– Thesis subject –

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Subject's title:

Exoplanet characterization at high spectral resolution with VLT/HiRISE

Subject description:

Understanding the origin and physics of extrasolar giant planets is crucial as they gravitationally dominate their systems, and they can either enhance or inhibit the subsequent formation of telluric planets with masses and separations comparable to those of the Earth. Their atmospheric composition provides essential markers of their most fundamental properties, such as their formation mechanism, formation location in the protoplanetary disk or internal structure. Current exoplanet imagers on 8-meter telescopes equipped with extreme adaptive optics, such as SPHERE on the Very Large Telescope (VLT), have been designed to study very faint planetary companions, but they only provide very low spectral resolutions ($R < 100$) for their characterization.

Over the past 5 years, LAM has been the leading institute in the development of the novel HiRISE instrument that will connect exoplanet imager SPHERE with the high-resolution spectrograph CRIRES+ on the VLT using optical fibres. The goal of HiRISE is to provide unique data at spectral resolutions up to $R = 100\,000$ on known companions. These high resolutions enable the detailed measurements of projected rotational velocities, which are connected to the planet's spin and might bear the signature of its initial angular momentum. They also enable resolving some spectral lines of particular interest to constrain, for example, the carbon-to-oxygen (C/O) abundance ratio that is now commonly assumed as a tracer of the formation location in the protoplanetary disk. And they open the door to the detection of molecules and some of their main isotopologues, which also relates to the formation channel of EGPs and brown dwarfs. HiRISE observations will be highly complementary to the ones possible with JWST, which does not offer very high spectral resolution, and will therefore probe a unique parameter space.

The HiRISE instrument is about to be installed on the VLT and will deliver the first science observations in the second half of 2023. A survey targeting ~20 known substellar companions is foreseen over the next 3 years.

The goal of the PhD project is to:

- Develop tools that will be used for the interpretation of HiRISE data as well as future instruments relying on high spectral resolution for the detection and characterization of exoplanets
- Analyze and interpret the science data from the HiRISE survey
- Perform a statistical analysis of the results on the full sample of the survey to study the formation processes of young giant exoplanets at a population level

The HiRISE survey is performed in collaboration with several institutes in France (LAM, IPAG, LESIA, OCA) and in Europe (University of Göttingen, University of Exeter, ESO). The successful applicant will be expected to collaborate with other researchers of the consortium for the analysis, interpretation, and publication of the results.

Direct spectroscopy of exoplanets at high spectral resolution is now a cornerstone of exoplanet science. All future facilities for the direct characterization of exoplanets (ELT instruments, post-JWST space observatories) will include some form of medium- or high-resolution spectroscopy. The student will therefore have plenty of opportunities to valorize the results of her/his work on the long term.

The PhD will be done at LAM in the planetary systems group (GSP). The selected applicant will benefit from the rich local scientific environment, working with world-leading experts in exoplanets and related instrumentation imaging. The student will also have the opportunity to disseminate the results of her/his research in the international community.

LAM is actively committed to equal opportunity in employment regarding gender, origin, religion or orientation. We strongly encourage people from underrepresented communities to apply.

Bibliography:

- Vigan et al., 2022, SPIE, 12185, https://arxiv.org/pdf/2207.06436.pdf
- Otten et al., 2021, A&A, 646, A150, https://arxiv.org/pdf/2009.01841.pdf
- Wang et al., 2021, AJ, 162, 148, https://arxiv.org/pdf/2107.06949.pdf