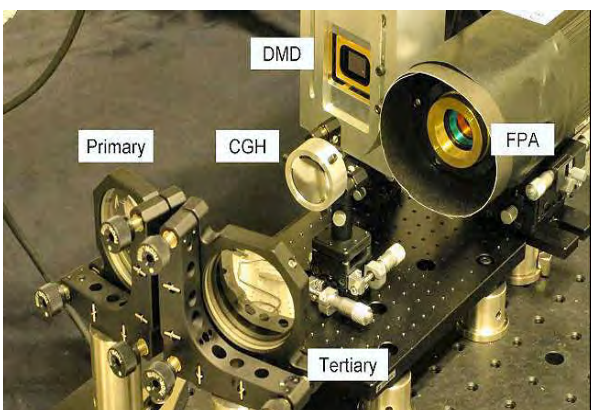
An Intelligently Reconfigurable Snapshot Imaging Spectrometer For Planetary Exploration. G.H.Bearman[1], W.R.Johnson[1], W.Fin[1]k and D.W. Wilson[1], [1] Jet Propulsion Laboratory, California Institute of technology, Pasadena, CA. gbearman@jpl.nasa.gov.

Introduction

We report a new approach to imaging spectroscopy using a framing or snapshot imaging spectrometer that acquires a complete spatial-spectral image cube in a single image. While imaging spectrometers have returned great science, e.g., Cassini, all of the instruments at present are slit based and rely on platform motion to assemble an image. Using diffractive optics, the JPL instrument multiplexes all the spatial/spectral content of a scene across a focal plane so a *single* image contains it all. A snapshot imaging spectrometer is ideal for a number of missions and science needs: descent imaging, rovers and landers, balloons and transient phenomena such as the recently discovered geysers at the Martian poles. This instrument has an “intelligent” option in which the spectral resolution can be *dynamically* reconfigured from ~ 50 bands to ~ 300 bands, adjusting the fundamental nature of the returned science. Lower spectral resolution can be used for surveying, target identification and prioritization, while the higher resolution mode is used for increased science and target discrimination.

The instrument relies on the extensive JPL investment in e-beam diffractive optics design and fabrication. Over the last 5 years, the JPL investigators



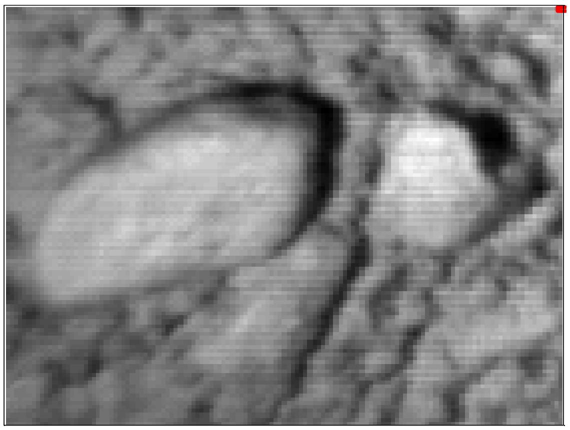
Benchtop version of the reconfigurable imaging

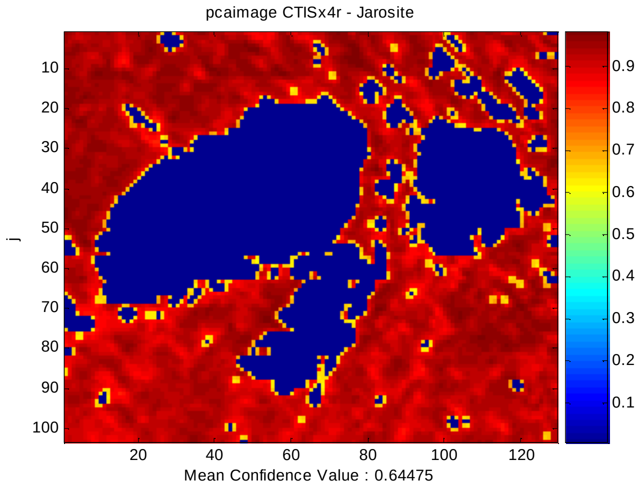
have built and delivered a number of systems for various programs and sponsors. While the instrument, CTIS (computed Tomographic imaging spectrometer) is not completely new, the reconfigurable aspect is. The figure above shows a benchtop version of the system. Future missions where such an instrument could be very important are: a Europa orbiter, a Titan orbiter/balloon mission, an Enceladus orbiter/lander mission, and future Mars missions where studies of the dynamic processes operating in Mars’ polar caps are becoming increasingly significant.

CTIS is a compact system with no moving parts. A diffractive optical element multiplexes the spatial and spectral content of a scene onto a focal plane so that a single image contains all data of a hyperspectral image cube. A benchtop prototype of the system has been tested and initial results shown a very good relative spectral accuracy measured against NIST standards (within a few percent all across the spectral range). The reconfigurable feature is implemented with a digital multi-mirror (DMD) that controls all the scene pixels. It is a unique CTIS feature that allows us to adjust the spectral resolution by changing the imaged scene via the DMM. We have already shown that the MEMS DMD allows for true background elimination from adjacent scene pixels, hence very high spectral resolution for specific targets of interest is possible

We will show data from hyperspectral imaging of typical Martian mineralogical analogs over two spectral ranges; 600-1100 nm and 0.9-1.7 µ. In both case, we will demonstrate the changes in spectral resolution using the multimirror to control the field stop. Using a combined scene of Jarosite and kaolinite, we imaged them with the higher spectral resolution mode, as shown in the next figure. A simple principale components analysis seprated the two minerals, as shown in the other figure inset.

Band Image Sum: 129 x 103 pixels





The left inset shows a scence consisting of two combined minerals, kaolinite and jarosite.

On the right, a false color image separates the two minerals, based entirely on spectra.