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The 2017 Great American Eclipse: first report on the observational campaign

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This is a short report on the observational campaign that has been performed during the total solar eclipse of August 21st, 2017 in U.S. After a short description of the eclipse properties, this report briefly describes the observation site, the instrumentation, and then lists and shows all the exposures that have been acquired during the totality.

1. The August 21st total solar eclipse

The main properties of the total solar eclipse (hereafter TSE) that occurred on August 21st, 2017 are shown in Figure 1: the totality path crossed the whole country of U.S. over a time of about 90 minutes starting around 10:15 am Pacific time on the West Coast and ending around 2:45 pm Eastern time (11:45 am Pacific time) on the East Coast. The maximum expected duration of the totality at the greatest duration point (Lat. 37°35'N, Long. 89°07'W) was 2 minutes and 40.2 seconds. The TSE was visible in a narrow corridor 110 km wide that crossed fourteen of the contiguous U.S: Oregon, Idaho, Montana, Wyoming, Nebraska, Kansas, Iowa, Missouri, Illinois, Kentucky, Tennessee, Georgia, North Carolina, and South Carolina; a list of times for of main U.S. cities and towns in the path of totality is provided in Table 1 (courtesy of NASA).

	Eclipse Begins	Totality Begins	Totality Ends	Eclipse Ends	
Madras, OR	09:06 a.m.	10:19 a.m.	10:21 a.m.	11:41 a.m.	PDT
Idaho Falls, ID	10:15 a.m.	11:33 a.m.	11:34 a.m.	12:58 p.m.	MDT
Casper, WY	10:22 a.m.	11:42 a.m.	11:45 a.m.	01:09 p.m.	MDT
Lincoln, NE	11:37 a.m.	01:02 p.m.	01:04 p.m.	02:29 p.m.	CDT
Jefferson City, MO	11:46 a.m.	01:13 p.m.	01:15 p.m.	02:41 p.m.	CDT
Carbondale, IL	11:52 a.m.	01:20 p.m.	01:22 p.m.	02:47 p.m.	CDT
Paducah, KY	11:54 a.m.	01:22 p.m.	01:24 p.m.	02:49 p.m.	CDT
Nashville, TN	11:58 a.m.	01:27 p.m.	01:29 p.m.	02:54 p.m.	CDT
Clayton, GA	01:06 p.m.	02:35 p.m.	02:38 p.m.	04:01 p.m.	EDT
Columbia, SC	01:13 p.m.	02:41 p.m.	02:44 p.m.	04:06 p.m.	EDT

Table 1: list of times and main cities in the path of totality (NASA).

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The event was massively followed by public throughout the U.S., and a large number of projects have been conducted for this special event, not only for outreach to the general public, but also to acquire new scientific observation of the inner solar corona. The occurrences of TSE are still today really unique opportunities to study in details the inner part of the solar corona, where the nascent solar wind is accelerated and the physical phenomena responsible for coronal heating are occurring. This part of the solar atmosphere cannot be observed from the space-based externally occulted coronagraphs for technical reasons (related with limited instrumental capability of rejecting the disk scattered light close to the solar limb), and can be observed with good S/N ratio only during total solar eclipses.

2. TSE observation site

Among different possible places in U.S., the final location for TSE observations was chosen in order to

- minimize the probability of cloud coverage in the summer season,
- allow the availability of a quiet and not crowded observation area,
- allow possible last-moment displacements along the centre of totality path,
- have a longer duration of the totality.

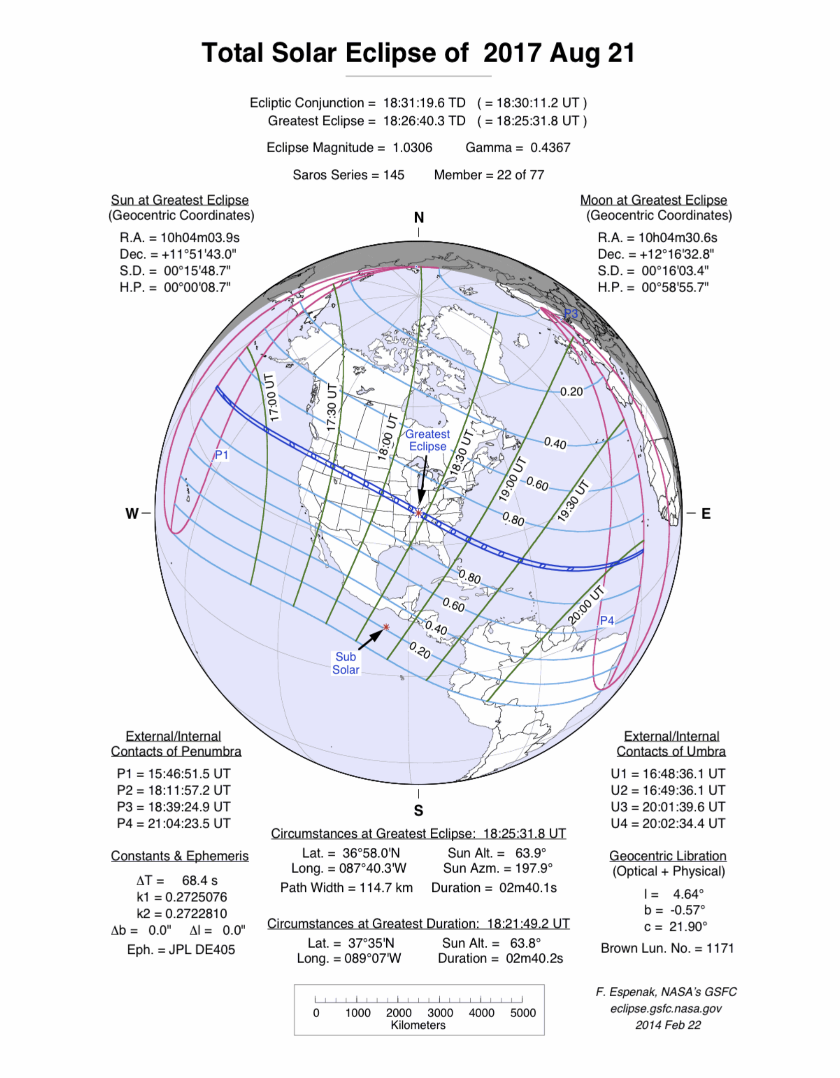

Figure 1: main characteristics of the August 21st 2017 total solar eclipse (NASA).

Considering all the above and other conditions, we decided to perform the observations in Idaho state, and to go Northward of Idaho Falls, Westward of Rexburg city, along Road 33 just before the junction with Interstate 15. The final site of the observations was located at following GPS coordinates (10 satellites):

Latitude: +43.827255

Longitude: -112.131433

Altitude: 1462.7 m

A couple of maps (with different zoom) showing the exact location of observations are in Figure 2, as provided by the NASA Google interactive map[†]. This interactive map also provides the expected local times for the first (C1, beginning of partial eclipse), second (C2, beginning of totality), third (C3, end of totality), and fourth (C4, and of partial eclipse) contacts between the Moon's and the Sun's disks, as well as the time for eclipse totality maximum (MAX); these times are listed in Table 2, together with local altitude and Azimuth for the Sun centre. The expected total duration of totality was 2 minutes and 18 seconds.

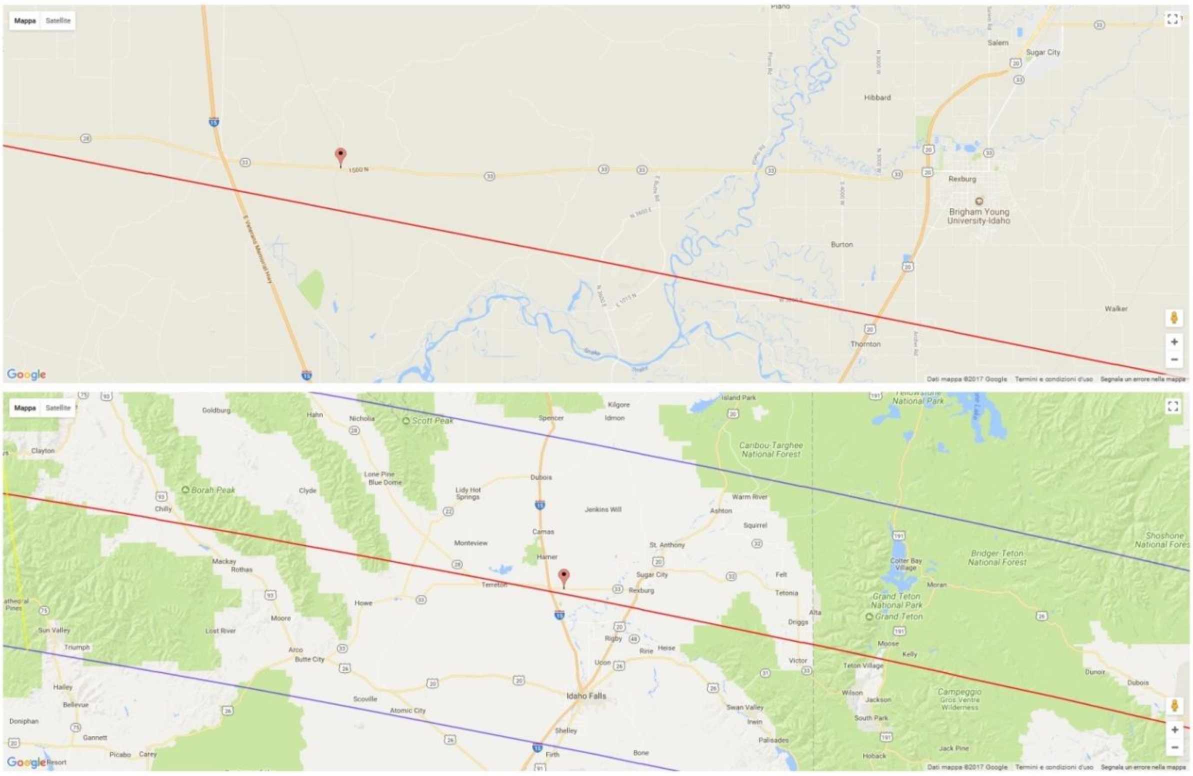

Figure 2: maps (with two different zoom) of the location chosen in Idaho for the 21st August 2017 TSE observations with respect to the centre of totality (red line) and the TSE area (blue lines, provided by the NASA Google interactive map).

Event	Date	Time (UT)	Time (local)	Altitude	Azimuth
C1	21/08/2017	16:15:17.2	10:15:17.2	+37.2°	111.8°
C2	21/08/2017	17:32:40.2	11:32:40.2	+49.1°	132.2°
MAX	21/08/2017	17:33:49.0	11:33:49.0	+49.2°	132.6°
C3	21/08/2017	17:34:57.9	11:34:57.9	+49.4°	132.9°
C4	21/08/2017	18:57:42.3	12:57:42.3	+57.2°	164.6°

Table 2: TSE times for the selected location of observations.

[†] https://eclipse2017.nasa.gov/sites/default/files/interactive_map/index.html

3. Instrumentation

The observations have been conducted by using the following instrumentation:

- Canon EOS 1100D DSLR Camera,
- Canon EF 75-300mm f/4-5.6 III Telephoto Zoom Lens,
- Camera tripod (alto-azimuthal mount, no tracking).

The exposures during the partial and total eclipses have been acquired by using the following filters:

1. Baader OD5.0 solar filter (filter sheet mounted on a sunshade),
2. Hoya 58mm Linear Polarizer Filter (B58PLGB).

The exposure sequences and bracketing have been remotely controlled by using the following hardware and software:

- Neewer LCD Digital Timer Remote Control,
- Samsung Tablet running the *DSLR Controller*[‡] app.

4. TSE observation sequence

To perform the observations the camera has been mounted on the tripod. The zoom has been set on the maximum available focal length by 300mm. The focus has been optimized manually by looking (with the OD5.0 filter installed) before the beginning of the partial eclipse at the solar limb and at the small sunspots visible on disk on August 21st 2017. At the time of observations the seeing was almost perfect, with no visible clouds of any type over the whole sky. A picture showing the location of observations and the camera mounted on the tripod is provided in Figure 3 (the camera was covered by a white tissue to reduce the heating under sunlight).

Figure 3: the observation site for the August 21st 2017 total solar eclipse.

The observations have been acquired by bracketing the exposures with 15 different exposure times, going from 1/4000 s up to 4 s, in order to cover the dynamic range of coronal brightness from the base of the solar corona up to the limits of the camera field of view. Each image has 4272 x 2848 pixels, resulting in a

‡ https://dslrcontroller.com/

final resolution of about 3.7 arcsec/pixel. For all the exposures the DSLR camera has been set with ISO100, Fnumber 5.6. All the images have been saved only in the RAW format (to minimize the storage time on the local memory), each file is automatically compressed by the camera with lossless compression, and occupies 12.7 MB of memory. A large number of dark frames have been acquired before and at the end of the partial eclipses; flat field images have been acquired at the end of observations. Moreover, full moon images were acquired before this campaign to perform future radiometric calibrations.

A total of 63 images have been successfully acquired during the TSE: these images are listed in Table 3 in paragraph 0, together with the acquisition times, exposure times, and used filters. Thumbnails of these images are provided in paragraph 7 of this document (last images are fully saturated). A quick-look to the images shows that the Moon's diameter occupies approximately 520 pixels, hence (by assuming as first approximation the Moon's diameter to have the same projected dimensions as the solar diameter), the resulting spatial resolution was ~ 1920 arcsec / 520 pix ~ 3.7 arcsec/pixel. Because the Sun is moving in the sky at the apparent speed of 15 arcsec/sec = 4 pix/sec, some blurring in the images is expected for exposures longer than 0.5 sec. Considering that the images have dimensions by 4272 x 2848 pixels, this spatial resolution translates into a camera field of view by approximately (altitude x azimuth) = (4.38° x 2.92°) ~ (16.43 R_{sun} x 10.95 R_{sun}). At the maximum of the totality the Moon's disk was centred approximately at pixel position (X, Y) = (2350, 1380).

An example of the main astronomical objects that were expected to be visible around the Sun during the totality is shown in Figure 4; a comparison with the real images shows that the star visible at the bottom left with respect to the Sun was Regulus.

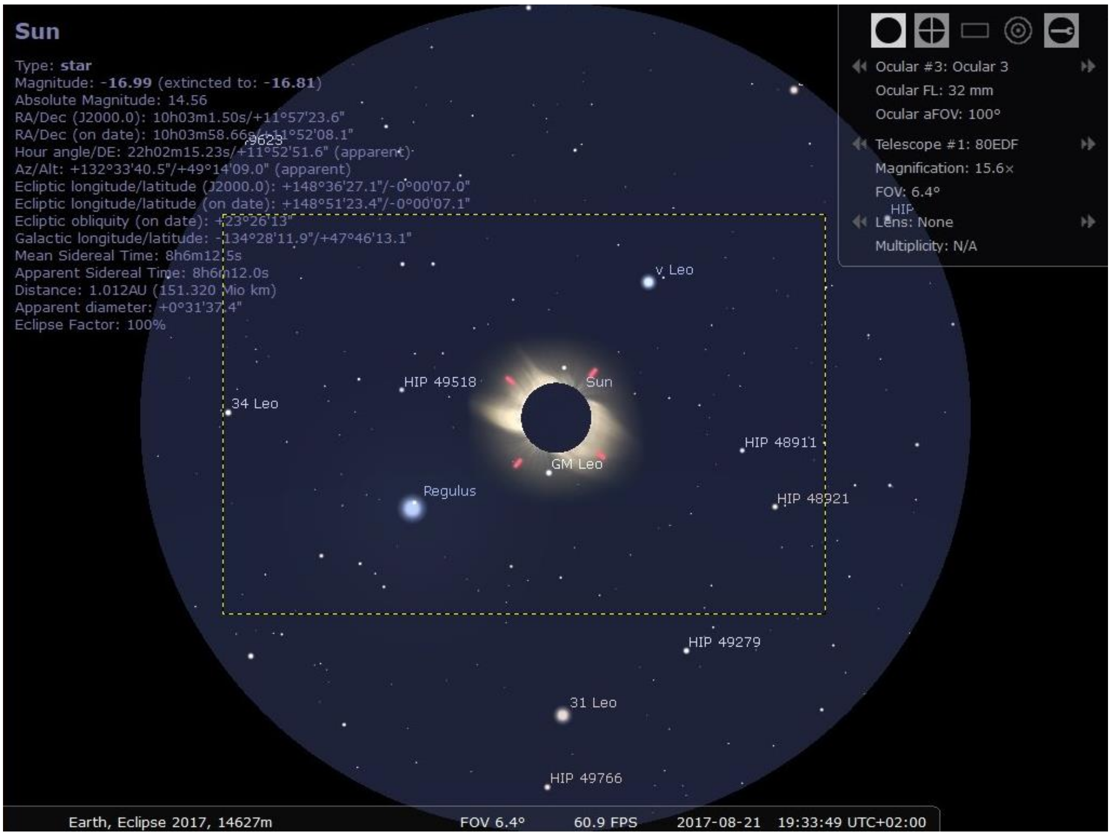

Figure 4: main astronomical objects located in the field of view of observations (yellow dashed line; figure obtained with Stellarium).

5. Preliminary data analysis

Results from a very preliminary data analysis (based simply on JPEG compressed images generated starting from the original RAW images) are shown in Figure 5. This Figure shows the differences between exposures acquired with two different orientations of the linear polarizer (rotation by 90° ± 2°) with exposure times by 1/30 s (top row) and 4 s (bottom row). The top row panels show that with this exposure time a good polarization signal was successfully detected in the lower corona from the limb up to ~1.5 R_{sun}, with clear "holes" in polarization located in correspondence of three prominence visible above the limb, as expected. On the other hand, images acquired with longer exposure times show a good polarization signal from ~1.5 R_{sun} up to at least ~4 R_{sun}. Unfortunately, the visible occurrence of a "lens flare" (due to internal reflections appearing after the insertion of the linear polarizing filter) will prevent an analysis on this part of the corona. The analysis of all the acquired images is now in progress.

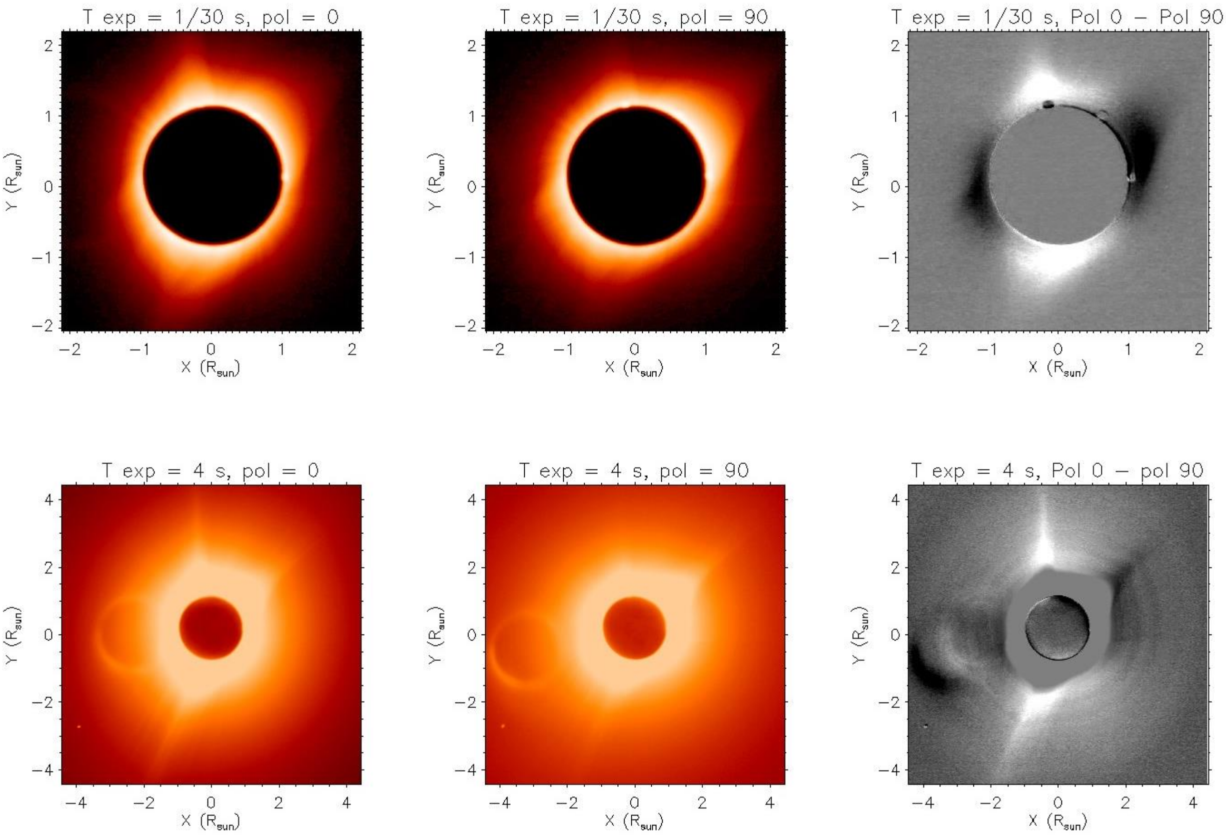

Figure 5: results from very preliminary analysis on data acquired with the linear polarizer.

Figure 6: group picture of people that performed the 2017 TSE observation campaign.

6. Appendix 1: list of TSE images

Exp #	Filename (.CR2)	Time (local)	Exposure (10^{-3} sec)	Filter #	Polarizer orientation
1	IMG_0084	11:32:44	0.250000	-	-
2	IMG_0085	11:32:47	0.250000	-	-
3	IMG_0086	11:33:02	0.250000	-	-
4	IMG_0087	11:33:12	0.250000	-	-
5	IMG_0088	11:33:13	0.500000	-	-
6	IMG_0089	11:33:14	1.00000	-	-
7	IMG_0090	11:33:15	2.00000	-	-
8	IMG_0091	11:33:17	4.00000	-	-
9	IMG_0092	11:33:17	8.00000	-	-
10	IMG_0093	11:33:19	16.6667	-	-
11	IMG_0094	11:33:20	33.3333	-	-
12	IMG_0095	11:33:21	66.6667	-	-
13	IMG_0096	11:33:22	125.000	-	-
14	IMG_0097	11:33:23	250.000	-	-
15	IMG_0098	11:33:25	500.000	-	-
16	IMG_0099	11:33:26	1000.00	-	-
17	IMG_0100	11:33:29	2000.00	-	-
18	IMG_0101	11:33:33	4000.00	-	-
19	IMG_0102	11:33:50	0.250000	2	0°
20	IMG_0103	11:33:51	0.500000	2	0°
21	IMG_0104	11:33:52	1.00000	2	0°
22	IMG_0105	11:33:53	2.00000	2	0°
23	IMG_0106	11:33:54	4.00000	2	0°
24	IMG_0107	11:33:55	8.00000	2	0°
25	IMG_0108	11:33:56	16.6667	2	0°
26	IMG_0109	11:33:57	33.3333	2	0°
27	IMG_0110	11:33:59	66.6667	2	0°
28	IMG_0111	11:34:00	125.000	2	0°
29	IMG_0112	11:34:02	250.000	2	0°
30	IMG_0113	11:34:03	500.000	2	0°
31	IMG_0114	11:34:05	1000.00	2	0°
32	IMG_0115	11:34:07	2000.00	2	0°
33	IMG_0116	11:34:11	4000.00	2	0°
34	IMG_0117	11:34:20	0.250000	2	90°
35	IMG_0118	11:34:21	0.500000	2	90°
36	IMG_0119	11:34:22	1.00000	2	90°
37	IMG_0120	11:34:24	2.00000	2	90°
38	IMG_0121	11:34:25	4.00000	2	90°
39	IMG_0122	11:34:26	8.00000	2	90°
40	IMG_0123	11:34:27	16.6667	2	90°
41	IMG_0124	11:34:28	33.3333	2	90°
42	IMG_0125	11:34:29	66.6667	2	90°
43	IMG_0126	11:34:31	125.000	2	90°
44	IMG_0127	11:34:32	250.000	2	90°
45	IMG_0128	11:34:33	500.000	2	90°
46	IMG_0129	11:34:35	1000.00	2	90°
47	IMG_0130	11:34:37	2000.00	2	90°
48	IMG_0131	11:34:41	4000.00	2	90°
49	IMG_0132	11:34:58	0.250000	2	45°
50	IMG_0133	11:34:59	0.500000	2	45°
51	IMG_0134	11:35:00	1.00000	2	45°
52	IMG_0135	11:35:01	2.00000	2	45°
53	IMG_0136	11:35:02	4.00000	2	45°
54	IMG_0137	11:35:05	8.00000	2	45°
55	IMG_0138	11:35:06	16.6667	2	45°
56	IMG_0139	11:35:08	33.3333	2	45°
57	IMG_0140	11:35:09	66.6667	2	45°
58	IMG_0141	11:35:11	125.000	2	45°
59	IMG_0142	11:35:13	250.000	2	45°
60	IMG_0143	11:35:15	500.000	2	45°
61	IMG_0144	11:35:17	1000.00	2	45°
62	IMG_0145	11:35:20	2000.00	2	45°
63	IMG_0146	11:35:23	4000.00	2	45°

Table 3: list of exposures acquired during TSE

7. Appendix 2: thumbnails of TSE observations

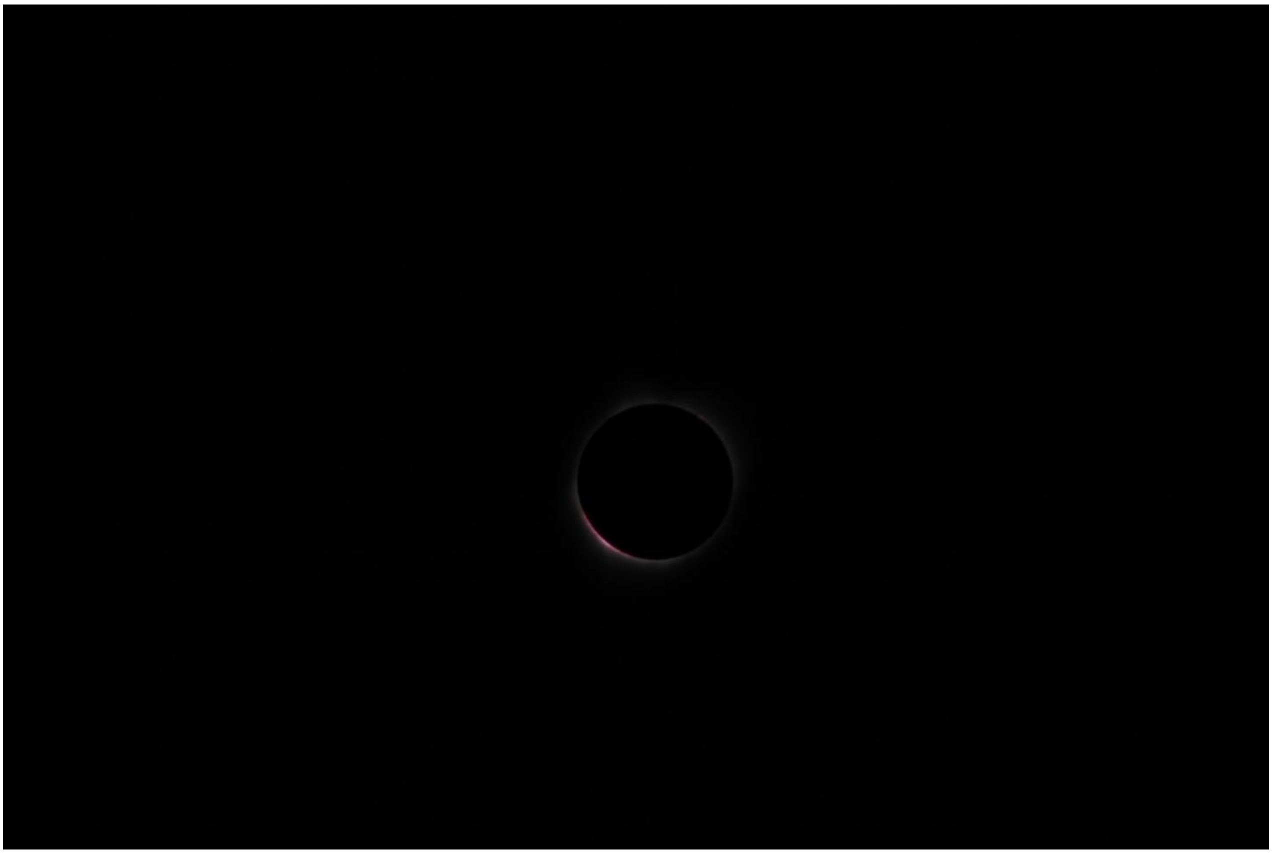

Figure 7: image 1

Figure 8: image 2

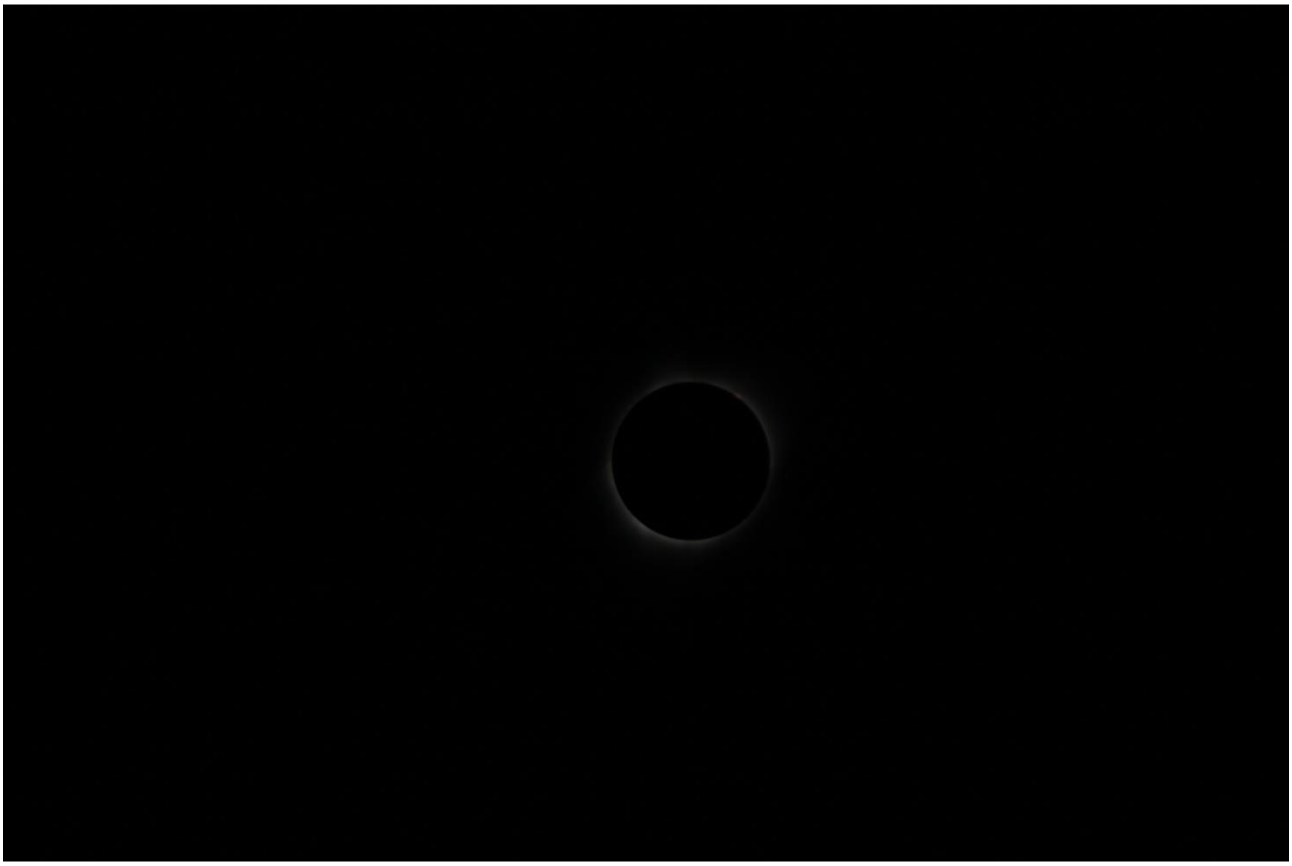

Figure 9: image 3

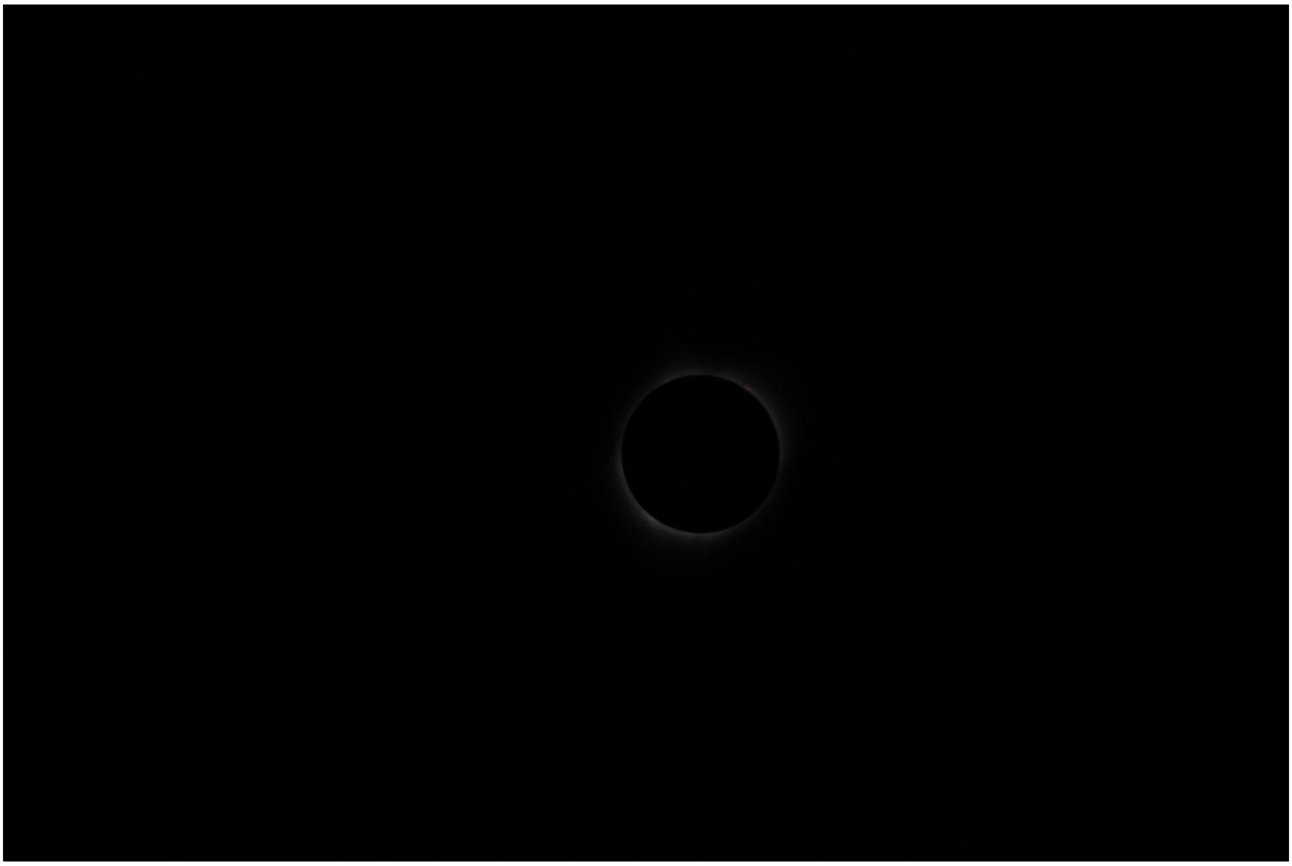

Figure 10: image 4

Figure 11: image 5

Figure 12: image 6

Figure 13: image 7

Figure 14: image 8

Figure 15: image 9

Figure 16: image 10

Figure 17: image 11

Figure 18: image 12

Figure 19: image 13

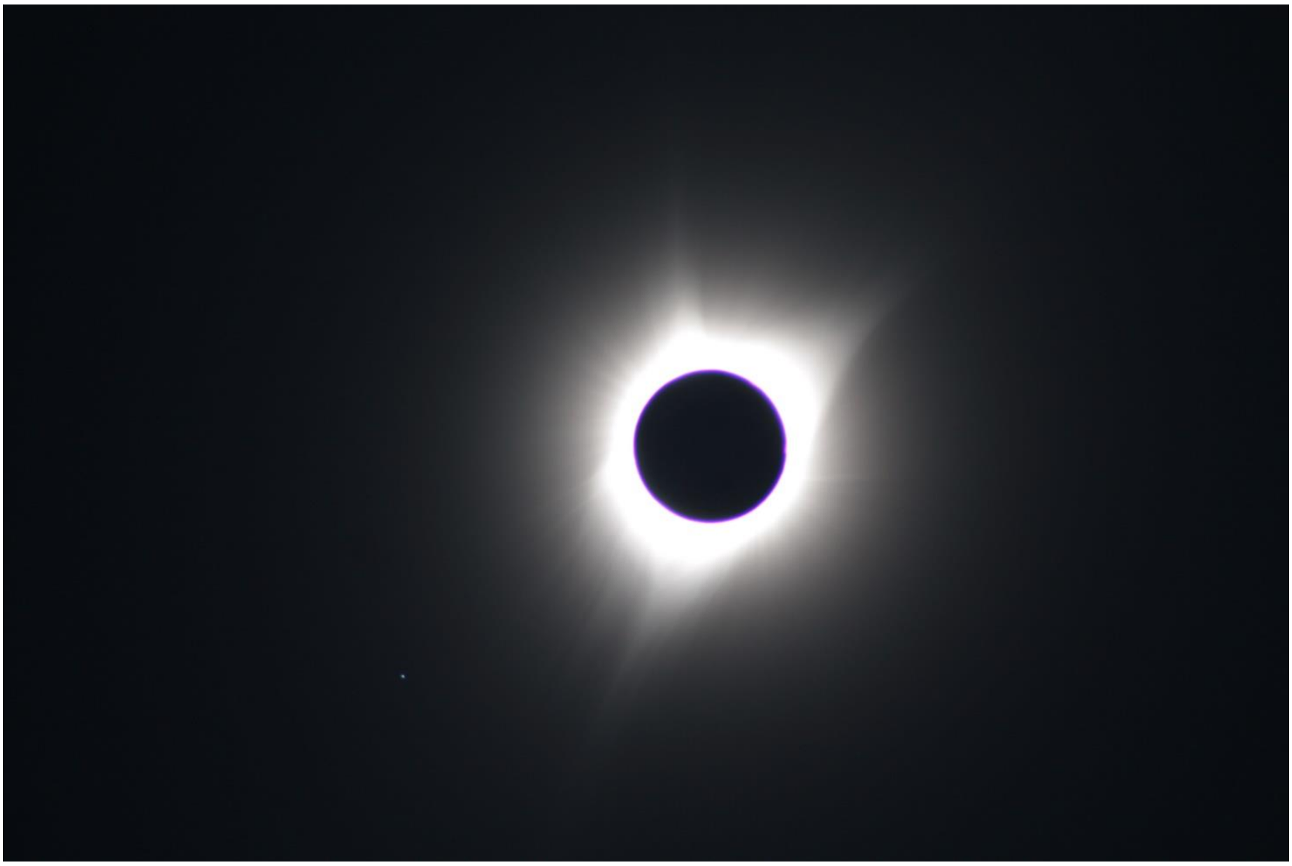

Figure 20: image 14

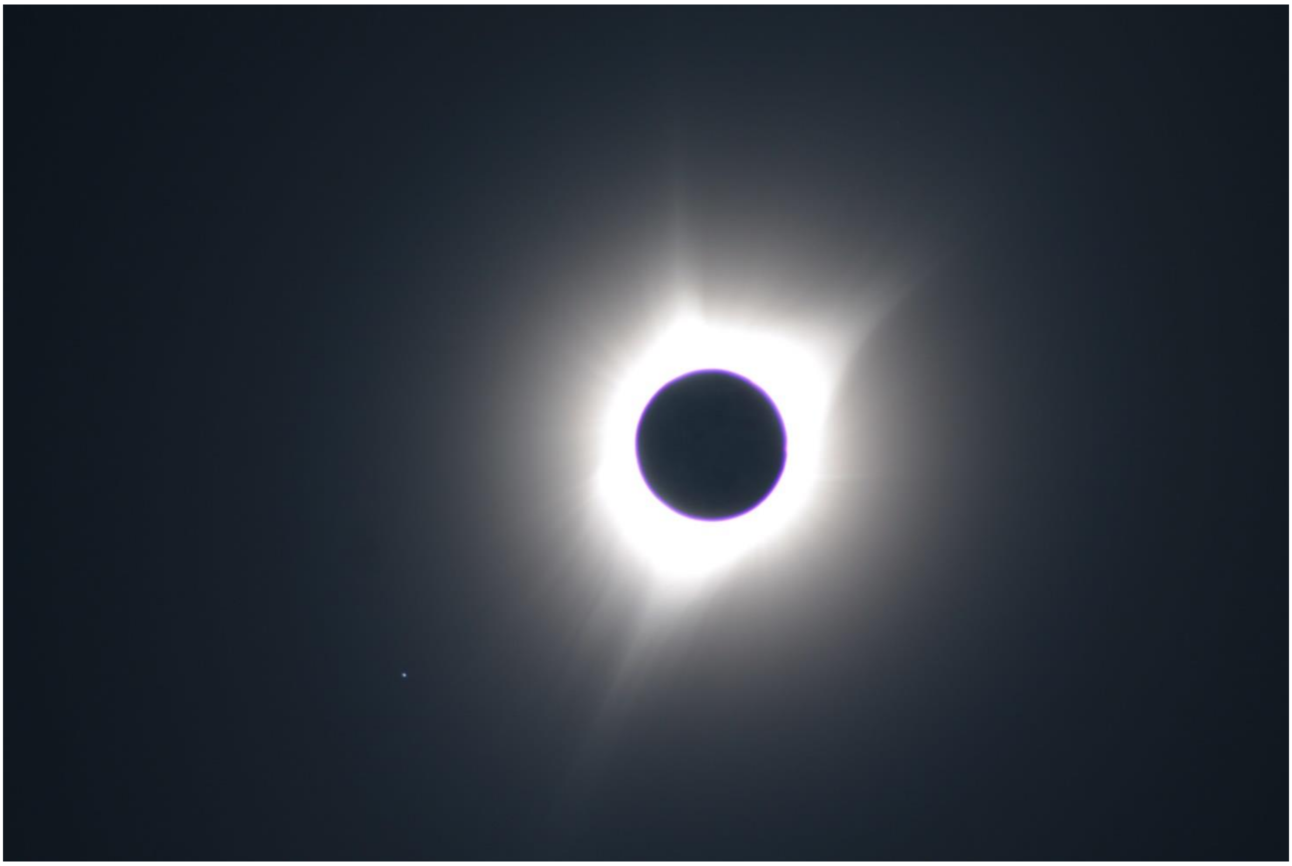

Figure 21: image 15

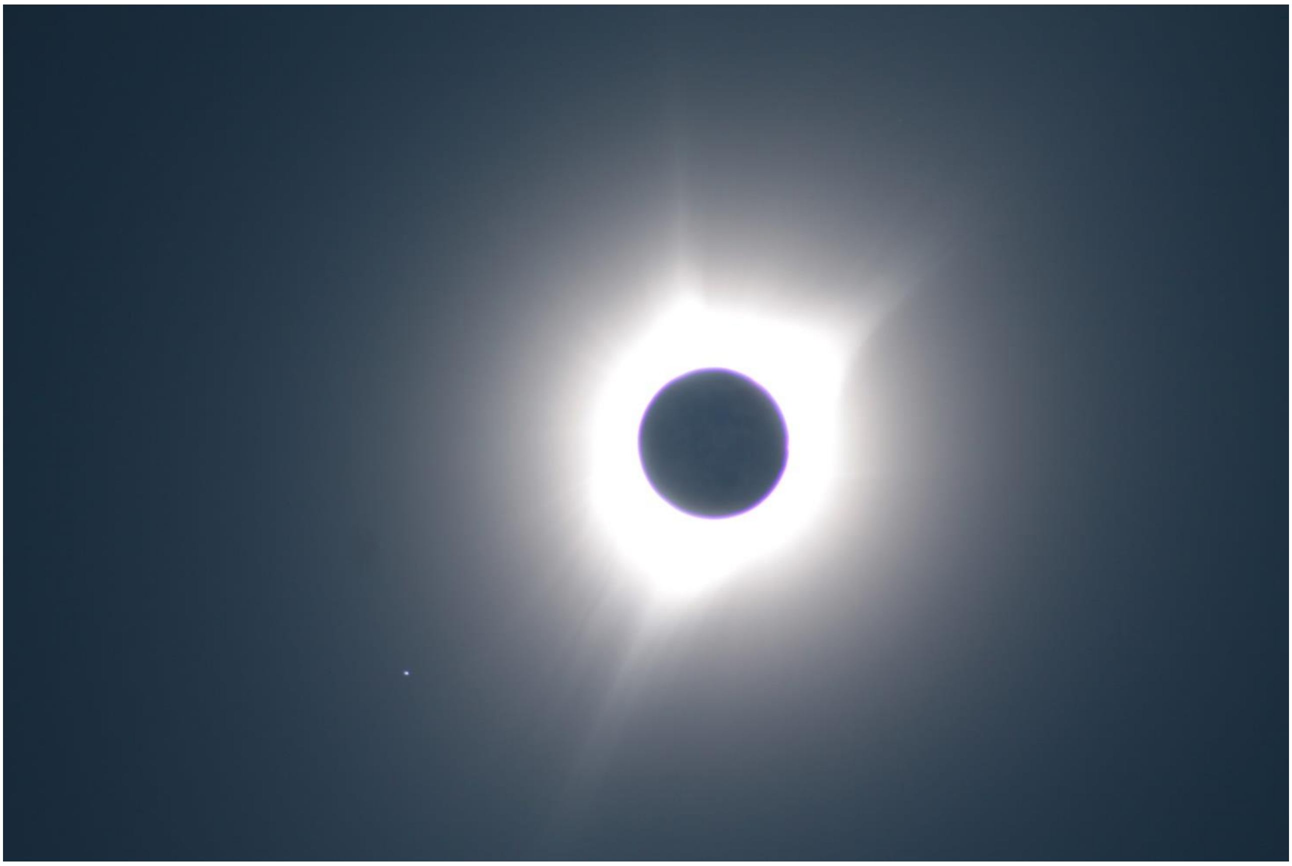

Figure 22: image 16

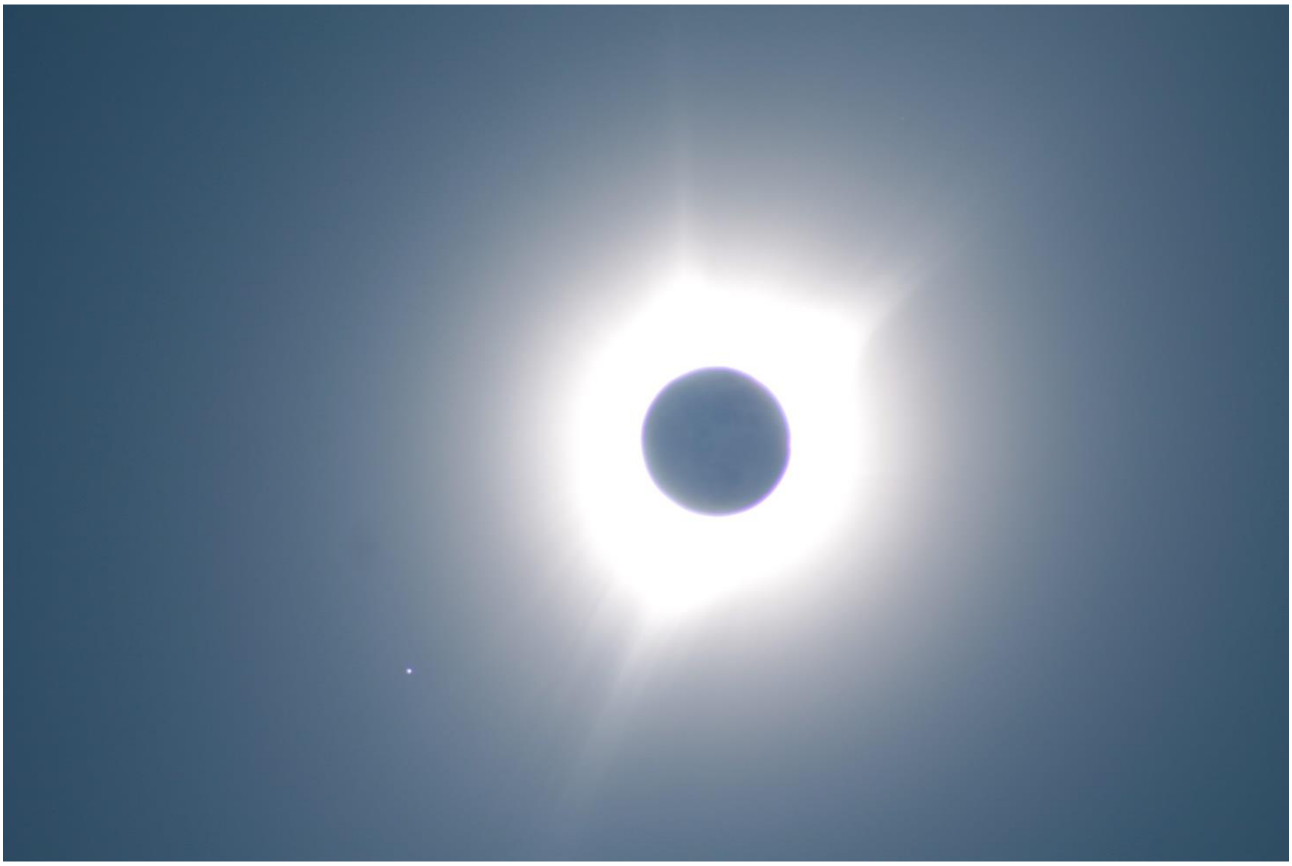

Figure 23: image 17

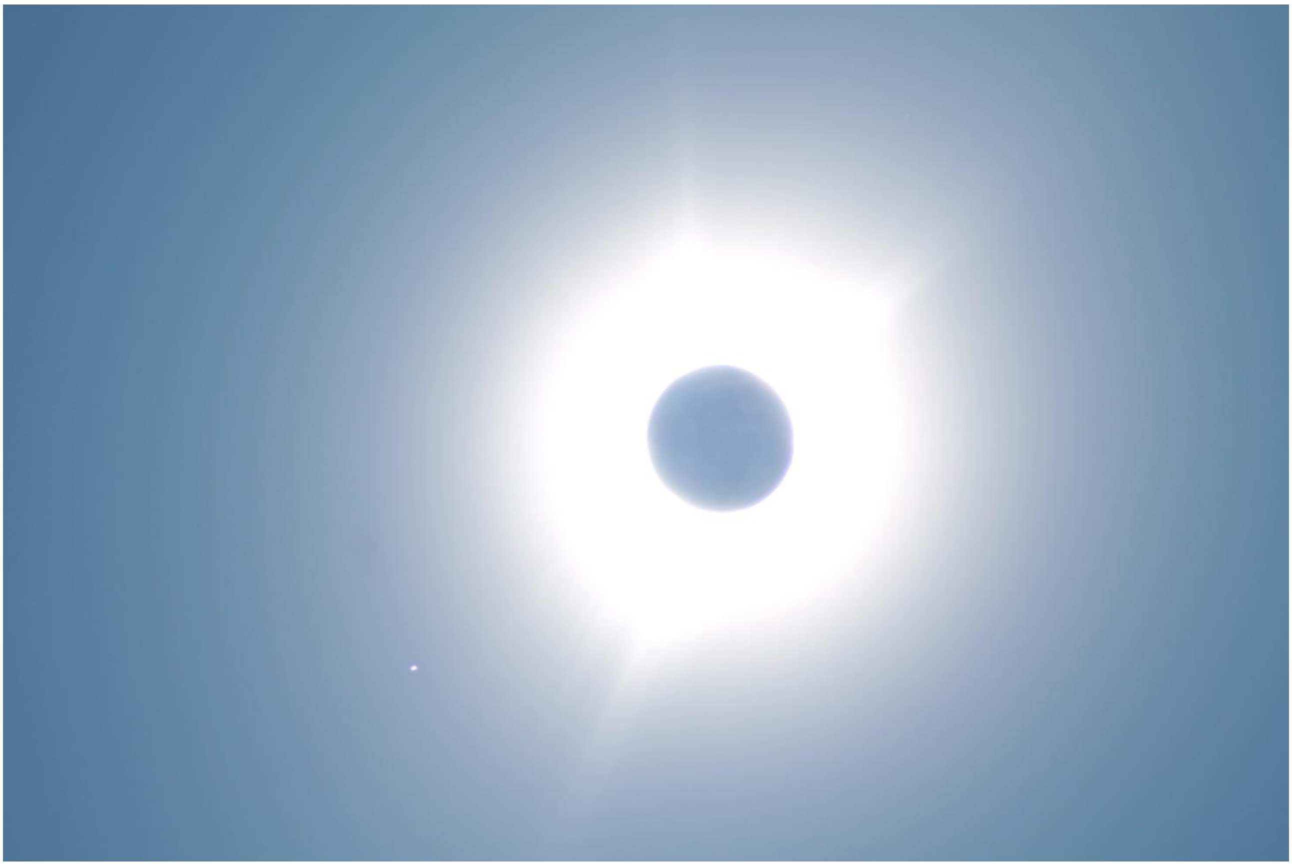

Figure 24: image 18

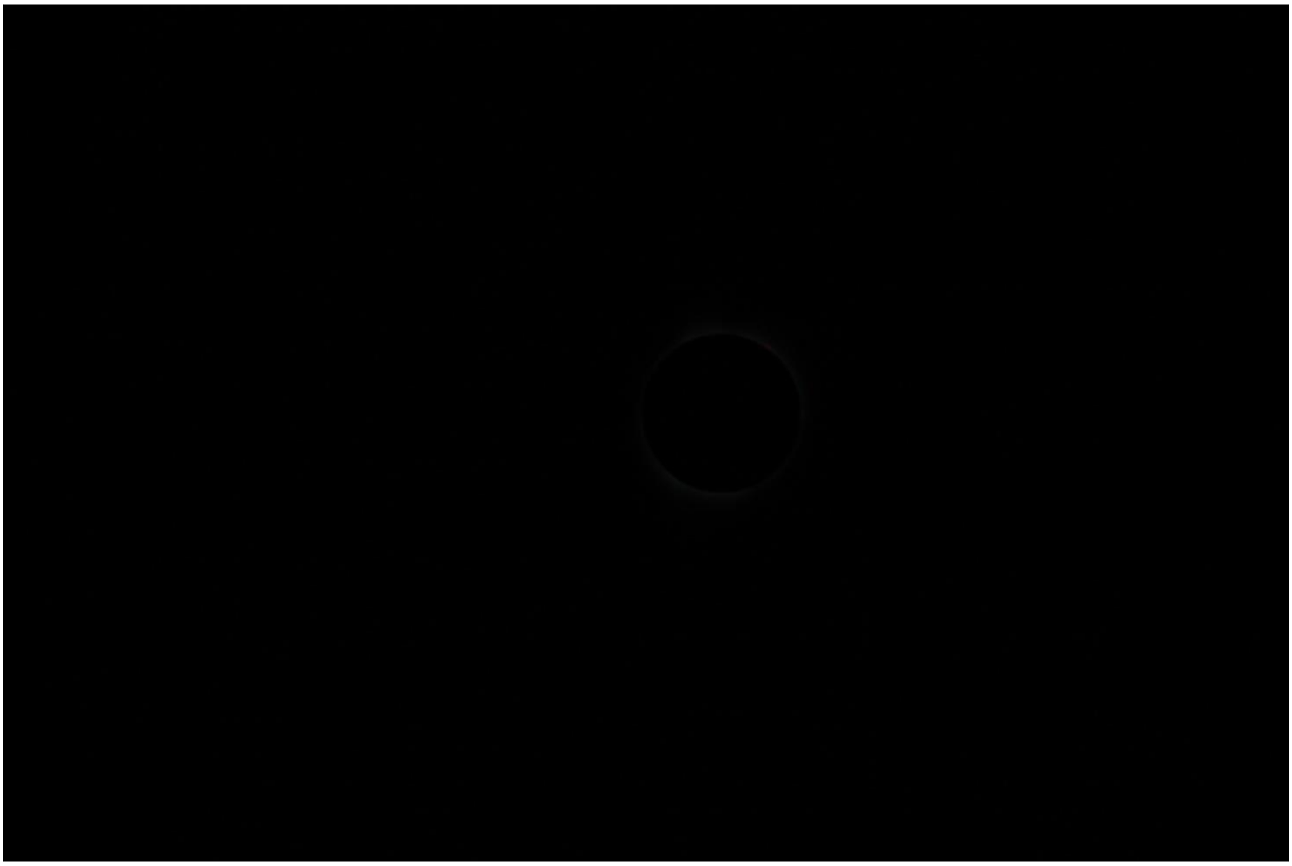

Figure 25: image 19

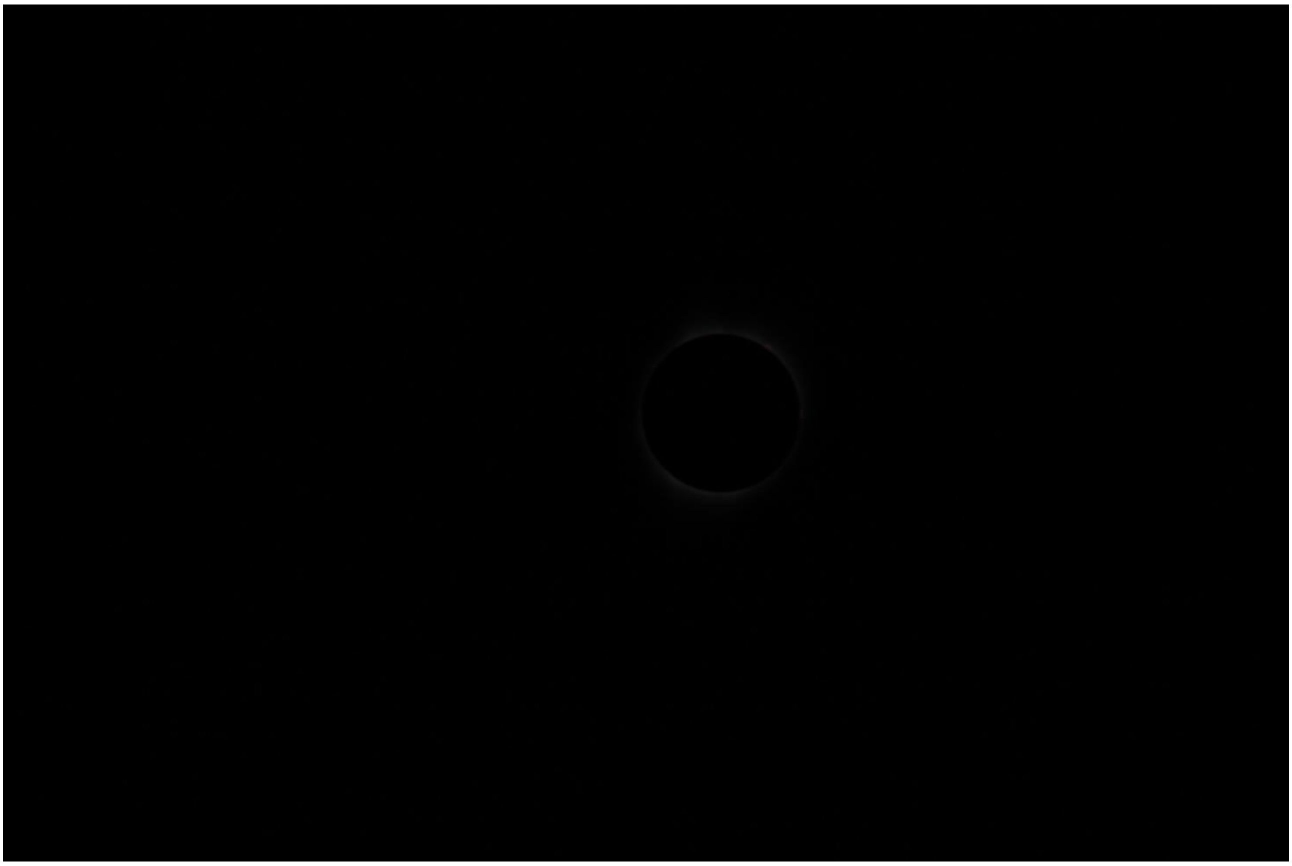

Figure 26: image 20

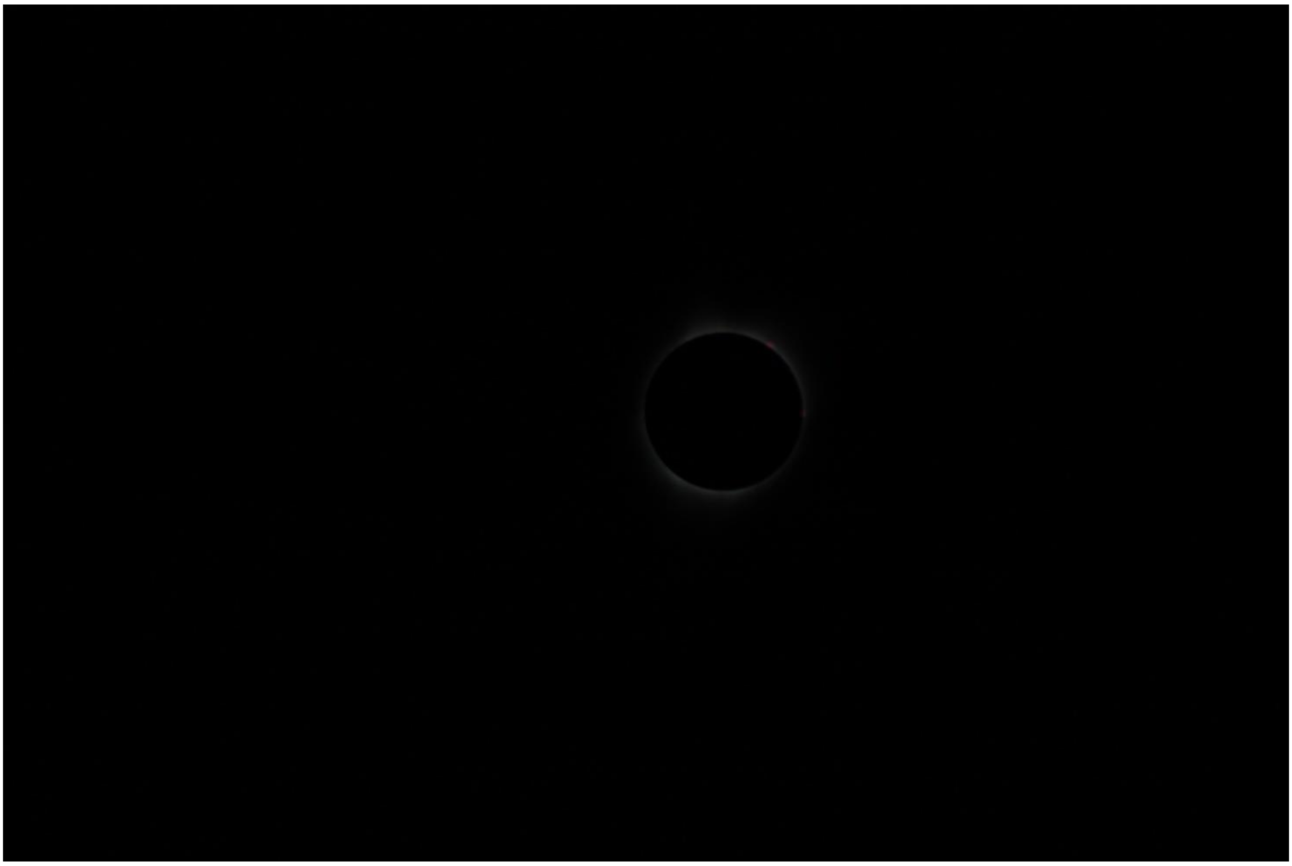

Figure 27: image 21

Figure 28: image 22

Figure 29: image 23

Figure 30: image 24

Figure 31: image 25

Figure 32: image 26

Figure 33: image 27

Figure 34: image 28

Figure 35: image 29

Figure 36: image 30

Figure 37: image 31

Figure 38: image 32

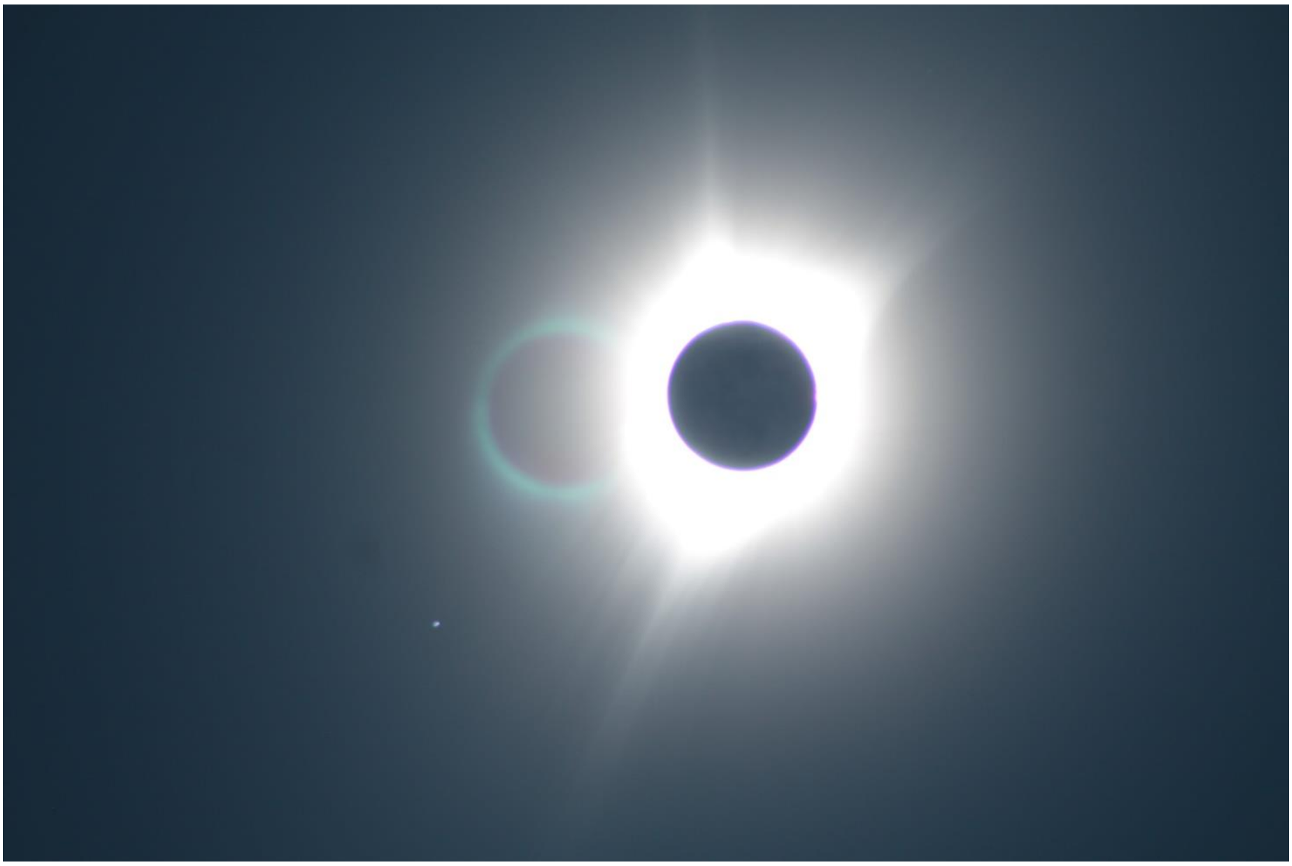

Figure 39: image 33

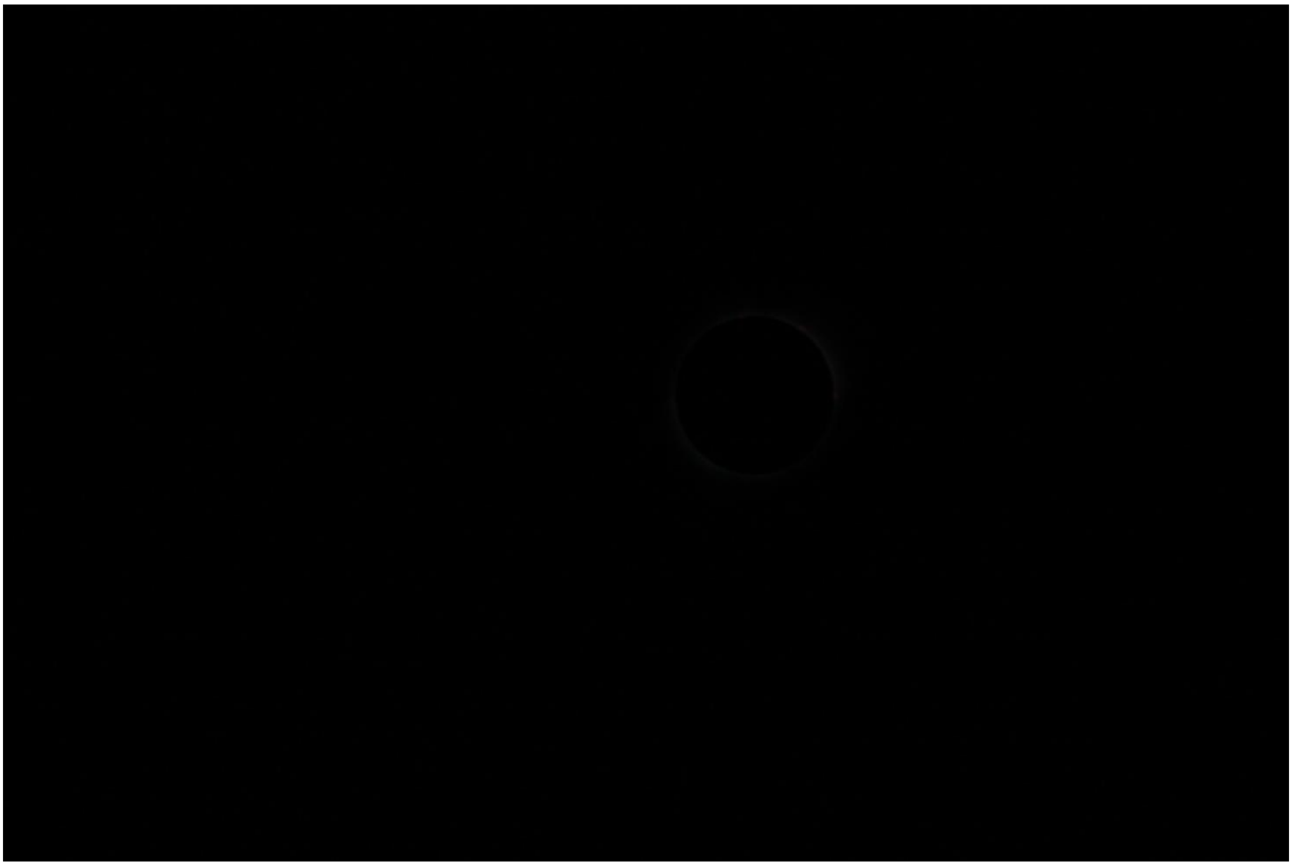

Figure 40: image 34

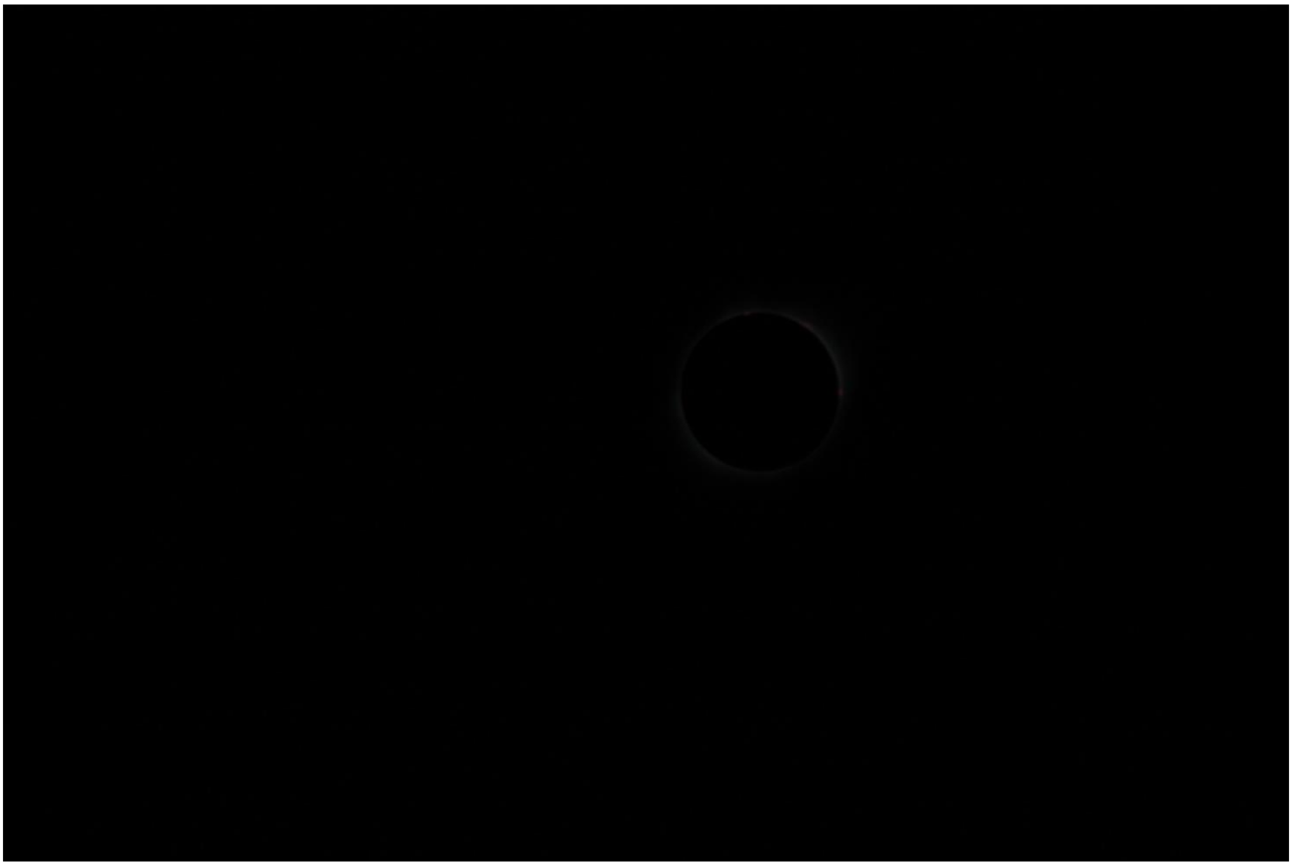

Figure 41: image 35

Figure 42: image 36

Figure 43: image 37

Figure 44: image 38

Figure 45: image 39

Figure 46: image 40

Figure 47: image 41

Figure 48: image 42

Figure 49: image 43

Figure 50: image 44

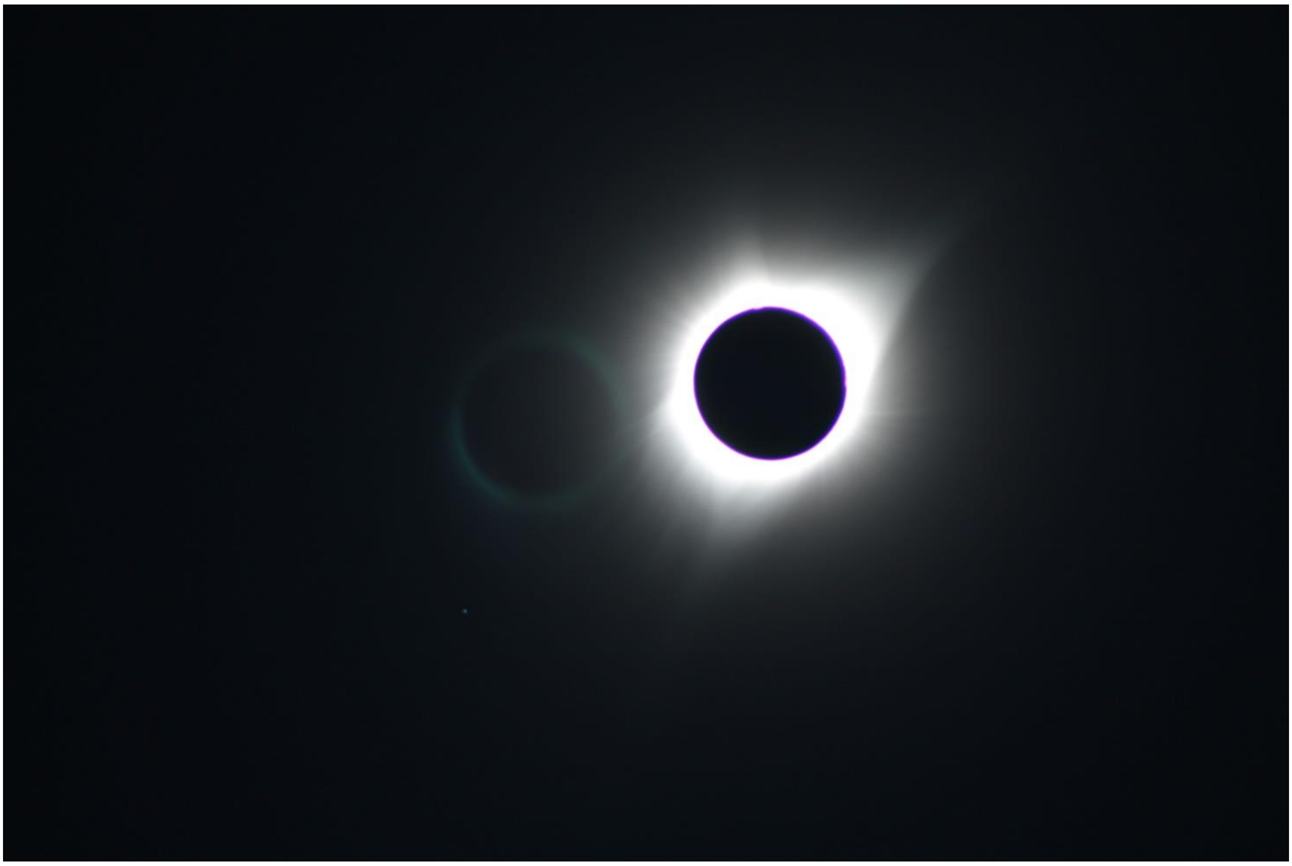

Figure 51: image 45

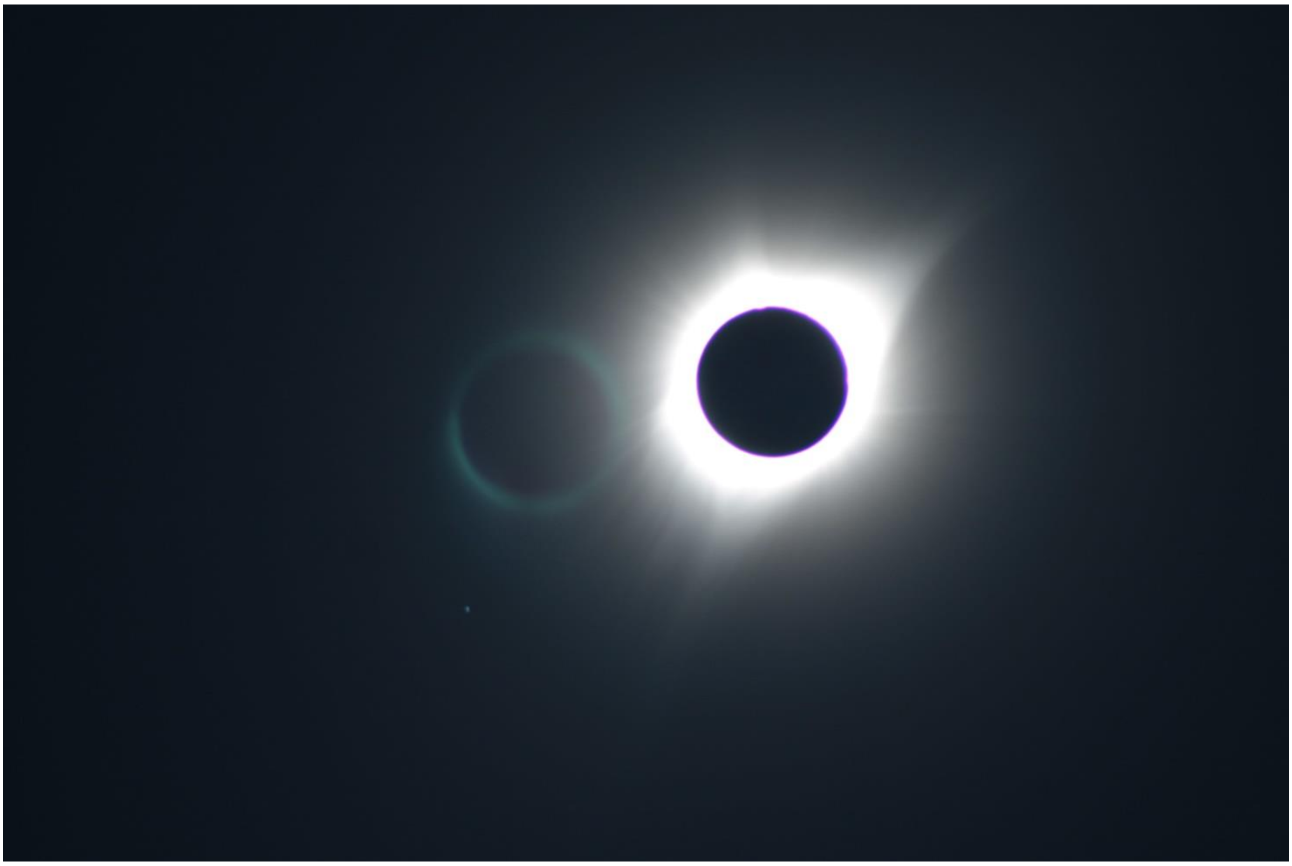

Figure 52: image 46

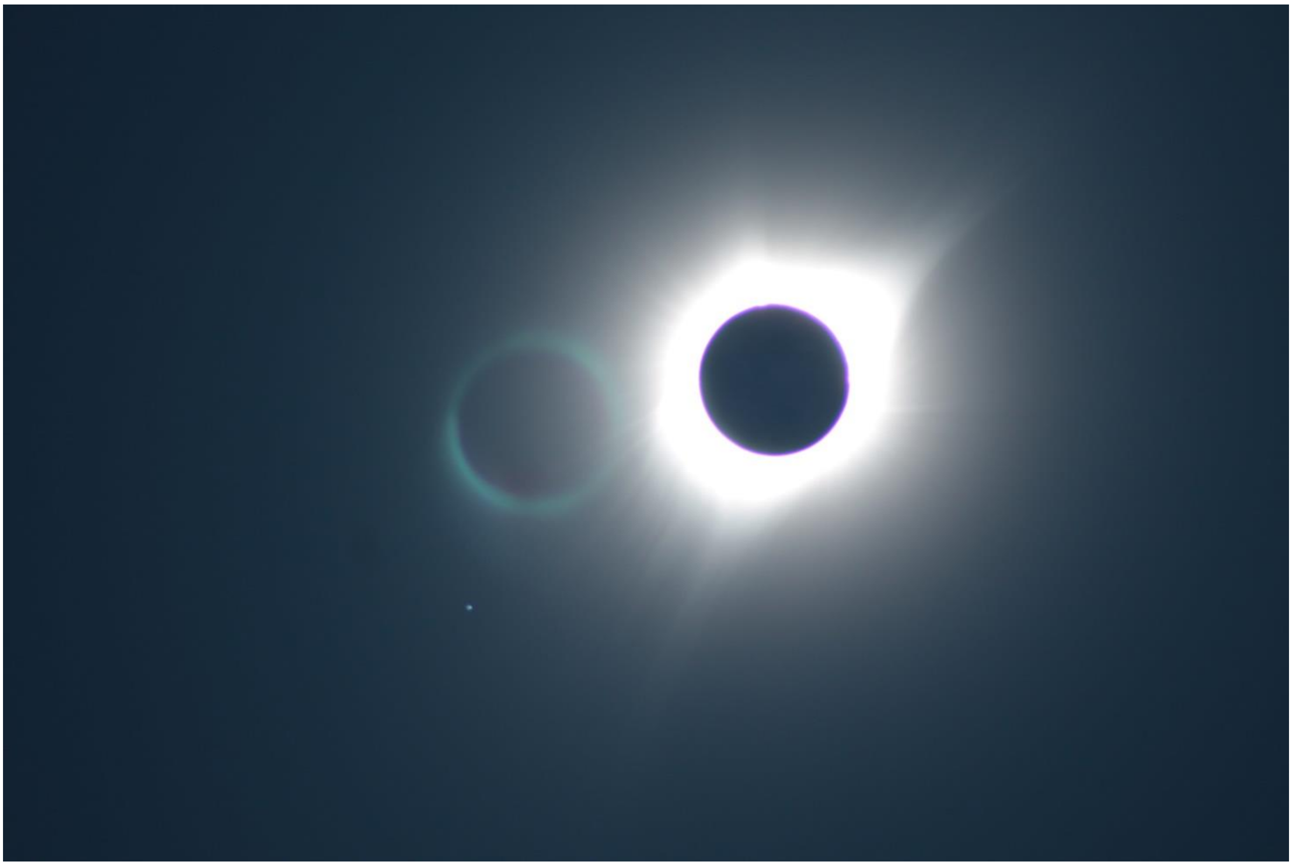

Figure 53: image 47

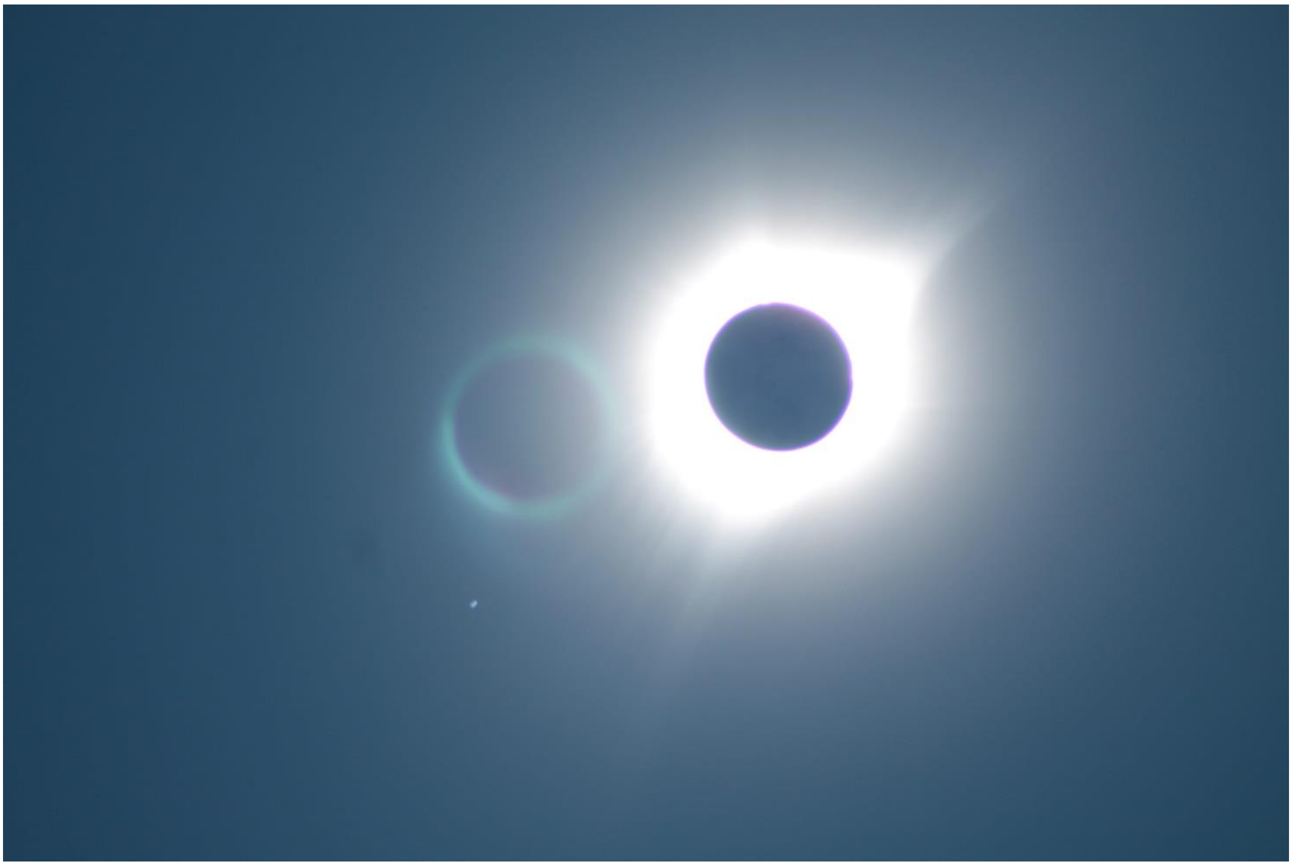

Figure 54: image 48

Figure 55: image 49

Figure 56: image 50

Figure 57: image 51

Figure 58: image 52

Figure 59: image 53

Figure 60: image 54

Figure 61: image 55

Figure 62: image 56

Figure 63: image 57

Figure 64: image 58

Figure 65: image 59

Figure 66: image 60

Figure 67: image 61

Figure 68: image 62

Figure 69: image 63