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Beyond the Habitable Zone: A Multiscale Approach to Exoplanetary Biosignature Detection for HWO

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The search for promising candidates for life necessitates moving beyond the traditional Habitable Zone paradigm, employing a **multiscale approach** that integrates biological, chemical, and astrophysical perspectives. This presentation will demonstrate how our current understanding of extremophilic microorganisms, coupled with their environmental tolerances, can effectively characterize the life potential of exoplanetary atmospheres.

We introduce a novel **Multiparametric Life Score (MLS)**, based on atmospheric pressure, temperature, and radiation conditions, which provides an initial assessment of atmospheric compatibility with known life forms. This framework offers a refined method for identifying high-priority targets for future observational campaigns, including those of the HWO.

Crucially, our future work involves enriching this model with metagenomic data from extremophiles. This will enable us to describe the **atmospheric biochemistry** that could arise in the most life-compatible atmospheres, ultimately highlighting the characteristic mix of prevalent molecules that define an 'atmospheric exobiome'. This predictive framework aims to guide the search for novel biosignatures, informing the design and scientific requirements of future missions like HWO and its advanced coronagraphic capabilities."

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