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The 2012 Lyrids from non-traditional observing platforms

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The NASA Meteoroid Environment Office (MEO) observed meteors during the Lyrid meteor shower peak on April 22, 2012, from three different observing platforms: the ground, a helium-filled balloon, and from the International Space Station (ISS). Even though the Lyrids are not noted for spectacular rates, the combination of New Moon and a favorable viewing geometry from ISS presented a unique opportunity to simultaneously image shower meteors from above the atmosphere and below it. In the end, however, no meteors were observed simultaneously, and it was impossible to identify Lyrids with 100% confidence among the 155 meteors observed from ISS and the 31 observed from the balloon. Still, this exercise proved successful in that meteors could be observed from a simple and inexpensive balloon-based payload and from less-than-optimal cameras on ISS.

1 Introduction

The Lyrids in 2012 attracted the attention of the Meteoroid Environment Office (MEO) for three reasons. First, though their zenith hourly rate (ZHR) is not particularly high—only 18 or so—the Moon was New on April 21, so the Lyrid peak on April 22 could be observed with little to no lunar interference. Secondly, the International Space Station (ISS) had an excellent viewing geometry. Not only had the Lyrid radiant risen, but it was visible from ISS during almost the entire night portion of its orbit. Lastly, astronaut Don Pettit, a skilled photographer and enthusiastic observer, was onboard ISS during the Lyrid peak. These circumstances led to a chance to observe meteors from ISS.

With this impetus, the project quickly expanded to include observations from, not only ISS at an altitude of about 400 km, but also from the ground—in the form of video meteor networks—and from a helium-filled balloon with a meteor camera payload at about 40 km. The timing was such that it was possible to observe from all three observing platforms during the night of the Lyrid peak, though observations were not guaranteed to have overlapping views. As such, we hoped to correlate any meteor seen from multiple platforms.

The results reported here are certainly not the first meteors to be imaged from ISS. There have been several serendipitous past observations of meteors from spacecraft, the most famous of which was a likely Perseid, observed by astronaut Ron Garan onboard ISS during Expedition 28 while over China in August 2011. Perseids were also imaged from the Space Shuttle Discovery, STS-105, in 2001.

Neither are these results the first meteors to be imaged from a balloon. In November of 1998, 1999, and 2000, NASA launched 3 balloon flights from Marshall Space Flight Center (MSFC) in Huntsville, Alabama, USA. The main purpose of these experiments was to capture micrometeorite particles in aerogel, but on-board cameras imaged several Leonid meteors, the whole of which was broadcast live on-line.

The difference between these past observations and the 2012 Lyrid undertaking is that it was a concerted effort to simultaneously observe meteors from each platform. It also shows the feasibility of inexpensive balloon missions to observe meteors during showers.

2 Observations and results

2.1 Timing and geometry

North American observers were well placed for the predicted peak time of the Lyrids on April 22, 2012, at $5^{h}30^{m}$ UT. Ground observations could be made from multiple video meteor networks across the continent throughout the night. The 90-minute ISS orbit took the spacecraft over parts of North America during the predicted peak as well as one orbit before and one orbit after the expected maximum. For each orbit, we calculated the time ISS would be able to overlap its field of view with 3 ground targets: (1) MSFC and the southeastern part of the NASA All Sky Fireball Network (Cooke and Moser, 2012), (2) southern New Mexico and the southwestern part of the NASA Network, and (3) central California where the balloon launched. A graphic illustrating these three orbits of ISS is shown in

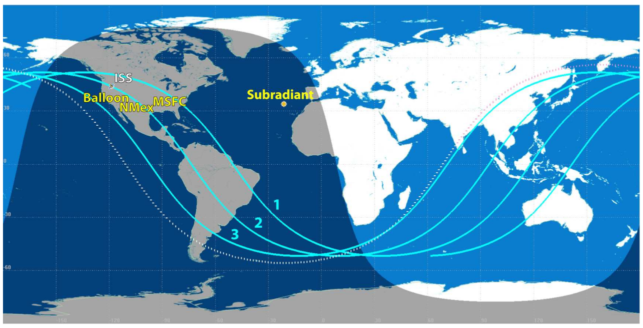


Figure 1 – ISS ground tracks (solid lines) for three orbits on April 22, 2012. The three ground targets are indicated as well as visibility for the Lyrid radiant (dotted line) and the Lyrid subradiant point.

Figure 1. This information was e-mailed to astronauts on-board ISS. In actuality, on-board cameras recorded images from roughly orbital sunset until orbital sunrise for each of the three orbits. These times are summarized in Table 1.

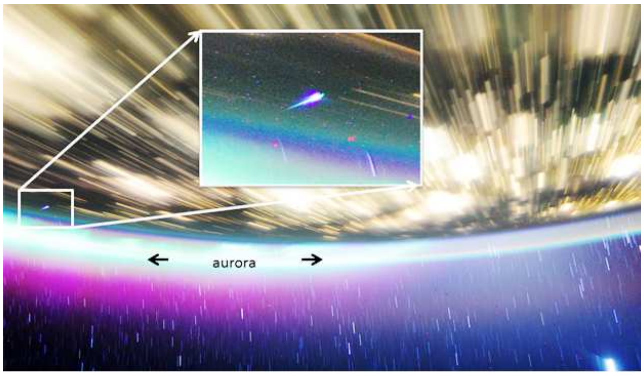
2.2 ISS

Astronaut Don Pettit, flight engineer on ISS Expedition 30, set up available on-board equipment to make observations of the Lyrids, namely 4 Nikon D3S DSLR cameras. Mounted in the Cupola, an ESA-built observatory module with 7 windows, the cameras were pointed in the forward, aft, port, and nadir (Earth-facing) directions. The "scratch panes", or innermost protective panels on the Cupola windows, were left in place. The scratch panes are non-optical in quality, but this was the best that could be achieved.

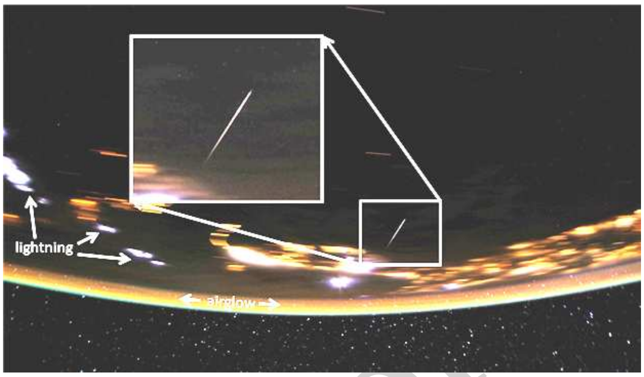
During each pass, ISS took images for about 32 minutes. The field of view overlapped with ground targets for about 9 minutes each orbit. Orbit 1 exposures were 15 seconds each, while 5 second exposure times were used for Orbits 2 and 3. With these exposure times, lights on Earth appear as streaks, lightning—due to its short duration—is not streaked at all, and stars are elongated. Several other atmospheric phenomena are present, including airglow, aurora, zodiacal light, and the equatorial Appleton anomaly. Meteors appear as streaks of light at angles different from both the stars and lights on Earth. Figure 2 shows just two of the meteors imaged from ISS.

A manual review of 2085 images from ISS is summarized in Table 2. A total of 155 meteors were detected, with the majority from Orbit 2, which covered the expected Lyrid maximum at $5^{\mathrm{h}}30^{\mathrm{m}}$ UT. These numbers are split evenly between the aft and port cameras; the forward camera imaged 20% fewer. Nadir results were not analyzed. We did not review the nadir images because the nadir view has a relatively small collecting area, as seen in Figure 3. On-board equipment also partially obstructs this view.

Without correlating each meteor with that seen from another platform, it is impossible to positively identify Lyrids in the data set. The radiant appears to move



(a) Orbit 1 (off South Carolina coast).



(b) Orbit 2 (over Gulf of Mexico).

Figure 2 – Meteors imaged from ISS during (a) Orbit 1 (just off the coast of South Carolina) from the aft camera, and (b) Orbit 2 (over the Gulf of Mexico) from the port camera. Lossless RAW images have an approximately 70° horizontal field of view. Both aft and port cameras were Nikon D3S DSLRs with 28 mm $f/1.4$D and 24 mm $f/1.4$G lenses, respectively. ISO was set to 1600. Orbit 1 exposure time was 15 s; Orbit 2 exposure time was 5 s.

Figure 3 – View from the ISS nadir camera during Orbit 2 (over Texas). A Nikon D3S DLSR camera with 8 mm $f/2.8$ lens was used with an exposure time of 5 s. The observing area is much reduced from that in Figure 2.

quite drastically relative to the location of ISS in its orbit. An analysis of the flight direction with respect to the Lyrid radiant has not been attempted at this time.

2.3 Balloon

Writer Dr. Tony Phillips and student group Earth to Sky launched a helium-filled balloon with a MEO-pro-

Table 1 – Summary of 3 periods of observation from ISS on April 22, 2012. The NASA All Sky Fireball Network had the best chance of overlapping with ISS during Orbits 1 and 2; the balloon's best opportunity for overlapping with ISS occurred during Orbit 3.

ISS Orbit	Predicted time (UT) over ground target	Predicted time (total)	Actual time (UT) imaged	Actual time (total)	Ground target
1	3^h50^m–4^h01^m	11 min	3^h52^m–4^h25^m	33 min	MSFC
2	5^h24^m–5^h34^m	10 min	5^h26^m–5^h58^m	32 min	New Mexico
3	6^h57^m–7^h07^m	10 min	6^h58^m–7^h29^m	31 min	California

Table 2 – ISS meteor results per Orbit for the forward, aft, and port cameras; nadir images—those missing in column 5—were not retrieved due to a small field of view and resource constraints.

ISS Orbit	Obs. time (total)	Actual time over ground target	Exposure	Images reviewed/ images taken	Meteors (total)
1	33 min	9 min	15 s	262/ 366	33
2	32 min	8 min	5 s	942/1272	70
3	31 min	9 min	5 s	881/1215	52

vided meteor camera payload from Bishop, California, USA, the night of the Lyrid peak. Earth to Sky, a group comprised of students from Bishop Union High School and Home Street Middle School, had 11 launches to their name at the time they undertook the commission to fly a meteor experiment.

The helium-filled balloon was roughly 180 cm wide at launch (Figure 4). It reached a width of about 1200 cm when the balloon burst, the result of over-expanding in the low pressure environment of the stratosphere. A parachute returned the payload to the Earth. The payload was a semi-rigid insulated pack with PVC pipe exoskeleton, roughly 28 cm × 23 cm × 23 cm, carrying a Watec 902H2 Ultimate video camera with a 6 mm lens, a light-weight digital video recorder with 32 GB SD memory card, 2 GPS units, a temperature gauge, and a power supply. The GPS unit tracked and periodically transmitted the balloon's location. The total cost of the balloon and payload was less than 1000 USD.

The balloon was launched at 6^h54^m UT from Bishop, California. At 8^h10^m UT, the balloon entered the stratosphere. Maximum altitude (35.8 km) was reached at 9^h46^m UT, when the balloon burst. The payload parachuted down and landed in the mountains at 10^h15^m UT. In all, total flight time was 3.35 hours. Much of the video is unsteady and the field of view rotates erratically. Around the time the balloon entered the stratosphere, the video became steadier and, therefore, searchable for meteors; a total of 1.6 hours of steady time was manually reviewed.

In 1.6 hours, 31 meteors were detected from the balloon. Of these, 14 were likely Lyrids with greater than 90% confidence based on analysis of the meteor flight direction. Eleven more meteors were classified as Lyrids with at least 70% confidence. The remaining 6 meteors were either ruled out as Lyrids or ruled as Lyrids with 50% or less confidence. An example of one of the brightest meteors detected from the balloon is shown in Figure 5.

Figure 4 – Students of Earth to Sky inflating the balloon prior to launch. Image courtesy of Earth to Sky.

Unfortunately, the balloon was launched just minutes before the third pass of ISS, when the platform was most unstable and difficult to analyze, so no correlations could be made. No overlapping ground coverage was discovered either.

2.4 Ground

To begin the ground campaign, the MEO sent a notice to meteor camera operators on April 17 calling for

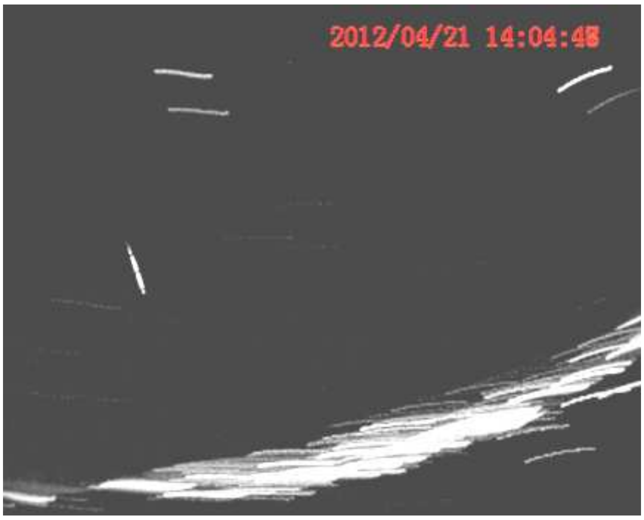


Figure 5 – Image of a meteor detected on April 22, 2012, at $9^h04^m46^s$ UT. The platform was swinging slightly. Streaks at the bottom of the image are from lights on the ground. Streaks at the top are from stars and/or planets.

Figure 6 – Composite image of meteors observed on April 22, 2012, by an all-sky camera located at New Mexico State University, part of the NASA All Sky Fireball Network.

observations during the night of the Lyrid peak. The goal of this request was to maximize the chance of simultaneous observations. Thirteen observers—James Beauchamp, Jeff Brower, Peter Brown, Apostolos Christou, John Eckert, Ralph Megna, D. R. Mynatt, Rick Nowell, Kevin Palivec, Chris Peterson, Wayne Sanders, Gordon Sarty, and Jim Wooddell—responded with observations, most running all-sky cameras.

Ground observers reported 155 meteors the night of the Lyrid peak, with most occurring between 8^h00^m and 8^h30^m UT, when the radiant was quite high in the sky. The southeastern U.S. component of the NASA All Sky Fireball Network was mostly cloudy, as was the whole of the Southern Ontario Meteor Network. NASA's southwestern network in New Mexico observed 26 meteors on April 22, 16 of them double-station. Only 6 of these 16 were confirmed Lyrids. Figure 6 shows meteors detected by the NASA meteor camera at New Mexico State University in Las Cruces, New Mexico, USA.

Not much can be said about the other meteors observed by ground-based cameras as observers were asked only to report the meteor times and not possible shower associations. Looking at event times alone, only 2 of the 155 meteors reported could possibly have been seen by ISS. Both of these had geometry inconsistent with those seen from ISS so they were ruled out as matches. Thus, no meteors were detected simultaneously from both ISS and ground observers.

3 Summary

The 2012 Lyrid meteor shower peak was observed by ground-based, balloon-based, and ISS-based observers in the hope that simultaneous detections could be made. Each observing platform successfully imaged meteors, some of them probable Lyrids. Despite our best efforts, no events were simultaneously observed by any of the cameras on the ground, in the air, or from orbit. Balloon observations were surprisingly successful and inexpensive, though difficult to calibrate. More meteors than expected were imaged from ISS despite non-optimal meteor cameras and window quality.

4 Acknowledgements

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