LIFE: Large Interferometer For Exoplanets

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(Based on Quanz et al. 2018, SPIE, in press)

THE PROJECT: LIFE is a new 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 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.

SCIENTIFIC MOTIVATION: One of the long-term objectives of extrasolar planet 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 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, none of the currently selected missions and projects will be able to deliver such a comprehensive dataset.

EXOPLANET YIELD PREDICTIONS:

MONTE CARLO APPROACH (BASED ON [1])

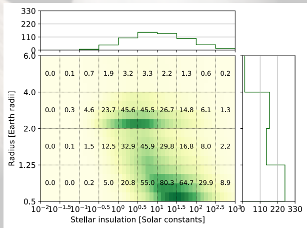
(a) Stellar sample: 320 (mostly single) FGKM stars within 20 pc

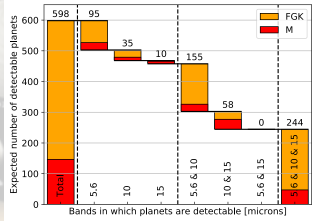
(b) Planet population: $R = [0.5\ R_{Earth}, 6\ R_{Earth}]$, $P = [0.5\ d, 300\ d]$
Distributions from [1] for M and [2] for FGK stars
Random circular orbits
Random albedos motivated by Solar System bodies

(c) Technical specs: Same as planned for Darwin [3]
4 free-flying collector telescopes (~2.8 m)
IWA of 5 mas @ 10 micron
10-sigma sensitivities in 10'000 s like JWST/MIRI

TOTAL PLANET YIELD FOR LIFE

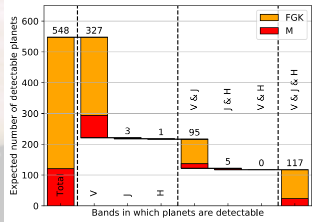
Doable in 2-3 years — depending on exozodiacal dust levels — assuming 40% overhead due to pointing, array rotation, detector readout etc.



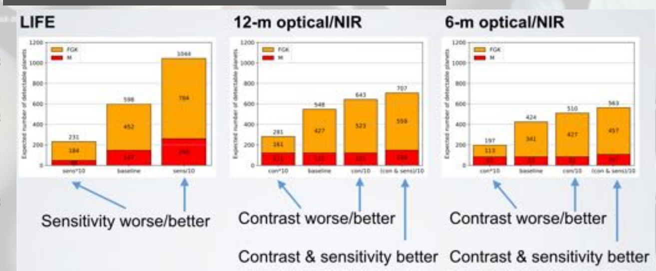


COMPARISON WITH OPTICAL/NIR SPACE TELESCOPE

Technical specs for optical/NIR telescope:
- 12-m primary mirror
- Contrast of 1e-10 at 2 lambda/D and beyond
- 10-sigma sensitives as LUVOIR in 10'000 s assuming broadband filters (V, J, and H band)



INFLUENCE OF KEY TECHNICAL ASSUMPTIONS

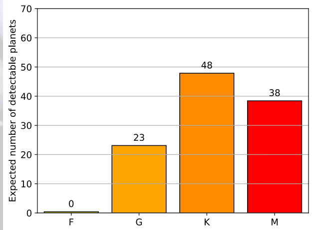


CONCLUSION

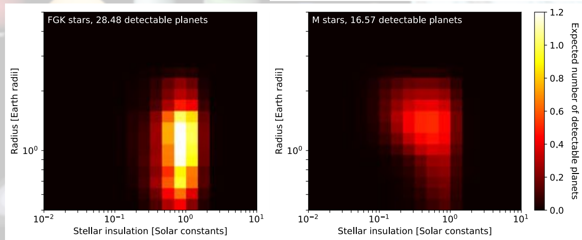
LIFE has the potential to detect ~600 exoplanets — more than a large optical/NIR mission — and would provide more characterization potential over a broader wavelength range

HABITABLE PLANET YIELD PREDICTIONS*:

Right: >100 planets detectable with radii $0.5\ R_{Earth} < R < 1.75\ R_{Earth}$ and insolation of 0.5 - 1.5 S_0



Bottom: based on estimates using the HUNTER tool [5] LIFE will detect ~28 habitable planets around FGK and ~17 around M stars



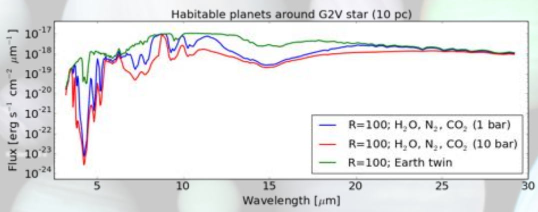
*requires a factor 10 better sensitivity than assumed in the baseline scenario, which — as one of the next steps — requires a prioritization and re-assessment of the stellar sample and an optimized observing strategy

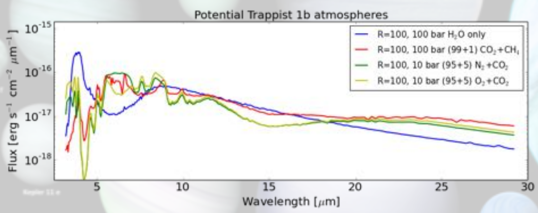
CONCLUSION

With an optimised observing strategy, LIFE has the potential to detect dozens of terrestrial planets which could be habitable

PRELIMINARY SCIENCE REQUIREMENTS:

In addition to sensitivity, wavelength coverage and spectral resolution need to be defined. In the mid-term, this will be done with atmospheric retrieval analyses. As most detected planets will be warmer than Earth, going as short as 3 micron seems useful; at the red end 25 micron is sufficient (see Figure below). 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 $(N_2)_2$ and CO_2 around 4.15 micron, as well as CH_4 and also N_2O and H_2O between 7.7 and 8 micron.





INTERESTED IN LIFE? WANT TO BE INVOLVED OR KEPT IN THE LOOP?

Please contact sascha.quanz@phys.ethz.ch or simply talk to me at the conference!

REFERENCES:
[1] Kammerer & Quanz, A&A 609, 4K, 2018; **[2]** Dressing & Charbonneau, ApJ 807, 45D, 2015; **[3]** Hsu et al., AJ 155, 205H, 2018; **[4]** Cockell et al., Exp. Astr. 23, 435C, 2009; **[5]** Zsom, ApJ 813, 9Z, 2015

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FNSNF Swiss National Science Foundation
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