Camera Test of a Sony α7S with a Canon FD 1.4/50 mm Lens about Blooming of overexposed Highlights in Regard of the Video Observation of Fireball 3414-2018

This test was made by Peter C. Slansky and Bernd Gährken in the studios of the University of Television and Film Munich on 2.11.2018.

Fig. 1: Fireball 3414-2018; video frame before the terminal flash, real time code 01:50:59:21, indicating UT with hours:minutes:seconds:frames at 25 frames per second.

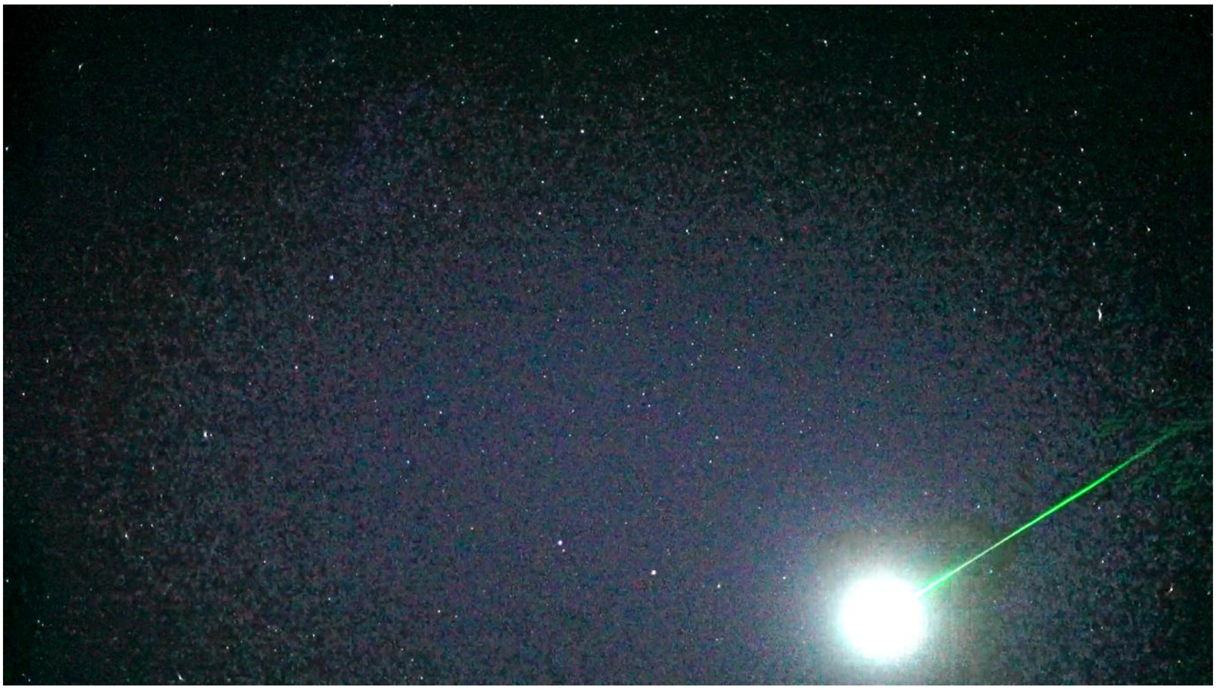

Fig. 2: Fireball 3414-2018, video frame of the terminal flash, time code 01:50:59:22. Note, that although the terminal flash is heavily overexposed there are not lens flares in the image.

Fig. 3: Fireball 3414-2018; video frame after the terminal flash, time code 01:50:59:23. The white overexposure by the terminal flash is followed by a green afterglow.

Fig. 4: Fireball 3414-2018; two video frames after the terminal flash, time code 01:50:59:24. The green afterglow becomes dominant over the white afterglow of the meteor wake.

Background of the test

Fig. 1 – 4 show the brightness distribution of fireball 3414-2014 around the terminal flash.

This test was made to decide the following question:

A) Does the terminal flash, as well as the green afterglow, result from a point shaped light source so that the round white clipped area of the terminal flash must go back to overexposure artefacts, so called "blooming", or
B) does the terminal flash (as well as the green afterglow) represent an areal light source that is only modestly overexposed in the video.

Blooming is the result of the limits of the camera sensor and the clipping function of the camera, that limit the signal amplitude to a maximum value, and the combination of various flare light artefacts caused by the camera and the lens. These artefacts can be caused by multiple reflections between the sensor and the cover glass, by the Bayer filter mask, by micro lenses or by the optical low pass filter, but it can also be caused by internal reflections and flare light inside the lens.

But interestingly even in the moment of the strongest overexposure of the meteor, the terminal flash (Fig. 2), there are no lens flares visible in the image.

The result of our tests is clear: The terminal flash cannot be seen as a point shaped light source, because to create a clipped area of 188 pixels in diameter in the image it would have had to be overexposed so strong that there would have been lanes flares. The absence of lens flares is only possible when the terminal flash is an areal light source. The artefacts caused by overexposure are only supplementary. As a result of this test, the terminal flash as well as the meteor head and the green afterglow are areal light sources with unknown brightness profiles.

II: Test setup

The camera and lens were the same as for the original video: a Sony α7S in video mode at 25 fps and ISO 409 000 with a Canon FD 1.4/50 mm lens at F = 1.4. Instead of the meteor two light sources were tested. A 100 W / 12 V tungsten bulb with a dimmer represented a point shaped light source. Because of the very high sensitivity of the camera the tungsten bulb had to be dimmed to the minimum so that its light turned to deep orange. An LED torch with a milky white calotte of 2,5 cm diameter on the front represented a uniformly lit areal light source. The studio was darkened with black cloth. With an ND 3.0 filter a relation in the exposure of two shots of factor 1 000 could be realized. This relation was chosen because in the video there is Polaris (2.1 mag). If the terminal flash had the brightness of -5.4 mag its overexposure would be 1000 times (1000 = $2{,}5^{7{,}5}$). On a laptop the resulting images could be compared directly to the original video frame. All shots were arranged so that the light source appeared at the very same position as the terminal flash in the video. This was very important for the occurance of lens flares. Fig. 5 shows the setup.

Fig 5: Peter C. Slansky with the test setup in the TV studio 1 of the University of Television and Film Munich. The Sony a7S camera with the Canon FD 1.4/50mm lens is pointed to the tungsten bulb (point shape light source). The alternative areal light source, a LED torch with a white calotte, lays on the trolley right from the laptop. For the real tests the other studio lights were switched off completely. Photo by Bernd Gaehrken.

First test: point light source (tungsten bulb)

Fig. 6: Point light source at normal exposure: No artefacts are visible.

Fig. 7: Point light source at 1000 times overexposure: There is a clipped area of the same size as for the terminal flash in the video but around it there is a wide orange halo. Also, there are strong lens flares opposite from the light source to the image center: multiple internal reflections of the light source on the lens' surfaces. The single bright "lens" flare comes from the UV-IR-blocking filter. The bigger lens flares are caused by the lens.

Result:

With an overexposed point light source it was <u>impossible</u> to create a clipped area of size of the terminal flash without creating lens flares and a wide halo, too. Both, lens flares and the wide halo, were not seen in the original video.

Second test: point light source with narrow band filter 540 nm (green)

To investigate the influence of the green light from the green train of the meteor and the green afterglow of the terminal flash a second test was made with the point shaped light source and a narrow band filter 540/10 nm was set in front of the lens. This wave length is close to the [O III] line of 558 nm of the green train.

Fig 7: Point light source with narrow band filter 540 nm at normal exposure: The only artefact is a small green flare because of the narrow band filter in front of the lens.

Fig. 8: Point light source narrow band filter 540 nm at 1000 times overexposure: There is a clipped area of the same size as for the terminal flash in the video but around it there is a very wide green halo. Also, there are

strong lens flares opposite from the light source to the image center. The filter flare is clipped to white. It has to be ignored for the test result.

Result:

With an overexposed point light source with narrow band green it was *impossible* to create a clipped area of size of the terminal flash without creating lens flares and a very wide green halo, too. Both the lens flares and the very wide green halo were not seen in the original video. So, the terminal flash cannot consist of green light but of „white“ light (white according to the spectral sensitivity curves and the white balance of the camera).

Third test: diffuse areal white LED light source

The third test was designed complementary to the first one. A totally diffuse light source was installed with a white LED torch and a milky white calotte of a light meter on the front. The calotte had a diameter of 2.5 cm. Also, a ND filter 3.0 was used to dim the light. Because this time the filter was mounted in front of the light source it could not produce a filter flare. The automatic white balance was set to the LED. At a distance of 1.2 m from the camera the light source appeared with a size of about 188 pixels diameter in the image. The exposure was set so, that a slight halo occurred around the white area just as for the terminal flash in the original video. Obviously, the amount of overexposure was “only” factor 40, by far lower than factor 1000 with the point light source.

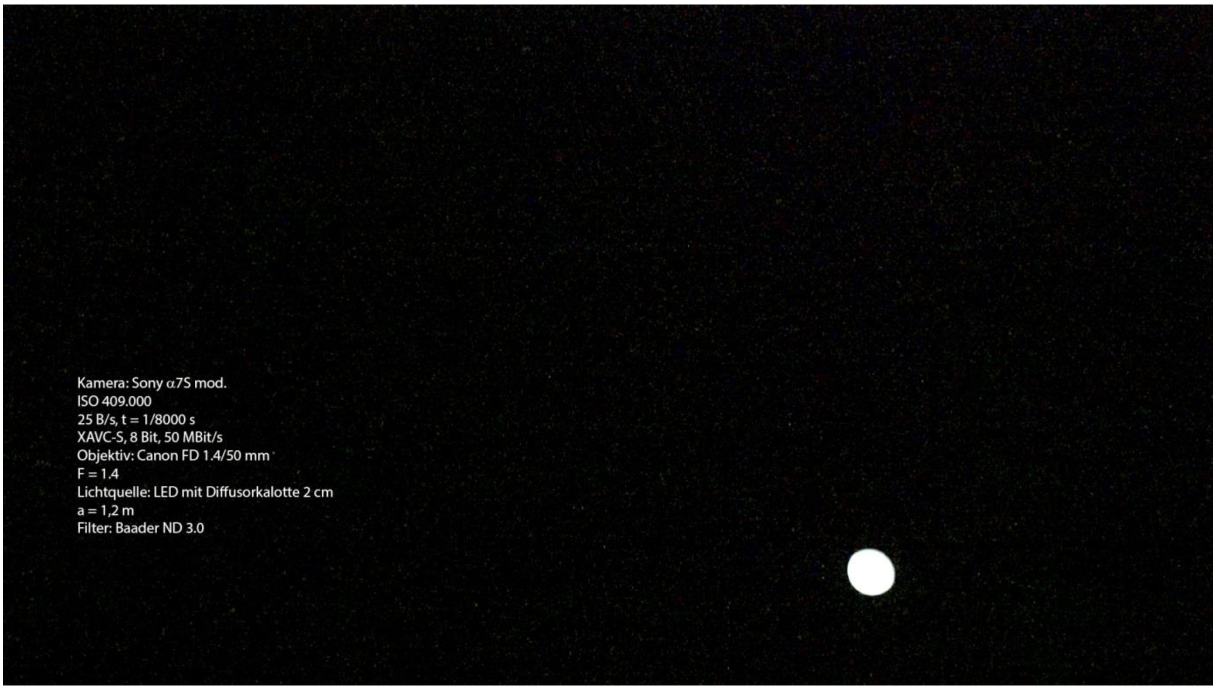

Fig. 9: Areal light source white LED with calotte with only slight overexposure. No artefacts are visible.

Fig. 10: Areal light source white LED with calotte with a 40 times overexposure. The clipped area is as large as in the original video but with much less overexposure. The halo around the light source is similar to the original video. Because the overexposure is comparably low there are no lens flares at all.

Result:

<u>Only with the areal light source it was possible to reproduce the same amount of clipping in the high light and halo at the same time, with no lens flares at all.</u>

Additional test with a flash light

To investigate the possibility of temporal camera artefacts caused by sudden flashes of light an additional test was made. These artefacts might have their reasons in the sensor or in the interframe data compression codec. For this test a compact camera flashed directly into the lens of the Sony α7S. The result: No temporal artefacts such as lag or ghosting or compression artefacts could be found in the recorded video.

General conclusion concerning fireball 3414-2018

With an overexposed point light source it was *impossible* to create a clipped area of size of the terminal flash of 3414-2018 without creating lens flares and a wide halo, too. Both, lens flares and the wide halo, were not seen in the original video. Also, with the additional use of a green narrow band filter it was *impossible* to create a clipped area of size of the terminal flash without creating lens flares and a very wide green halo, too. Both the lens flares and the very wide green halo were not seen in the original video. So, the terminal flash cannot consist of green light but of „white“ light (white according to the spectral sensitivity curves and the white balance of the camera).

Only with an areal light source it was possible to reproduce the same amount of clipping in the high light and a narrow halo at the same time, with no lens flares at all. Blooming of the camera and the lens has only supplementary effect. So, the terminal flash of the meteor must have distinct dimensions.

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