Europa Raman Spectrograph for Ocean worlds (ERSO): Integrating Cavity Enhanced Raman

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The Raman technique can provide key measurements of complex, biologically-relevant molecular species mixed within icy surfaces. Our Europa Raman Spectrograph for Ocean worlds (ERSO) instrument is a new Deep-UV+VIS dual-laser Raman system capable of detecting complex molecular species, e.g., constraining abundances of organics, isotopes, and amino acids.

Standard Raman instruments utilize a confocal technique where the excitation laser is focused to a small spot on the sample. Our integrating cavity enhanced Raman design is demonstrated to enhance the Raman signal by up to 4 orders of magnitude relative to the confocal approach, enabling the detection of complex distributions of molecules indicative of life [1]. Cavity enhanced fluorescence has already demonstrated nanomole sensitivity to Glycine mixed in ice (Phillips-Lander et al., LPSC, 2019), femtomolar level sensitivity for urobilin in liquid water, benzo[a]pyrene at 700 nanomole sensitivity, and for bulk pyrene down to 37 nanomole [2].

The integrating cavity material is optimized for high total internal Deep-UV reflectance. Samples of 1 mm to 1 cm scale are measured in bulk across their surface areas once placed inside the cavity. An additional fiber-fed frontend sensor provides contextual spot-targeting in stand-off mode. The advantages of ERSO for biosignature searches include: higher signal-to-noise / sensitivity, lower energy, and lower data volume per measurement without time-consuming raster scans and less UV photodestruction. Tests of the cavity in a MeV electron beamline at MIT representative of the Europa radiation environment have demonstrated no measurable performance degradation.

When assessing biosignatures at parts per billion or less abundances that are a priori unknown, it is imperative to disentangle the many Raman and fluorescence signals from volatiles, salts, and minerals in samples with an additional VIS laser capable of characterizing these components and their hydrates. ERSO's development effort is targeted to attain the high sensitivity needed for the measurement of biosignatures and other trace constituents that are key to understanding the potential for life on Europa.

References:

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[2] Bixler J. N. et al. (2014) *Proceedings of the National Academy of Sciences*, 111.20, 7208-7211.