– PhD Position at LAM –

Optical fiber injection for the direct characterization of exoplanets at high-spectral resolution

Location: Laboratoire d'Astrophysique de Marseille (LAM; https://www.lam.fr/)
Funding: ERC HiRISE (PI Arthur Vigan, grant agreement #757561)
Duration: 3 years
Starting date: Fall 2018 (flexible)
Deadline: 1 April 2018

Supervisor: Arthur Vigan (CNRS/LAM)
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Summary

A PhD position supported by the ERC HiRISE (High-Resolution Imaging and Spectroscopy of Exoplanets) is offered at Laboratoire d'Astrophysique de Marseille (France) to work with Dr. Arthur Vigan on the optical fiber coupling of VLT/SPHERE and VLT/CRIRES+ to enable the characterization of young giant exoplanets at very high spectral resolution.

Context

The atmospheric composition of giant gaseous exoplanets provides essential markers of their most fundamental properties, such as their formation mechanism, formation location in the protoplanetary disk or internal structure. The new-generation exoplanet imagers on 8-meter telescopes equipped with extreme adaptive optics, VLT/SPHERE and Gemini/GPI, have been designed to detect very faint planetary companions (contrast ratio > 10^5) at small angular separations (<0.5") in the near-infrared, but they only provide very low spectral resolutions (R<100) for their characterization. Their measurements can be used to constrain the basic atmospheric properties of the planets but their low resolution does not allow studying their very detailed chemical composition. For a leap in the understanding of giant exoplanets, the spectral resolution needs to be increase by 2 to 3 orders of magnitude.

High-dispersion spectroscopy at resolutions up to R=10^5 is the most promising pathways for the detailed characterization of exoplanets, but it is currently out of reach for most exoplanets. Self-luminous, young giant planets that are directly imaged constitute ideal targets because of their intrinsic brightness in the near-infrared, but current high-dispersion spectrographs in the near-infrared were not optimized for the characterization of these faint objects: they lack coronagraphs to attenuate the stellar signal or the spatial resolution necessary to resolve the planet.

The goal of ERC project HiRISE is to bring high-spectral resolution to the best exoplanet hunter available today, SPHERE at the Very Large Telescope. We will implement a prototype fibre coupling with CRIRES+, the high-dispersion near-infrared spectrograph for the VLT, and use it for the characterization of a sample of know young giant exoplanets. The project will explore the key instrumental and astrophysical aspects of the coupling using theory, instrumental and astrophysical simulations, modelling, and laboratory validation of components and methods on our high-contrast imaging testbed (MITHIC). Data acquired on-sky with the prototype will be used to answer cutting-edge astrophysical questions on young exoplanets.

More information on HiRISE: http://astro.vigan.fr/hirise.html

PhD work

The successful applicant will be at the heart of the instrumental part of HiRISE.

To enable the characterization of exoplanets at high resolution, HiRISE will rely on the injection of the planetary signal into an optical fiber. However, an almost perfect coupling is required to not waste any useful scientific photon from the planet. The image stability in high-contrast imaging instruments is ensured with an extreme adaptive optics system, but additional wavefront shaping can also be used to optimize the image quality at the level of the coronagraph or to optimize the wavefront at the entrance of the fiber.

The main goal of the PhD will be to develop novel wavefront control techniques to optimize the injection of the planetary signal into the fiber and apply them on MITHIC, the high-contrast imaging testbed at LAM. The student will:

1) Work on the theory of fiber injection and propagation in the context of high-contrast imaging using a simulation model currently in development in HiRISE that (s)he will participate to improve;
2) Propose and implement a fiber injection unit on MITHIC;
3) Use the injection unit to compare simulation and experiment, for different type of fibers;
4) Implement and optimize wavefront control schemes to maximize the coupling efficiency between the planetary PSF and the fiber.

Over the course of the PhD, the student will work in close collaboration with the HiRISE team (6 people at LAM, plus external collaborators) to define the specifications of the prototype injection unit that will be implemented in VLT/SPHERE. (S)He will finally participate to the implementation of the final prototype.

The PhD will be done at LAM in the instrumental R&D group (GRD). The successful applicant will benefit from the rich local scientific environment, working with world-leading experts in adaptive optics, high-contrast instrumentation and exoplanet imaging. (S)He will also have the opportunity to disseminate the results of her/his research in the international community and reinforce the collaboration between the national and international institutions involved in the project.

Application

Applicants should send a PDF file by e-mail containing:

- A one page letter of motivation;
- A curriculum vitae;
- A copy of the highest-level diploma;
- Marks and ranking at the Master's level

to Arthur Vigan (arthur.vigan@lam.fr). Please also arrange for 2 letters of recommendation to be e-mailed directly.

Applications sent before 1 April 2018 will receive full consideration. Past this date applications will be considered upon availability of the position. LAM and CNRS are actively committed to equal opportunity in employment.

Bibliography

- Oppenheimer & Hinkley, ARA&A, 47, 253: https://arxiv.org/abs/0903.4466
- Snellen et al., 2015, A&A, 576, A59: https://arxiv.org/abs/1503.01136
- Wang et al., 2017, AJ, 153, 183: https://arxiv.org/abs/1703.00582
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- Jovanovic et al., 2017, A&A, 604, A122: https://arxiv.org/abs/1706.08821