-2021) co-supervised with S. Codis and F. Bernardeau
- Celine Gouin (2015-2018) co-supervised with C. Pichon
- Florence Brault (2008-2012) co-supervised with Y. Mellier