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The Spatial Extent of Lunar Impact Flashes

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Abstract

On the 1st January 2017, a small sub-kilogram mass meteoroid impacted into the Mare Nubium. The flash was observed independently from Switzerland and the UK. There are indications that the shape of this flash may not have been a point source, and we discuss terrestrial and lunar explanations for the cause of this.

1. Introduction

If a meteor strikes the Moon outside of a known meteor shower, then very little can be determined by terrestrial telescopic observations of the impact, other than its kinetic energy [1]. However, for three simultaneously observed lunar impact flashes, all on different dates, these suggest that there may occasionally be elongations to be seen in the flashes. If this effect were to be lunar in origin then this might help us to ascertain the impact azimuth, and whether this was related to a shallow incidence impacts. This could help narrow down candidate asteroidal or cometary orbit sources for the meteoroid, hence allow us to infer a velocity and estimate a mass.

2. 1st January 2017 Flash

On this date at 17:47 UT Stefano Sposetti (Gnosca) videoed and discovered a candidate lunar impact flash. Video from a remotely operated telescope at Aberystwyth University (UK) was later examined and confirmed the flash at a location of ~17.2˚ W, ~22.0˚ S, a few km to the NW of Wolf crater. An enlargement of both recorded flashes can be seen in Fig 1, where the images have been affine transformed together, so that they have the same scale and orientation. The Swiss flash appears larger than the British flash as the camera used in the former covered a larger area of the Moon, and so the spatial image scale was ~3.4 km/pixel, compared to ~2.1 km/pixel in the UK. Nevertheless both flashes show similar alignment along the SW-NE direction, with a small portion of the flash occurring to the SW of the pixel of greatest intensity and a significant portion to the NE. During the beginning of January the Earth encountered the Quadrantids meteor shower, targeting the Moon from the North, however none of these could have reached so far south. A smaller Delta Cancrids meteor shower also occurred during January and targeted most of the Earth facing side of the Moon, however these would have been approaching from the W., but this was not the direction the flash lay in.

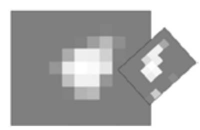

Figure 1: Enhanced images of the 1/1/2017 impact flash observed North-West of Wolf crater. Flash on the left observed from Gnosca, Switzerland. The flash on the right observed from Aberystwyth, UK. These images are from TV fields, namely 1/50th and 1/60th sec respectively in duration.

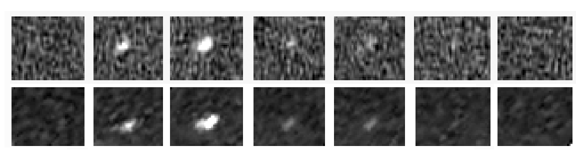

Figure 2: Time sequence of 1/60th sec TV fields of the 19/11/2001 UT 00:18:58 Leonid lunar impact flash (6˚ E, 15˚N), after alignment. (Top) from Alexandria, VA, USA, (Bottom) from White Rock, NM, USA.

3. 19th November 2001 Flash

On this date Anthony Cook (Alexandria, VA, USA) and David Palmer (White Rock, NM, USA) simultaneously videoed a 5th magnitude [1] lunar impact flash, which was assumed to be a lunar Leonid. Despite being approximately separated by 2.5 thousand km, the elongations of the flashes appear very similar, (see Fig 2). A third observer, David Durham, located near to the first observer, recorded the flash too, however the image resolution and observing conditions were worse, and it showed no apparent elongation.

4. Other Non-Point Like Flashes

Images of a Perseid impact flash, taken on 12/8/2013 at 19:45:47 UT [2] (See Fig 4 from the referenced paper) reveal slight ellipticity. Furthermore an 8th magnitude candidate impact flash [3] from 26/2/2015, videoed by Marco Iten (Switzerland), located near Lippershey P, just on the dark side of the terminator, exhibited an apparent plume like effect spreading 80 km further onto the night side of the Moon and lasting several seconds.

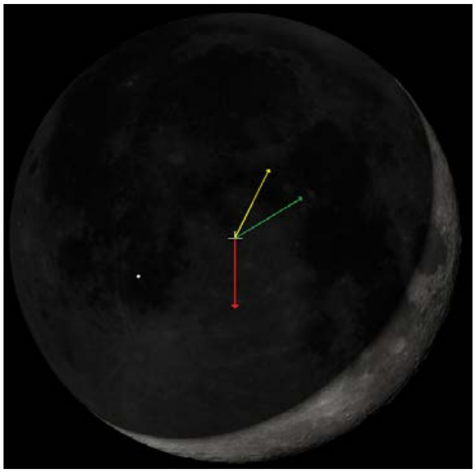

Figure 3: Computed generated phase and orientation of the Moon at the time of the Jan 1st 2017 impact flash from Aberystwyth. Red arrow represents direction to horizon. Yellow represents North on the Moon. Green represents apparent direction of the impact flash. White dot represents the impact site.

5. Discussion

Both the 2001 and 2017 flashes have elongations at significantly different angles to the perpendicular line of the Moon with respect to the observers' horizons, so this effectively rules out refractive effects [4] in our atmosphere as being a cause. Furthermore the impact flash observed simultaneously on 19/11/2001 showed similar morphology from both observing sites, as the flash developed (see Fig 2), which suggests that neither atmospheric turbulence, nor chromatic aberration in scope optics, can be a cause.

Hypothetically lunar topography could have an influence in the shapes of some flashes. For example, if a nearby mountain slope had been be illuminated by an especially bright flash on the lunar night side, this might alter the apparent spatial extent of the observed shape of the flash. Although the 19/11/2001 flash was on the western shore line of the Montes Appeninus, the impact on 1/1/2017 struck the Moon in a seemingly flat area of Mare Nubium.

Impact flashes near to the terminator could result in ejecta clouds being illuminated by sunlight, and may account for the 26/2/2015 event. However the other elongated flashes were all located far from the terminator.

We are uncertain as to a firm explanation of the effects we have seen, however we speculate that they may be a result of grazing or shallow angle impacts. This offers an explanation if the material from the meteoroid, and resulting ejecta, were thrown over kilometre scale distances. However this would necessitate the events seen on: 19/11/2001 and 12/8/2016, to be non-meteor shower impactors, unless the gradients of local meter scale topography, were steep enough to mimic shallow impacts angles?

We recommend that impact flash monitoring programmes attempt to record lunar impact flashes at a higher angular resolution, in future, to see if elongations, or spatial shapes in resulting fireballs, or ejecta clouds, are indeed detectable and confirmable. Greater than two simultaneous observations would help to eliminate any uncertainty.

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