NASA Astrobiology ECCA Report
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During my two-week NASA Early Career Collaboration Award (ECCA) research visit at the Jet Propulsion Laboratory (JPL), I worked with Dr. Edith Fayolle (Jet Propulsion Laboratory, California Institute of Technology) under the Planetary Studies Group in the Cryogenic Chemistry Lab to investigate the photodesorption behavior of SO_2 ice under simulated Europa-relevant surface conditions. Understanding the stability and UV-driven desorption of sulfur-bearing species on Europa is essential for interpreting surface composition data from upcoming missions such as NASA's Europa Clipper and ESA's JUICE.

A key part of this training included learning UV lamp irradiance characterization, a skill essential for deriving quantitative photodesorption parameters that underpin fundamental chemical models of icy surfaces. This experience was particularly valuable because it directly informed the development of the unique sample plate irradiation setup, enhancing the experimental capabilities of the Boreas cryo-vacuum chamber at the Astrobiochemistry lab at the University of Texas Rio Grande Valley, ensuring that photon flux can be accurately calibrated and uniformly distributed across multiple ice analog samples.

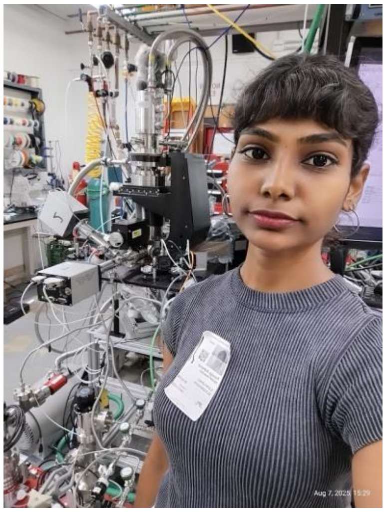
At JPL, the experiments were conducted in an ultra-high-vacuum chamber operating at a pressure of around 10^{-10} torr, simulating Europa's tenuous atmosphere. SO_2 ice was deposited via vapor deposition onto a gold-coated Quartz Crystal Microbalance (QCM), which enabled real-time monitoring of ice thickness and sublimation rates by measuring vibrational frequency shifts. To calibrate the incident photon flux, we positioned the in-situ SXUV100 photodiode (Opto Diode Corp.) at the sample location to measure the broadband deuterium (D_2) UV lamp's output across the 200–300 nm range. A set of narrowband UV bandpass filters with peak transmissions at 200, 220, 240, 260, 280, and 300 nm was used to isolate individual wavelength contributions to the total flux.

The measured photocurrent (in μA) was converted to optical power using the photodiode's wavelength-dependent responsivity (A/W) from the manufacturer's calibration data. The photon flux was then calculated using:

$$\Phi = (I / R) / (E \times A)$$

where I is the measured current, R is the responsivity, E is the photon energy, and A is the photodiode's active area (1×10^{-4} m^2). From this, we determined a calibrated photon flux density of approximately 5.2×10^{17} photons m^{-2} s^{-1}, integrated over the 200–300 nm wavelength range.

This calibration was critical to quantifying desorption yields accurately. The experiments were performed across a range of cryogenic temperatures (10 K to 90 K) to examine the influence of temperature on photodesorption rates. The results demonstrated UV-driven photodesorption of SO_2 ice under Europa-like conditions, with a clear dependence on the ice temperature.



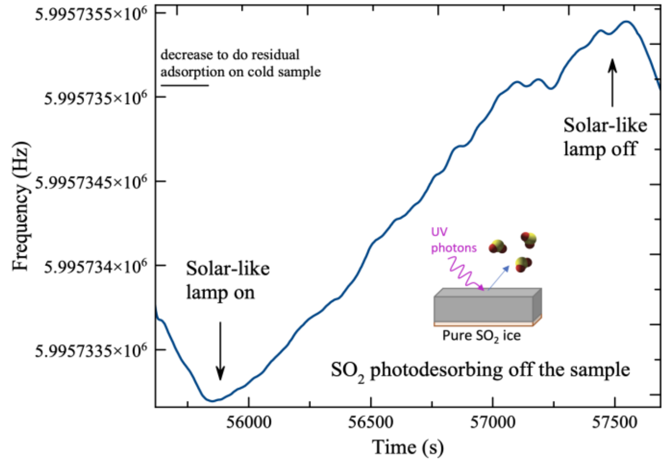
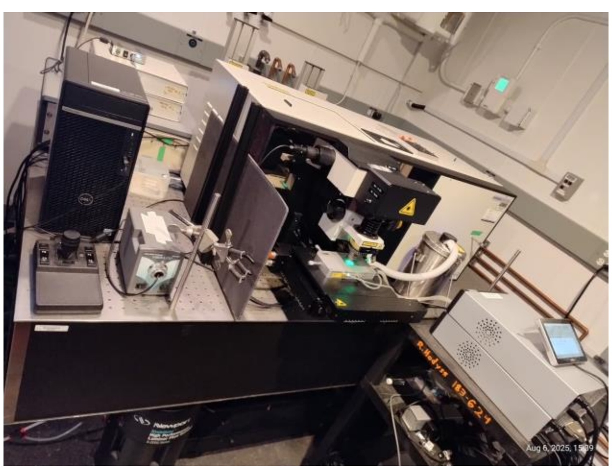


Fig.1 QCM UHV Chamber at the Cryogenic Chemistry Laboratory, JPL

Fig.2 Real-time experimental monitoring interface during SO_2 ice photodesorption experiments at JPL. The plot shows the quartz crystal microbalance (QCM) frequency response as an SO2 ice sample is being irradiated at 60K by the D2 lamp

Beyond the core experiments, this collaboration also enabled critical knowledge transfer to strengthen our Boreas chamber at UTRGV. I successfully integrated a nitrogen purge box for contamination control and implemented cryocooler temperature automation using resistance-based thermal sensors, significantly improving experimental reproducibility and stability for future work. In addition, I received hands-on training in Cryo-Raman spectroscopy from Dr. Morgan Cable's laboratory at JPL, where these techniques are used to study co-crystallization processes under Titan-relevant conditions. This training will directly enhance our ability to perform Raman-based surface characterization of Europa and Titan analog ices at UTRGV.



This NASA ECCA collaboration has provided critical experimental data, enhanced our instrumentation capabilities, and strengthened collaboration with JPL researchers. The findings from this work will serve as a foundation for upcoming experiments involving layered ice analogs combining H_2O ice, amino acids, and salts, as well as future Raman and RGA-based analyses to identify photoproducts.

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