Shedding Ultraviolet Light on Icy Solar System Satellites. T. M. Becker[1], K. D. Retherford[1], G. R. Gladstone[1], P. Molyneux[1], L. Roth[2], T. K. Greathouse[1], U. Raut[1], [1]Southwest Research Institute, San Antonio, TX (tbecker@swri.edu), [2]KTH Royal Institute of Technology, Stockholm, Sweden

Introduction: Ultraviolet (UV) studies of Solar System bodies continue to reveal unique compositional properties of their surfaces and atmospheres. Of particular interest, laboratory studies have shown that strong spectral features in the ultraviolet can be used to distinguish a number of ices and atmospheric constituents that are pertinent to our exploration of the satellites of the outer planets, including H_2O, NH_4, CO, CO_2, SO_2, N_2, and O_2 [1]. Here we discuss current, planned, and future studies of icy satellites in the UV.

Hubble Ultraviolet Studies of Europa: UV observations of Jupiter's icy moon Europa from the Hubble Space Telescope (HST) have confirmed the tenuous O_2 exosphere [2] and detected putative plumes erupting from underneath the surface [3, 4].

A recent HST campaign using the Space Telescope Imaging Spectrograph (STIS) has revealed strong differences in surface reflectance between the leading, trailing, anti-Jovian and sub-Jovian hemispheres of the moon, including an absorption feature near 280 nm that is strongest at the apex of the trailing hemisphere (Fig. 1). This feature has previously been attributed to SO_2 and may be exogenic deposits from Io's volcanos [5, 6].

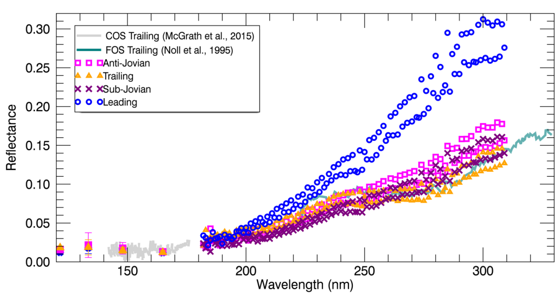

Figure 1: HST reflectance of the leading, trailing, anti-Jovian, and sub-Jovian hemispheres of Europa from HST.

Notably, the spectra show gradual slopes from ~160 nm to 300 nm rather than the sharp edge observed at 165 nm for water ice in the lab and on Saturn's icy rings and satellites like Enceladus [7]. This suggests some non-H_2O contaminant or processing of Europa's uppermost surface. Recent HST observations of Ganymede have shown a similarly sloped spectrum, which may be explained by small contaminant inclusions within the water-ice grains at the surface [8].

Europa Clipper UV Investigation: The Europa-UVS instrument on board the Europa Clipper spacecraft will investigate the composition and chemistry of Europa's atmosphere from auroral and airglow emissions and from transmission spectra through the atmosphere during stellar occultation and Jupiter transit events. The detection of emissions from Cl, Ca, S, and Mg, which also have emission lines in the UV, may help to constrain the salinity, alkalinity, and/or acidity of the subsurface water reservoirs. The spread of stellar occultation events across latitudes and longitudes over the duration of the mission will reveal the abundances and distribution of atmospheric constituents such as O_2, CO_2, H_2, N_2, CO, and NH_3 and how they may change with time.

Water vapor plumes at Europa were first identified through the observation of coincident H and O auroral emissions over a period of several hours [3]. Europa-UVS will search for plumes using the same technique, but with higher spatial resolution than is currently possible with HST.

Through high spatial resolution surface reflectance observations, Europa-UVS will measure the distribution of ices across the surface and potentially identify fresh water ice deposits by locating regions that display a prominent water-ice spectral feature in the UV that is otherwise missing from the more global view of the satellite.

Future Exploration of Satellites in the UV: Applying similar observational techniques to more distant icy satellites promises valuable scientific return. Triton's surface may be composed of nitrogen, water ice, ammonia-water ice, carbon monoxide, carbon dioxide, methane, and/or sulfur dioxide [9], all of which are known to have identifiable features in the UV as both a solid and a gas. The Uranian satellites display an asymmetric distribution of H_2O and CO_2 that can be further assessed by a UV instrument [10]. Tentative evidence of NH_3-hydrate has also been identified in infrared observations of the Uranian moons [11,12]; a UV instrument could confirm its presence and map its distribution. Other minor constituents have likely not yet been identified on these distant satellites, but the abundance of ices detectable in the UV necessitate the described investigations.

Although the UV solar flux is low in the outermost parts of the Solar System, UV investigations can take advantage of other light sources including starlight and

Lyman-α skyglow; this technique has been successfully applied by the Lyman Alpha Mapping Project on the Lunar Reconnaissance Orbiter to identify water frost in the permanently shaded regions on the Moon [13]. UV surface reflectance measurements should be included in future planetary mission baseline science objectives to capitalize on these new techniques and discoveries.

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