Observations Of The LCROSS Impact From The MMT Observatory

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On the night of 9 Oct 2009 (UT), the MMT Observatory watched with multiple ‘eyes’ as NASA crashed the two LCROSS spacecrafts into the Cabeus crater near the south pole of the Moon. The primary goal of the observations was to address the LCROSS mission’s first science goal: “Confirm the presence or absence of water ice in a permanently shadowed region on the Moon”.

Using the MMT in conjunction with three optical cameras and CLIO (Fig. 1), a thermal infrared camera coupled with a low-resolution prism, we obtained images of various scales and mid-infrared spectra across the impact crater, Cabeus, throughout the event. We present a snapshot of the night.
**Imaging**

**CCD47:** A 20” x 20” FOV, fast temporal (12.7 Hz) optical camera with a 0.7 µm medium band (Δλ = 400nm) filter. We used a low-spatial, high temporal resolution mode order to maximize our changes of studying the time evolution of the plume, particularly immediately after impact. Filter selection was designed to be sensitive to the 0.7 µm Fe$^{2+}$ to Fe$^{3+}$ charge transfer transition in oxidized iron in phyllosilicates, in combination with other broadband photometry. Reduction is on-going at this time.

**STELLACAM:** A video frame rate, optical non-filtered camera mounted on the 6.5m MMT gave us a “zoomed-in” image of the impact site that we streamed online in real-time for public access.

**MAT:** A 6” telescope mounted on the telescope structure gave a 10.7’ x 18.5’ FOV with the pointing accuracy and tracking of the MMT. Image was also streamed at video rate in real time.

Figure 2: Artist's rendition of the 4,400-pound (2,000-kilogram) Centaur upper stage rocket hitting the moon's surface near the south pole. The LCROSS shepherding satellite observed the plume of material with a suite of six instruments to look for water ice and examine lunar soil kicked up by the impact.
**Spectroscopy**

**CLIO:** covering a spectral range of ~2.5 - 4.5 µm, with a low resolution (R ≈ 50) prism.

The spectra taken with CLIO bracket 3 µm to identify the 3-µm absorption feature caused by adsorbed and/or interlayer water in minerals created by the process of aqueous alteration, which could be present in plume dust if water ice is present in the impacted crater.

The slit was aligned to be parallel to the lunar surface and run along the crater straddling the impact trajectory (Fig. 3).

Thorough reduction of the CLIO spectra is ongoing at this time. We aim to look for variations in the spectra as the plume develops, through out more than 500 spectra acquired.

*Figure 3: An example 2D spectra (left image) of Cabeus taken with CLIO. The right hand image represents the location of the slit (green line) and the impact trajectory of LCROSS (red line)*
Streaming to the World

As an observatory we used this unique observing night to reach out to the public and give them a glimpse of the professional astronomy world. By jointly hosting a streaming server ourselves and using a free online host we were able to beam our images around the world (Fig. 4) with thousands of ‘hits’ and confirmed ‘viewers’ from as afar a field as New Zealand to Scotland. We also piped a feed into a lecture hall at The Citadel Military College of South Carolina where at least 80 people came bright and early to watch the impact. We also further utilized the internet by ‘blogging’ through the night on the MMTO’s website and the popular social networking site Facebook.

**Acknowledgements:** This research was partly supported through a USRA contract to conduct ground based telescopic observations of the LCROSS impact. V. Bailey was support by a UofA College of Science Fellowship. The MMT is jointly operated by the SAO & the UofA. Thanks goes to M. Cushing (JPL) for the CLIO reduction software.