Thesis subject

Name of the laboratory: LAM

Thesis advisor: Isabelle Boisse
Email and address: isabelle.boisse@lam.fr
Tel: 04 91 05 69 55

Co-advisor:

Subject's title: Optimization of the SPIRou data processing : improve exoplanet detections and characterisations around low-mass stars

Subject description:

One objective of the current exoplanet science is to find and characterise habitable Earths and Super Earths. Among the 3800 planets detected (and many more candidates), very few are in the habitable zone (HZ) of their host stars (distance where liquid water can be stable at the surface), and none is equivalent to Earth.

The exoplanetary scientists have several reasons to focus on low-mass M dwarfs around which small/low- mass planets are easier to detect. Indeed, the radial-velocity (RV) signal of a planet is inversely proportional to M_{star}, so the method is more favorable to the coolest dwarf stars. It is also faster and easier to detect planets in the HZ of M stars since it is located at a distance where planets orbital periods are in the range 10 to 50 days, and that RV semi-amplitude is inversely proportional to P_{orb}. M dwarfs dominate the stellar population in the Galaxy, and most of them host planets. They are also advantageous for transiting planets.

Since M dwarfs are faint in the visible, high-resolution high-precision spectrographs are needed in the near-infrared (nIR). Few instruments are becoming available, and other projects are under construction. SPIRou, the new near-infrared spectropolarimeter and velocimeter for CFHT, is designed to be a world-leader in this scientific field. This high-precision RV instrument is designed for the detection of exoplanets around low-mass stars and for the detection of magnetic fields of young stellar objects. It is mounted on the 3.6m Canada-France-Hawaii telescope, since summer 2018.

Since very accurate RV in the near-infrared is a new domain, several challenges have to be faced when pursuing the search for telluric planets in the habitable zones of M dwarfs. For example, numerous telluric lines are present in the nIR part of the spectra. These lines do not have an equal contribution on each observation

depending on time and weather conditions. One should carefully mask or remove them, before deriving the radial-velocity of the star. Another limitation is the level of activity of low-mass M dwarfs that creates noise in RV and could hamper the detection of planets.

The PhD advisor is an expert in precise radial-velocity in the optical. The objective of the thesis will be to improve the technique in the niR domain. The main work of the student will be to search how to derive the best precise RV from the data: test and improve the current data reduction system, develop and test methods to handle the contributors of errors previously mentioned, optimise the RV extraction for M dwarf spectrum, and identify and correct systematic instrumental noise. The student will further have the opportunity to collaborate on the scientific analysis of the data obtained with SPIRou, and to be involved in the scientific analysis of interesting exoplanetary systems. She/he will be in strong interaction with the team at LAM, but also with the collaborators at IAP-Paris, IPAG-Grenoble and IRAP-Toulouse, as well as international collaborations (IReX-Montreal, IA-Porto, Obs.de Geneve).

SPIRou is an international project (7 countries) driven by France. LAM is one of the main contributor. Particularly, it is responsible for the delivery of the data reduction system (DRS) and of its continuous improvement. I.B. is the head of the SPIRou Science group in Marseille. The exoplanet group at LAM is also strongly involved in several other projects: NIRPS, SOPHIE, SPHERE, CHEOPS, TESS and PLATO.

Bibliography:

http://spirou.irap.omp.eu/Science2

- SPIRou: a spectropolarimeter for the CFHT
Moutou, C., Boisse, I., Hebrard, G., et al. 2015, sf2a,
http://adsabs.harvard.edu/abs/2015arXiv151001368M

SPIRou @ CFHT: data reduction software and simulation tools
Artigau, E., Bouchy, F., Delfosse, X. et al. 2012, SPIE, 8451, 3
http://adsabs.harvard.edu/abs/2012SPIE.8451E..3IA

- World-leading science with SPIRou - The nIR spectropolarimeter / high-precision velocimeter for CFHT
Delfosse, X., Donati, J.-F., Kouach, D. et al. 2013, sf2a, 497
http://adsabs.harvard.edu/abs/2013sf2a.conf..497D

- Predictions of planet detections with near infrared radial velocities in the upcoming SPIRou Legacy Survey-Planet Search
Cloutier, Artigau, Delfosse, et al. 2018, AJ, 155, 93
https://arxiv.org/abs/1712.06673