REMOTE SENSING OF PHOTOSYNTHETIC LIFE WITH SPECTROPOLARIMETRY

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Life on Earth had evolved to utilize stellar light as a source of energy through photosynthesis which emerged early in the history of Earth. The ability to harvest such a significant energy resource could likely also develop on habited exoplanets.

Recently, we have developed a polarimetry-based remote-sensing method for detecting and identifying life forms in distant worlds and distinguishing them from non-biological species (Berdyugina et al. 2015). We have designed and built a bio-polarimetric laboratory experiment BioPol for measuring optical polarized spectra of various biological and non-biological samples. Using our lab measurements, we have modeled intensity and polarized spectra of Earth-like planets having different surface coverage by photosynthetic organisms, deserted land, and ocean, as well as clouds.

Here we extend this work to photosynthetic bacteria. These bacteria are commonly found in various environments of the biosphere. In fact, the surface biosphere emits a substantial amount of bioaerosols to the atmosphere, where they on average comprise 25% of total airborne particles larger than 0.2 μm (Jaenicke et al. 2007). Our samples were collected from the Earth atmosphere and sunsequently grown in the lab. We have studied both liquid and dry samples and obtained reflected polarized spectra at various angles. In addition, we obtained transmission spectra for unpolarized and polarized light. We have found a similar spectral response of photosynthetic pigments to illumination as in plants, namely that maximum linear polarization is associated with the major absorption bands of biopigments (Fig. 1).

Our results demonstrate that linearly polarized spectra provide very sensitive and rather unambiguous detection of photosynthetic pigments in photosynthetic organisms of various kinds. This work paves the path towards remote sensing of microbial ecology on the Earth and of extraterrestrial life on other planets and moons.

References:

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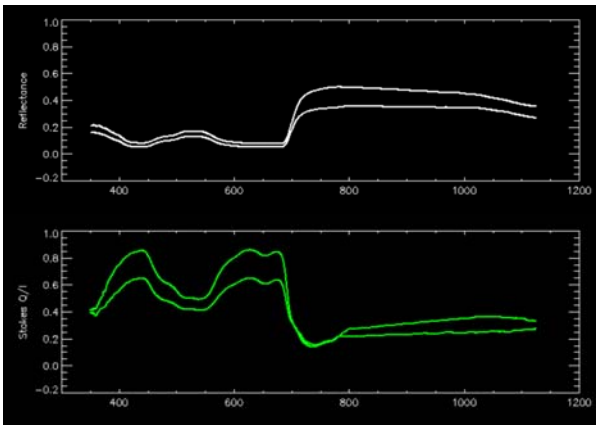

Figure 1: Reflectance (top) and linear polarization (bottom) spectra of cyanobacteria collected from the Earth atmosphere. Linear polarization peaks at the maximum absorption of biopigments.