Instructions for 2009 TSE

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March 18, 2009

Camera

Camera type

For high-resolution high-quality corona imaging, digital cameras should be used. A DSLR camera is necessary. We have experience with Canon and Nikon cameras only and therefore we cannot guarantee if also other cameras marks can be used. Generally, higher resolution is not an advantage. According to our experience, the best Canon cameras for eclipse photography are 5D and 350D! From the nowadays sold cheaper Canon camera, also 400D proved as a very good one. The worst Canon cameras are EOS 450D (big noise) and 1Ds Mark II (vertical stripes). All Canon 1D cameras suffer from vertical stripes which is not possible to remove even by an enormous amount of calibration images. Older cameras like 300D and 10D can be used as well, but they need much longer time for saving images to memory cards. Therefore, they are suitable for observing places with longer totality and with lenses with shorter focal length.

12 bit vs. 14 bit cameras

Surprisingly, there is no difference between 14 and 12 bit Canon cameras. Theoretically, 14 bit cameras should be better, but these Canon cameras have also smaller pixels and therefore the advantage of higher dynamic range is lost. For example, a 12 bit 350D camera is even much better than a 14 bit 450D one.

Sensor cleaning

Dust on the camera sensor causes serious problems in image processing. Images taken cameras with many dust particles on the chip will not be processed! (Only in case the images are totally unique, we may process them with big difficulties.) Therefore, the camera sensor must be cleaned before the eclipse. After that, lenses must not be changed, the only change allowed is removing the lens installed after sensor cleaning and installing the lens used for eclipse imaging. Clean the chip thoroughfully with a special camera-sensor cleaning tool or have the camera cleaned in a good

service. We can recommend Fotoantik in Mendlovo náměstí in Brno, the Czech Republic for Canon 350D and similar cameras. Cameras with automatic sensor cleaning cause serious problems, because they usually do not remove the dust totally, they mostly shift it to different places making it harder to detect and remove them by means of flat-field images. Do not use cameras with automatic sensor cleaning or if it is possible, disable this function. If it is not possible, disable automatic camera switching off and do not switch it off between taking eclipse images and calibration images.

Lens

Generally, all lens with a full-frame equivalent focal length from about 200 mm to 1600 mm can be used. It is necessary that the lens does not produce reflexes when capturing highly contrasty objects.

Mount

An astronomic paralactic mount, a coelostat or a siderostat is needed. Make sure that the system is highly resistant to vibrations! There can be (often there is) quite a strong wind during the eclipse at the observing site. Old wooden tripods are often better than modern aluminium ones. A fixed mount should only be used for focal lengths up to 350 mm full-frame equivalent. If you need to use a fixed mount for a longer focal length lens for any reason, do not use lenses with field distortion like ED lenses with field flatteners. The best possibility are Maksutov-Cassegrain mirror lenses, especially the Russian ones.

Image sequences

The images must be saved in RAW format (*.crw, *.cr2, *.nef). **It is not possible to process images saved in JPEG format!**

Image set M, S, L

The most important data set (denoted M), we need from any observing place, is a sequence of images with various exposures taken with optics of 750 – 1000 mm focal length (for 24 × 36 mm sensor format). If it is possible to obtain more data sets (more observers, automated equipment, etc.), a longer focal length set L or a shorter focal length set S may be taken.

Recommended exposure sequences for a moving paralactic mount

The cameras must be set to ISO 100.

Camera type	Set M	Set S	Set L
Canon EOS 1D, 1Ds Mark II, III, 5D, 5D Mark II, Nikon D3, D700	500 – 1000 mm	200 – 500 mm	1000 – 1600 mm
Canon EOS 1D Mark II, II N, III	400 – 750 mm	150 – 400 mm	750 – 1200 mm
Canon EOS 10D, 20D, 30D, 40D, 50D 300D, 350D, 400D, 450D, 1000D	300 – 600 mm	135 – 300 mm	600 – 1000 mm
All Nikon digital SLR cameras except for D3 and D700	300 – 650 mm	135 – 300 mm	650 – 1000 mm

Table 1: Recommended focal lengths of camera optics

Aperture	Exposure [sec]												
	1/500	1/250	1/125	1/60	1/30	1/15	1/8	1/4	1/2	1	2	4	8
F/11	0	2	3	4	4	4	4	4	5	5	5	5	5
F/8	2	3	4	4	4	4	4	5	5	5	5	5	0

Table 2: Set M – recommended minimal numbers of images for a moving paralactic mount

Aperture	Exposure [sec]														
	1/1000	1/500	1/250	1/125	1/60	1/30	1/15	1/8	1/4	1/2	1	2	4	8	16
F/8	0	0	1	2	2	2	2	3	4	4	4	4	4	4	2
F/5.6	0	1	2	2	2	2	3	4	4	4	4	4	4	5	2
F/4	1	2	2	2	2	3	4	4	4	4	4	4	5	5	0

Table 3: Set S – recommended minimal numbers of images for a moving paralactic mount

Aperture	Exposure [sec]											
	1/250	1/125	1/60	1/30	1/15	1/8	1/4	1/2	1	2	4	8
F/16	0	2	2	3	4	4	4	4	5	6	6	6
F/11	2	2	3	4	4	4	4	5	6	6	6	0

Table 4: Set L – recommended minimal number of images for a moving paralactic mount

Recommended exposure sequences for a fix mount

The cameras must be set to ISO 200.

Aperture	Exposure [sec]									
	1/1000	1/500	1/250	1/125	1/60	1/30	1/15	1/8	1/4	1/2
F/11	0	1	1	2	3	4	5	6	7	7
F/8	1	1	2	3	4	4	5	5	6	5

Table 5: Set M – recommended numbers of images for a fix mount

Aperture	Exposure [sec]											
	1/2000	1/1000	1/500	1/250	1/125	1/60	1/30	1/15	1/8	1/4	1/2	1
F/8	0	0	1	1	2	2	3	4	5	6	6	6
F/5.6	0	1	1	2	2	3	3	4	5	5	5	5
F/4	1	1	2	2	3	3	4	4	4	4	4	4

Table 6: Set S – recommended numbers of images for a fix mount

Aperture	Exposure [sec]								
	1/1000	1/500	1/250	1/125	1/60	1/30	1/15	1/8	1/4
F/16	0	1	2	3	4	5	6	7	8
F/11	2	2	3	3	4	4	5	6	7

Table 7: Set L – recommended numbers of images for a fix mount

Comments:
If you succeed to take more images than recommended, then increase the number of longer exposures. If you are not able to take such a high quantity of images, decrease the number of images for every exposure time approximately proportionally. It is necessary to take at least one image for every exposure time.

Distribution of exposures

It is necessary to take short exposures both after the beginning and before the end of the total eclipse. Exposures longer than 1/30 s should not be taken earlier than ten seconds after the second contact and later than ten seconds before the third contact. For a manually operated camera on a paralactic mount, the following exposure sequence can be used as a good example:
1/500 s (1), 1/250 s (1), 1/125 s (3), 1/30 s (4), 1/8 s (4), 1/2 s (4), 2 s (5), 8 s (5), 4 s (5), 1 s (5), 1/4 s (4), 1/15 s (4), 1/60 s (4), 1/125 s (3), 1/250 s (1), 1/500 s (1).
The number in brackets says how many images of the particular exposure time are taken. At an observing site with totality longer than three minutes, it is better to repeat a similar sequence twice of three times.

For automated cameras, it is better to change the exposure time for each frame. An example on a good sequence might be:
1/500 s, 1/250 s,
1/125 s, 1/30 s, 1/8 s, 1/2 s, 1/2 s, 2 s, 8 s,
1/60 s, 1/15 s, 1/4 s, 1 s, 4 s
Repeat the previous two lines as many times as possible, do not necessarily start from such short exposures each time. The starting exposure may vary from 1/125 s to 1/4 s.
Before the end of the eclipse: 1/4 s, 1/15 s, 1/30 s, 1/60 s, 1/125 s, 1/250 s, 1/500 s.

Calibration images

For each sequence of digital images, it is necessary to add the following calibration images. These images should be taken shortly before or after the total eclipse without changing the lens and its focusing. Take the images directly at the observing place so that the temperature does not change much between the eclipse and calibration images.

Bias images

Set the camera to the shortest exposure time the camera enables, the lens must be covered with a cap, ISO setting must be identical with the eclipse images. The number of bias images must be at least four times as high as the total number of eclipse images.

Dark-frame images

The ISO setting must be identical with the eclipse images, the lens must be covered with a cap. For each image with exposure longer than 1/30 s, there must be at least four dark frames. This means that if four eight-second eclipse images were taken, at least sixteen eight-second dark frames are needed.

Flat-field images

Do not move the camera much between taking the eclipse images and the flat-field images, so that the dust particles on the chip do not move. (Even if the camera was cleaned in an authourized service, there may still be some dust particles.) Direct the camera to the sky and cover the lens with a diffusor, for example a flimsy paper. ISO setting and aperture value must be identical with the eclipse images. The images must be taken using autoexposure mode with aperture priority with exposure correction $-2/3$. The number of flat-field images must be at least four times as high as the total number of eclipse images. If the exposure time of the flat-field images is longer than 1/30 s, it is necessary to take dark-frame images for the flat-field images too.

Camera orientation

The Sun must be in the image center and the long side of the image must be parallel to the Sun equator.

Additional descriptive files

Processing of eclipse images is a time-consuming work. Therefore, we would like to ask you to prepare the following additional descriptive files. They must be raw text files created using Notepad or a similar software, not for example MS Word or Excel.

*.lim files

Lim files are lists of image files of the same properties. Each image file name must be on a separate line. It is also possible to use a mask to list more image files on one line. The mask structure is `FileNamePrefix???.Suffix<NumStart;NumEnd>`, for example `IMG_16??.CR2<07;66>`. The number of question marks (`?`) must be the same as the length of the numbers in `< >`. Both approaches may be combined. Examples of lim files:

- `IMG_16??.CR2<07;66>`
- `IMG_1752.CR2`
`IMG_1766.CR2`
`IMG_1774.CR2`
- `IMG_1752.CR2`
`IMG_175?.CR2<5;9>`
`IMG_1762.CR2`

Create the following lim files:

`Flat_field*.lim`
The list of all flat-field image files. Replace the asterisk (`*`) with any descriptive information, for example create a lim file `Flat_field_600mm.lim`

`Bias_*.lim`
The list of all bias image files. Replace the asterisk (`*`) with any descriptive information, for example create a lim file `Bias_600mm.lim`

`Dark_frame*.lim`
For each dark-frame exposure time, create a separate lim file, i.e. create lim files `Dark_frame8.lim`, `Dark_frame4.lim`, ... `Dark_frame2s.lim`, ... Each of these files is the list of all dark-frame images taken with the given exposure time.

`Img_*.lim`
For each exposure time, for which you have dark-frame images, create a separate lim file listing the images taken with this exposure time. All other image files must listed in another lim file. This means that it is necessary to create lim files `Img_8.lim`, `Img_4.lim`, ... `Img_2s.lim`, ... and `Img_AllOther.lim`

Cba file – eclipse and image description

Create a file `*.cba`, for example `500mm.cba`, with the following structure and fill in all required information you know. Comments which will be ignored can be written after a double slash (`//`). The structure of the cba file is shown using an example. The numbers used in the example are not true for the real case.

```
ID             TSE 2008 Hana  Klyuchi 500mm   // image set identification
Umbral_Depth   -76.4     // see comment (2)
Ratio_Moon/Sun 1.03654     // see comment (2)
Duration       136.2     // eclipse duration in seconds, see comment (2)

EclDate  01.08.2008   // eclipse date in format dd.mm.yyyy (without spaces)
C2_UT    17:44:37 // time of second contact C2 in UT in format hh:mm:ss (without spaces)
Obs_Long E083;54.365 // longitude of observing place in format Xddd;mm.mmm (X is E or W), see comment (1)
Obs_Lat  N54;56.33  // latitude of observing place in format Xdd;mm.mmm (X is N or S), see comment (1)
Author   Hana Druckmullerova   // author=your name

Obs_Place       Klyuchi, Novosibirsk, Russia  // your observing place
Obs_Altitude    156    // observing place altitude in meters
Obs_Conditions  excellent  // observing conditions
Sun_Altitude    30    // Sun altitude at mid eclipse, see comment (2)
```

```
Ecl_Magnitude   1.023 // eclipse magnitude, see comment (2)
Camera          Canon EOS 1D Mark II  // used digital camera
Camera_ISO      100    // ISO setting on the camera
Optics          Maksutov-Cassegrain MC 3M-5CA, 8/500 mm  // used optics


//---- List of images ------------------------------------------------------
//FileName      Time (see comment(3))  Exposure (see comment (4))
begin
IMG_001.CR2          -1                      1/500
IMG_002.CR2           5                      1/4
IMG_003.CR2           9                      1.5
IMG_004.CR2          15                       8
end
```

Comments

1. Measure your precise coordinates using a GPS receiver or possibly by means of Google Earth.

2. Enter your coordinates into an eclipse calculator, for example at `http://xjubier.free.fr/en/site_pages/SolarEclipseCalculator.html`. This page works off-line too, you may download it. Its version with improved graphical interface and diagrams is at `http://xjubier.free.fr/en/site_pages/SolarEclipseCalc_Diagram.html`. `Umbral_Depth` for the cba file is in percent. If the observing place was to the north from the totality belt central line, multiply the `Umbral_Depth` value computed by the eclipse calculator by -1, i.e. umbral depth 76% to the north from the central line is -76. Other values with comment `(2)` are taken from the calculator as well.

3. List all images taken during the total eclipse. The `Time` value is the relative time in seconds after the second contact, i.e. how many seconds after the second contact the image was taken. Read the precise time when the image was taken from its EXIF information. For this purpose, you can use the freeware software IrfanView. Load the image and press `E`. If you have no image of the second contact, but you have an image of the third contact, calculate the `Time` value from the third contact. If you do not have contact images at all, try to estimate the time of the second contact. It is not necessary that the `Time` value is absolutely correct in respect to the second contact. It is more important that the values are correct between various images, i.e. if image A has `Time 5` and image B `Time 17`, image B must have been taken exactly twelve seconds later than image A. The error of 1 s is acceptable.

4. The exposure value must be in a form `1/a`, e.g. `1/500`, `1/2`, or as a decimal number, e.g. `0.5`, `2.5`, or as an integer, e.g. `2`.

Web side

Check the web page `www.zam.fme.vutbr.cz/~druck/Eclipse` for updates of these instructions.

Contacts

If you have any question concerning total solar eclipse imaging, feel free to contact us on the following addresses.

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