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Oxygenic phototrophs exposed to simulated exoplanetary conditions: possible biosignatures in different organisms

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Oxygenic photosynthesis generates atmospheric and surface biosignatures, ideal targets for investigating the detectability of life beyond Earth. These are linked, respectively, to the oxygen release activity of oxygenic photosynthesis and to the absorption of their photosynthetic pigments, which on Earth generate a distinctive reflectance spectrum. As prime exoplanet targets for astrobiology are the ones orbiting in the habitable zone of M-dwarf stars, this poses the question whether such stars could sustain this remarkable metabolism, ultimately generating detectable biosignatures.
Most of oxygenic photosynthetic organisms rely indeed on harvesting Sun's visible light (VIS, 400-700 nm) to produce organic compounds and oxygen, while M-dwarfs'exoplanet receive a spectrum poor in VIS light and mainly enriched in far-red and infra-red light (FR, 700-750 nm, IR, 750-1000 nm), wavelengths that generally do not drive common oxygenic phototrophs. Interestingly, our planet offers terrestrial niches that can be considered exoplanets'light analogues, resembling the light generated by M-stars, found to surprisingly host some oxygenic photosynthetic organisms. Peculiar morpho-physiological adaptations can allow the use of very dim VIS light and FR photons, both in prokaryotes and eukaryotes. Some cyanobacteria can utilize constitutively FR light through chlorophyll d or acclimate to FR through mechanisms like Far-Red Light Photoacclimation (FaRLiP) [1, 2]. Some eukaryotic algae can harvest FR light by changing the organization of their light harvesting systems without synthesizing specific FR-absorbing pigments [3]. Even on plants, recent studies demonstrated that shade adapted understory species have evolved peculiar strategies to photosynthesize under very dim FR enriched light spectra [4]. In our laboratory, we developed a set up to simulate exoplanetary conditions in terms of anoxic atmosphere and irradiance, recently implemented with a custom-made UV lamp that simulates the flares reaching exoplanets orbiting M-dwarf stars. The set up allows to test the viability and growth of some of these FR-adaptable organisms also recording their oxygen evolution responses and reflectance spectra in real time, to evaluate the biosignatures that they would generate in an M-dwarf planetary system. The proposed talk will explore the photosynthetic responses in FR-enriched and simulated M-dwarf spectra, illustrating how the study of photosynthetic biodiversity coupled with laboratory simulations can help assessing the plausibility of oxygenic photosynthesis on exoplanets orbiting M-dwarfs and understanding what kind of biosignature this metabolism could possibly generate.

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