ANALYSIS OF LUNAR IMPACT FLASHES RECORDED DURING THE ACTIVITY PERIOD OF THE LYRID METEOR SHOWER IN 2013. J.M. Madiedo[1, 2], J.L. Ortiz[3], N. Morales[3] and J. Cabrera-Caño[1]. [1]Depto. de Física Atómica, Molecular y Nuclear, Facultad de Física, Universidad de Sevilla, 41012 Sevilla, Spain, madiedo@uhu.es. [2]Facultad de Ciencias Experimentales, Universidad de Huelva, Avda. de las Fuerzas Armadas S/N. 21071 Huelva, Spain. [3]Instituto de Astrofísica de Andalucía, CSIC, Apt. 3004, 18080 Granada, Spain.

Introduction: The flux of interplanetary matter impacting our planet can be studied by analyzing the flashes produced by the impact of meteoroids on the lunar surface [see e.g. 1-3]. This technique, however, does not provide the velocity vector of the projectile, but just the position vector of the impact site [4]. As a consequence, the orbital elements of the meteoroid cannot be obtained and the source meteoroid stream of the projectile cannot be unambiguously established. This may lead to incorrect results in the determination of the luminous efficiency and other parameters such as crater size, impactor mass, etc. [5, 6]. To address this issue we have developed a technique to quantify the probability that an impact flash is associated with a given meteoroid source [5, 6]. Here we apply this method to the impact flashes identified during the activity period of the 2013 Lyrids.

Instrumentation and data analysis methods: For the 2013 Lyrid impact flashes detection campaign we have employed a 28 cm and two 36 cm SC telescopes, all of them endowed with f/3.3 focal reducers and Watec 902H Ultimate CCD video cameras operating in CCIR mode. These cameras generate interlaced video files with a resolution of 720x576 pixels and a frame rate of 25 fps. The images taken by these devices are stored and digitized on multimedia hard disks as AVI video files. GPS time inserters are used to stamp time on every video frame with a precision of 0.001 seconds. These video files are analyzed with the MIDAS software [5].

Date and time (UTC)	Selenographic coordinates	Dur. (s)	App. mag.	θ (º)	Most likely source	p
16 Apr. 2013 20h35m41s	Lat.: 36.8±0.3 ºN Lon.: 31.2±0.3 ºW	0.02	9.1±0.2	66	LYR	0.87
17 Apr. 2013 21h38m02s	Lat.: 30.3±0.4 ºS Lon.: 27.5±0.3 ºW	0.10	8.7±0.1	6	SPO	0.57
17 Apr. 2013 22h12m25s	Lat.: 4.8±0.3 ºS Lon.: 36.4±0.3 ºW	0.04	8.7±0.2	27	LYR	0.77
17 Apr. 2013 22h39m00s	Lat.: 1.4±0.3 ºN Lon.: 74.2±0.5 ºW	0.02	9.1±0.2	56	LYR	0.86
18 Apr. 2013 22h25m50s	Lat.: 2.2±0.4 ºN Lon.: 53.7±0.5 ºW	0.04	8.3±0.3	37	LYR	0.84

Table 1. Lunar impact flashes identified on 16-18 April 2013. θ is the impact angle with respect to the local horizontal by assuming that the meteoroid is associated with the Lyrids. The probability that the flash is associated with the indicated source is p.

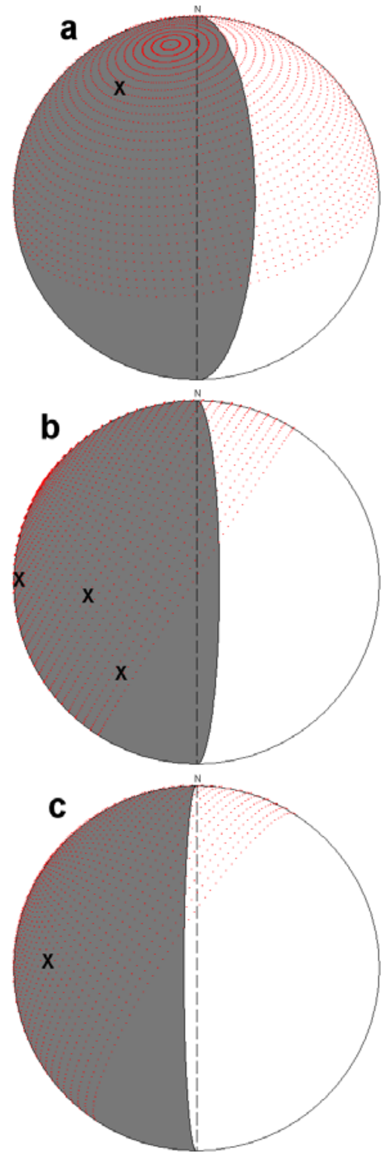

Figure 1. The lunar disk as seen from Earth on 16 (a), 17 (b) and 18 (c) April 2013 at 21:00 UT. Gray region: night side; white region: area illuminated by the Sun; dotted region: area where Lyrid meteoroids could impact. The position of the impact flashes recorded each night is marked with an X.

Preliminary results: The lunar impact flash monitoring campaign developed in 2013 between April 16 and April 18 took place during the activity period of the Lyrid meteor shower. This activity extends from about April 16 to April 25, peaking around April 22 [7]. The impact flashes identified during this monitoring are listed in Table 1. Their positions are shown in Figure 1.

The apparent visual magnitude estimated for these events ranges from 8.3 to 9.1. The longest flash had a duration of 0.1s, and the other events lasted between 0.02 and 0.04 s. In order to determine the most likely origin of these flashes it has been considered that they could be produced either by Lyrid meteoroids or by the sporadic background. For the Lyrids we have assumed for the population index r=2.0. The calculated impact velocity of Lyrid meteoroids on the Moon yields 48 km/s [6], and for sporadic events we have used an average value of 17 km/s for this parameter [8]. For the luminous efficiency we have taken $\eta=2\cdot10^{-3}$ [9, 10]. By following the technique described in [5, 6] we have obtained for each event that the probability that the flash is associated with one of the two abovementioned sources. These probabilities are listed in Table 1. According to these results, the most likely source of these events is the Lyrid meteoroid stream, with probabilities ranging between 77 and 87%. The only exception if the flash identified on April 17 at 21h38m02s UT, with a probability of 57% for its association with the sporadic background.

The luminous efficiency for these Lyrid impacts was calculated by following the technique described in [11, 12]. The result, by taking into account only the four events with association probabilities above 50%, yields $\eta=2.6\cdot10^{-3}$, which is very close to the $2\cdot10^{-3}$ value assumed to obtain the probability parameter p. In fact, the probabilities in Table 1 do not change when the calculations are repeated with this new value of η, which proves that our previous assumption was correct. The calculated luminous efficiency also agrees with the recent results published in [13].

Date and time (UTC)	**Impactor mass (g)**	**Crater diameter (m)**
16 Apr. 2013 20h35m41s	17±3	2.35±0.11
17 Apr. 2013 21h38m02s	787±129	4.52±0.19
17 Apr. 2013 22h12m25s	28±5	2.13±0.10
17 Apr. 2013 22h39m00s	17±3	2.28±0.11
18 Apr. 2013 22h25m50s	40±7	2.61±0.12

Table 2. Meteoroid mass and crater size.

Estimated projectile mass and the size of the crater produced by these impacts are shown in Table 2. As can be seen, the diameter of these fresh craters ranges from about 2 to 4 m, and the mass of the meteoroid varies between 17 and 787 g.

Conclusions: We have presented a preliminary analysis of the lunar impact flashes recorded on 16-18 April 2013, during the activity period of the Lyrid meteor shower on Earth. Four of these flashes can be associated with the Lyrid meteoroid stream with probabilities ranging from 77 to 87%. However, the most likely source of the flash recorded on 17 April 2013 at 21h38m02s UT is the sporadic background with a probability of about 57%. The calculated value for the luminous efficiency of Lyrid impacts on the Moon yields $\eta=2.6\cdot10^{-3}$. The mass of the impactors ranges between 17 and 787 g.

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