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IR spectroscopy for study of the composition of the icy Galilean Satellites

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The composition of the surfaces of the icy Galilean satellites and the distribution of compositions in relation to morphology and physical characteristics are obviously extremely important to understanding the origin, evolution and present state of the objects. From initial accretion of the material forming the objects, through differentiation, to the current processes acting within and on the surface of the objects, chemical processes have been operating that altered and combined the initial materials to produce the present-day compositions and their structures within and on the surface of the objects. This has been recognized in all previous studies of possible exploration missions to these objects and is a major aspect of the current mission plans. It also has been a focus of earlier Earth-based studies concerning the objects.

Since we can only observe directly the surfaces, this aspect is the major focus of these studies. Linking the surface composition to the state of the interior requires a combination of observation and geological and geophysical modelling and inference, although gravity and magnetic field measurements are helpful. Further, measurement of materials leaving the surface, such as those sputter by particle bombardment in this case, can aid in identifying some of the elemental constituents of the surface.

In the case of these objects, a serious complication is the heavy radiation environment, especially for the inner satellites. This effect both delivers foreign materials to the surface and alters the surface materials, chemically. Thus, simply identifying all the surface elemental and molecular components does not necessarily relate to the interior but may also represent processes and ingredients of an exogenic nature. This is one of the unusual aspects of these objects that makes their exploration exceptionally interesting: There is such a rich range and blend of physical and chemical processes operating involving these objects, which are complex and interesting themselves. And, there are several objects with somewhat different energy inputs and different evolutionary histories to study.

One method to study the surface composition is spectroscopy at the wavelengths of visual and infrared light. This is not a new technique but technology advancements over the past few decades have made the technique much more powerful. Also, our understanding of the physics of the interaction of light with the relevant materials has been greatly increased, due to both advancements in physics and laboratory studies of actual candidate materials. With the new Jupiter System missions being planned, we have an opportunity to apply these new capabilities as never before.

Even so, it is inevitable that limitations of resources and spacecraft capabilities will require compromises between what we could achieve and what is possible and practical. Spectroscopy is a technique particularly vulnerable to these compromises. This partly due to the large data volume involved in mapping spectroscopy and to the requirement for simultaneous high spectral and spatial resolution with high signal to noise ratios over the broadest wavelength range. Thus, trade-offs among these important measurement parameters and resource limitations are critical. We must make them very carefully and with as full knowledge as possible. Yet, we must not be overwhelmed in having to make these compromises so that we do not fully appreciate the still very useful data it will surely be possible to collect.

In this workshop, some of these trade-offs could be discussed and examples presented for previous experience and measurements.