Exploring the Nearest Ultracool Dwarfs for Potentially Habitable Exoplanets Well-suited for Detailed Atmospheric Characterization

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2017 Balzan Prize for The Sun's Planetary Systems and Exoplanets

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Period: 2018-

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About Exoplanetology

Our view of our solar system has widened greatly within the last two decades, thanks to the thousands of exoplanet detections achieved since the seminal discovery of 51 Pegasi b in 1995. Most stars of our galaxy harbour their own cortege of planets, and most of these exoplanetary systems have an architecture very different from ours. Their global study has drastically improved our understanding of planetary formation and evolution mechanisms, while revealing their intrinsic stochastic natures. Furthermore, for a fraction of the exoplanets known to transit nearby stars, a detailed characterization is now within reach of our instruments: orbital parameters, precise measurement of the mass and size – the resulting density constraining the bulk composition – and study of the properties of the atmosphere, including its chemical composition.

Within the last decade, several molecules and atoms have already been detected in the atmosphere of highly irradiated giant planets. These pioneering results have inaugurated a new field of astronomy: comparative exoplanetology, the detailed study of planets orbiting other stars than the Sun. The best is yet to come for this nascent

field, as upcoming astronomical facilities like the James Webb Space Telescope should enable similar results to be obtained for smaller and more temperate planets, including for potentially habitable rocky planets. The search for chemical traces of life beyond our solar system is thus within reach, but it requires the detection of suitable targets, i.e., temperate rocky planets transiting stars small and nearby enough to make possible their detailed atmospheric characterization with current technology.

The project SPECULOOS (Search for habitable Planets EClipsing ULtracOOl Stars) has grown out of these developments. This new exoplanet transit search targets the nearest ultracool dwarf stars, i.e., stars of very low-mass (<10% the mass of the Sun) and size (about the one of Jupiter) lying at the bottom of the main sequence. These tiny stars have been mostly overlooked by exoplanet searches so far, and their planetary population is poorly explored. Gillon's recent detection of the amazing TRAPPIST-1 planetary system with the prototype of SPECULOOS suggests that compact systems of temperate Earth-sized planets are frequent around ultracool dwarf stars, and that SPECULOOS should find many of them, which will become – like TRAPPIST-1 planets – exquisite targets for detailed characterization with James Webb and other upcoming facilities.

The Balzan Project

In this context, the goal of this Balzan project is to maximize the potential of SPECULOOS to explore the nearest ultracool dwarf stars. SPECULOOS is now based on one facility, the SPECULOOS Southern Observatory (SSO), which is composed of four 1m robotic telescopes currently in installation at Paranal Observatory in Chile. The idea is to extend the project to the Northern sky, to perform a complete exploration of all nearby ultracool dwarf stars. In collaboration with MIT, Gillon and his team at the University of Liège will initiate this extension by installing a first 1m Northern SPECULOOS telescope at Teide Observatory in the Canary Island of Tenerife. This project will fund a part of the installation cost of this new telescope (ground work plus cabling), and it will also fund the first year of research of a postdoctoral scientist who will be based at IAC in Tenerife to work on all aspects of the project (technical follow-up, target selection, planning of observation, data analysis, scientific exploitation). The Balzan Prize will also be used to fund the last two years (2019-2021) of the PhD of an undergraduate scientist working on the scientific optimization and exploitation of SSO, and to hire a two-year, half-time postdoctoral fellow who will manage the technical aspects of SSO and work on the scientific exploitation of SSO in data the other half of his/her time.

The remaining Balzan Prize funds will be used for the following:

- to fund a scientific workshop that will gather at Liege all the scientists involved in the project at the end of 2019, and a Balzan international conference on the planetary systems of ultracool dwarfs, to take place at Liege at the end of 2021;
- to procure equipment and operating credit (PC/laptops, replacement hardware pieces, travel cost to Chile or Tenerife or to conferences).

This Balzan project will represent a significant contribution to the success of the SPECULOOS initiative and to the search for life elsewhere in the Universe, by optimizing SPECULOOS potential for detecting potentially habitable rocky planets well-suited for detailed atmospheric characterization.