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The estimate of the amount of ejecta in LCROSS mission

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The LCROSS (Lunar Crater Observation and Sensing Satellite) mission sent two spacecrafts to impact a permanently shadow region in Cabeus Crater. The goal of LCROSS mission is to investigate whether there is water in the regolith of permanently shadowed areas (PSA's) on the moon. We observed ejecta thrown by the LCROSS impacts over the rim of Cabeus crater using the Subaru telescope.
We observed ejecta using the slit viewer system of the Infrared Camera and Spectrograph (IRCS), which can observe 2-dimensional images (1024 x 1024 pixels) simultaneously with spectroscopic observation. In order to reduce the effect of atmospheric water absorption, we chose Kp band for the ejecta imaging observation. Each image was obtained with ~ 1 seconds.
Although translational shift analysis indicates that the tracking error was very small (~ 1 pixel), subtraction between two consecutive images leave substantial residual. More specifically, the boundary between a dark region and a bright region in the images is sometimes very sharp but some other time rather diffuse. This fluctuation is probably caused by scattering by the telluric atmosphere, more specifically by cirus clouds seen in the night of LCROSS impacts. In order to quantify the atmospheric scattering effect, we calculated the slope across the boundary between a dark region and a bright region. A steep slopes corresponds to high contrast between the bright and dark regions; i.e., clear sky. In order to minimize the influence of scatter, we picked up with high slope values.
Then, we searched for impact ejecta in the images with high slope values. First, we compared images taken before an impact and those taken after the impacts, we could not find an ejecta plume. Second, we subtract images before an impact from those after and examined whether there is ejecta. However we were not able to identify significant ejecta in the subtracted images either. Third, we removed atmospheric influence from the images. However, there is no obvious brightness peak during this period of time; a significant amount of ejecta was not observed.
Although these three examinations of images for impact ejecta plumes can not rule out all the possibility of detecting a plume completely yet, the fact that these standard three types of examination failed to detect an ejecta plume is significant. Thus, we estimated an upper limit for the mass of ejecta above the height of crater rim and telescope slit width. Based on the amplitude of the fluctuation in brightness within the area on the moon where impact ejecta was expected, we obtain the upper estimate for the light flux from the impact ejecta plumes to be 1 x 10^(-11) W.
The total area and total mass of ejecta can be given using the size distribution of lunar regolith particles[1] (1um ? 1mm). Thus, we obtain an upper limit for the mass of ejecta, about 1 x 10^3 kg using the size distribution of lunar regolith outside PSA's[1] and the observational results.
The obtained upper limit for the ejecta mass beyond 2 km is only 1/20 of a preimpact the theoretical estimate[2]. Although this estimate for the upper limit of ejecta mass is still preliminary, it is important in discuss possible mechanisms for this small amount of ejecta from

LCROSS impacts. We inferred two possibilities.
One possibility is that the ejecta cut-off velocity, above which ejecta mass is greatly reduced, is much lower than theoretical estimate[2]. The other is that the ejecta plume was ejected a much lower angle than the standard 45 degrees. Because both possibilities involve impact mechanics, further impact studies are needed to reach a decisive conclusion. In other words, our observation results suggest physical processes induced by the LCROSS collisions may involve impact mechanisms that we have not understood yet.

References:
[1] Heiken G.H. et al., (1991), LunarSourcebook, Cambridge Univ. Press
[2] Korycansky D.G. et al., (2009), MAPS, 44, 603.