Doctoral School 352 Physics and Science of Matter

Thesis subject

Name of the laboratory: Laboratoire d'Astrophysique de Marseille

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Subject's title: **Development and performance evaluation of a convolutional neural network for the detection and classification of planetary transits.**

Subject description:

Space missions for the search of exoplanets provide very precise light curves with a duration ranging from a few months to several years, with a time sampling that can be of a few minutes. These light curves are analyzed to detect the signatures of planets in transit in front of their host star. Until now, conventional detection techniques such as BLS, based on the periodicity of the signal and its shape, have been implemented. The performance of the methods clearly depends on the filtering and correction techniques used upstream. Moreover, many stellar configurations have a photometric signature which can be confused with that of a planet and therefore after the detection it is therefore essential to make sure of the nature of the object in transit. To that purpose, the information contained in the light curve itself can be used, but also additional data on the star and its environment. The performances of both the detection step and the control step are therefore critical points in the complete process of searching and characterizing planets outside the solar system

The goal of the thesis is to explore the use of machine learning processes for automatic detection of planetary transits and their classification. These techniques allow to consider more information during processing than more conventional techniques, while maintaining a reasonable calculation time and thus might be closely considered for the analysis of future space missions such as PLATO (ESA M3 mission, launch 2026).

A first exploratory phase allowed us to choose an original approach, not based on the periodicity of the transits. A prototype, based on a well-documented computer vision architecture, has been developed and is operational. It is now necessary to move on to fine-tune the model and to train it more thoroughly. The work program consists of generating an extended simulated data set to train the network, adjust the hyperparameters of the model, and evaluate the final performances on the different types of planets (size, orbital period, etc..). The ultimate goal is to built up a network fine -tuned for the specific case of PLATO future data (2-year duration, 24 light and centroid curves plus "*imagettes*" at a 25 sec cadence) but the performance will also be tested on real data from space missions such as Kepler or K2. In a second step, the model will be extended in order to carry out classification simultaneously, i.e. to distinguish planetary transits from those of other objects such as eclipsing binaries.

The student will join the Planetary System Group and will benefit from a vibrant research environment setting inter-wining planetary and exoplanet sciences. She/he will benefit the team's current exoplanet programs on planets characterization with radial velocity and high precision photometric observations (CHEOPS, TESS). She/he will also collaborate with the PLATO Science Management team.

Bibliography:

- Ansdell et al. : *K2 variable catalogue - II. Machine learning classification of variable stars and eclipsing binaries in K2 fields 0-4,* 2018, ApJ 869
- Osborn et al. : *Rapid Classification of TESS Planet Candidates with Convolutional Neural Networks,* arXiv:1902.08544
- Armstrong et al. *K2 variable catalogue - II Machine learning classification of variable stars and eclipsing binaries in K2 fields 0-4*, 2016, MNRAS 456