SPECTROPOLARIMETRY OF BIOSIGNATURES IN EUROPA'S PLUMES AND AT THE SURFACE.

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Introduction: The phenomenon of homochirality is a powerful biosignature. All known self-replicating life forms, including archaea, bacteria, eukaryotes and even viruses, encode left handed amino acids into proteins and right handed sugars into multiple biopolymers including DNA and RNA. The homochirality phenomenon is likely to be generic to all biochemical life, arising as a consequence of self-replication, and hence this biosignature has the potential to reveal biological material even if it differs substantially from terrestrial life. Because of the optical activity of biological molecules, i.e. their influence on the polarization of light, and homochirality, this biosignature can be remotely observed on macroscopic scales using circular polarization spectroscopy. Precision full Stokes spectropolarimetry is required, and we describe an extremely compact, robust instrument concept which is well-suited to exploration of the Europa plumes and surface to seek evidence of chiral organics.

Optical activity from biomolecules:

Self-replication is a fundamental hallmark of life, and plausibly gives rise to the phenomenon of homochirality. Coupled to the optical activity of biomolecules, homochirality can result in a macroscopic singature in the circular polarization spectrum. *"No other chemical characteristic is as distinctive of living organisms as is optical activity"*[1]

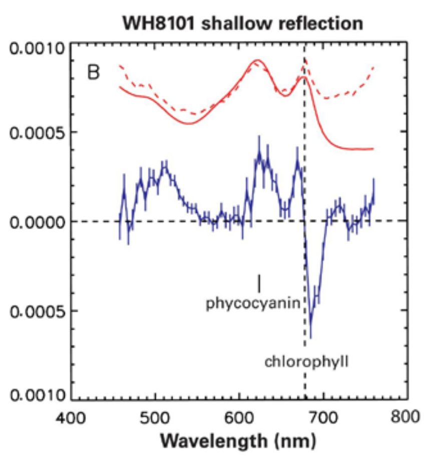

Fig 1: circular polarization spectrum (blue) and arbitrarily scaled absorbance spectrum (red) of photosynthetic cyanobacteria *Synechococcus* WH8101.

The circular polarization spectrum of light reflected from a culture of photosynthetic cyanobacteria is shown in Fig. 1, with its associated absorbance spectrum, revealing correlations between the strong transitions of photosynthesis and features in the circular polarization spectrum[2]. While we do not expect photosynthesis at Europa, similar transitions occur elsewhere in the UVOIR spectrum for biological molecules in general, forming the basis for the well-known biophysical technique of circular dichroism spectroscopy.

A compact and robust spectropolarimeter: Robust, compact, static optics can be configured to encode full Stokes spectropolarimetry onto a single data frame of a 2D detector with no moving parts[3], Fig. 2. With cubesat-scale instrumentation, the concept is extremely well-suited to space application, and is under active development.

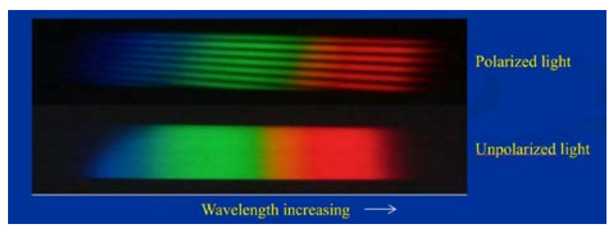

Fig. 2: Illustrating the spectropolarimetry concept – a 2D spectrum (lower); fringes encode all Stokes parameters when the instrument is illuminated with polarized light (upper).

With a small, sensitive, remote-sensing full Stokes spectropolarimeter flown as a very modest augmentation to a major Europa mission, we may seek evidence of chiral material in the plumes, as opportunity arises, and on the surface where material has arisen from the saline ocean below, thorough cracks or impacts.

References:

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