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The LIFE mission: a mid-infrared space interferometer to study the diversity of terrestrial exoplanets

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Summary: Studying the atmospheres of a statistically significant number of rocky, terrestrial exoplanets -- including the search for habitable and potentially inhabited planets -- is one of the major goals of exoplanetary science and possibly the most challenging question in 21st century astrophysics. However, despite being at the top of the agenda of all major space agencies and ground-based observatories, none of the currently planned projects or missions worldwide has the technical capabilities to achieve this goal. In this contribution we present new results from the LIFE Mission initiative, which addresses this issue by investigating the scientific potential and technological challenges of an ambitious mission employing a formation-flying nulling interferometer in space working at mid-infrared wavelengths [1,2,3]. We will focus on new yield estimates and the release of our simulator software as well as improvements on our input catalog. Advances in our knowledge of the exoplanet population as well as significant progress in relevant technologies justify the need, but also the feasibility for a future mission like LIFE to investigate one of the most fundamental questions of mankind: How unique is the phenomenon we call life in the universe?

Artist's impression of the LIFE concept.

Context: One of the long-term objectives of exoplanet research is the investigation of the atmospheric properties for a large number (~100) of terrestrial exoplanets. This is partially driven by the idea to search for and identify potential biosignatures. But such a statistically significant dataset is - in a more general sense - invaluable for understanding the diversity of planetary bodies. While exoplanet science is omnipresent on the roadmaps of all major space agencies and ground-based observatories and first steps in this direction will be taken in the coming 10-15 years with funded or selected ground- and space-based projects and missions, none of them will be able to deliver such a comprehensive and consistent, big data set. An alternative to the mainly discussed large space-based coronographic missions or the starshade concept is to separate the light emitted by the planet from that of its host star by means of an interferometer. In [4] for example we showed that Proxima Centauri b is a prefectly suited target for a space-based nulling interferometer with relatively small apertures.

LIFE is a project initiated in Europe with the goal to consolidate various efforts and define a roadmap that eventually leads to the launch of a large, space-based MIR nulling interferometer. This mission should be able to investigate the atmospheric properties of a large sample of (primarily) terrestrial exoplanets. Centered around clear and ambitious scientific objectives the project will define the relevant science and technical requirements. The status of key technologies will be re-assessed and further technology development will be coordinated. LIFE is based on the heritage of ESA/Darwin and NASA/TPF-I, but significant advances in our understanding of exoplanets and newly available technologies will be taken into account in the LIFE mission concept.

New Results and Progress: In a previously presented work [5], we used Monte Carlo simulations to demonstrate that a MIR space-based nulling interferometer like LIFE, could yield at least as many exoplanet detections as a large, single aperture optical/NIR telescope. Here we will present an elaborate update on this first study. A key aspect that we have investigated more closely is the specific treatment of stellar leakage and exozodical light in our simulations. We also had a critical look at the stellar input sample and its properties with a specific focus on multiplicity.

The details and exact number of planets depend on the assumed technical specifications and the underlying exoplanet populations, but from an exoplanet science perspective such an interferometer should be considered an attractive mission concept, at least complementary if not superior to an optical/NIR mission.

We will present our newest data simulator that incorporates various telescope sizes and a new noise model that takes into account all astrophysical noise sources. This enables us to systematically study our mission requirements in order to optimize our observing strategy.

As most detected planets will be warmer than Earth, going as short as 3 µm seems useful; at the red end 25 µm seems sufficient. This wavelength range features absorption bands of CO_2, H_2O, O_3, CH_4, $(N_2)_2$, and N_2O and also contains windows to probe surface emission. The spectral resolution (R ~ 20-100) is very likely to be driven by the need to avoid line contamination of certain molecules such as N_2O and CO_2 around 4.15 µm, as well as CH_4 and also N_2O and H_2O between 7.7 and 8 µm.

In another submission to this conference (Konrad et al. 2020) we discuss more details on our progress in spectral retrieval.

Future steps: Our analysis also shows that getting a better handle on the overall planet statistics is crucial for planning larger future missions. We are therefore working on a detailed simulation of the impact on scheduling for the survey and characterisation phases of the LIFE mission. In this context we are also currently investigating modern machine learning methods that crucial to scale up front to end simulations of the full LIFE survey. This in turn will not only inform aforementioned scheduling consideration but also help to define sensitivity, wavelength coverage and spectral resolution requirements on the technology side.

References: [1] Quanz, S. P., Kammerer, J., Defrère, D., et al. 2018, Optical and Infrared Interferometry and Imaging VI, 10701,107011I. [2] Defrère, D., Léger, A., Absil, O., et al. 2018, Experimental Astronomy, 46, 543. [3] Quanz,S. P.,et al. 2019. , arXiv e-prints arXiv:1908.01316. [4] Defrère, D., Léger, A., Absil, O., et al. 2018, Optical and Infrared Interferometry and Imaging VI, 10701,107011H. [5] Kammerer, J., & Quanz, S. P. 2018, A&A, 609, A4