



# Image Processing for Comets

## 2.5 Surface

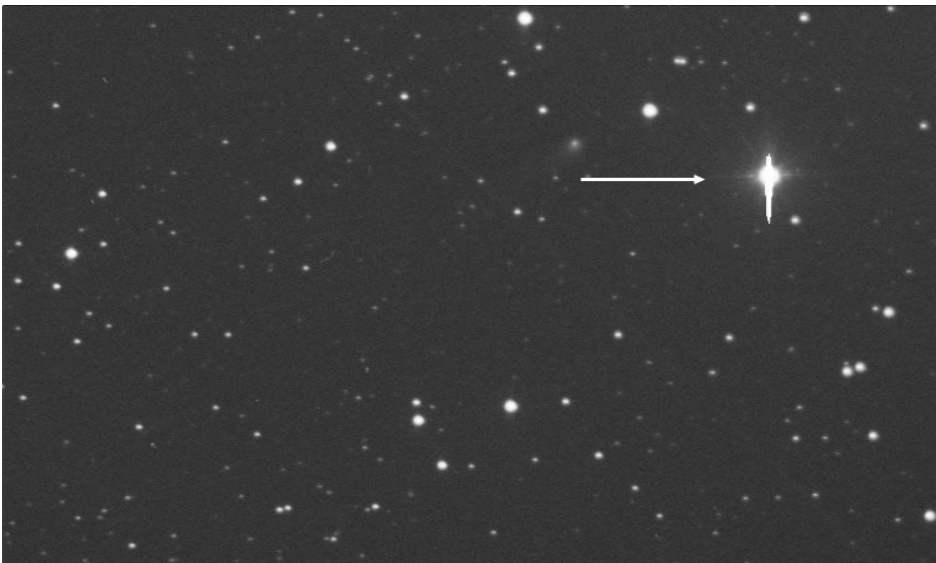
Today, there are sensors of 768 x 512 pixels up to 8176 x 6132 pixels ( 49,1 mm x 36,8 mm), that's bigger than the old 35mm film.

The size of the chip determines the magnification factor which is also known from standard digital cameras. Due to the small pixels, the quality of the optics is important. The optics should provide a well-lit flat field so that the sensor can be used completely.

## 2.6 Characteristics of the image sensors

The CCD sensors are available with different characteristics. First, there are so-called NABG and ABG sensors (non anti-blooming gate and anti-blooming gate). This is the property of the sensors referred to whether a pixel has an electron overflow protection (ABG) or not.

A sensor with ABG has a lower sensitivity because when the pixel is filled with electrons (full well capacity) all further incoming photons of light do not give a better signal. NABG sensors do have problems with bright stars due to overflow of electrons to neighboring pixels which leads to blooming in the image. Color sensors (CCD or CMOS) contain filters of red / green / blue in front of each pixel. The composition of the filter depends of the manufacturer of the camera.



Comet C/2005 L3 (McNaught) taken on May 11<sup>th</sup>. 2008.  
CCD-Camera with NABG-Chip, blooming is marked.

## 2.7 Cooling

For CCD sensors, cooling is essential. Cooling is the best way to avoid hot pixels or column errors and is typically done with one or two stage thermoelectric cooling elements. The hot air gets dissipated by a fan + cooling fins. Some cameras offer the ability to use water for cooling, which allows lower temperatures, but it introduces more technical complexity. This makes mobile observing more difficult and needs more equipment to handle.

## 4. Standard image processing and calibration

### 4.1. Calibration of the data

After the observation, the images must be calibrated using Dark frames, Bias frames and possibly with Flat frames. Calibration takes place according to the following standard method:

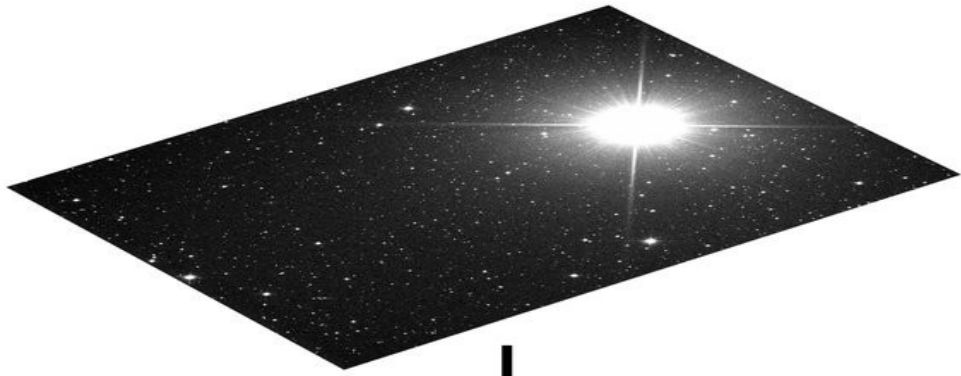
$$(\text{Image} - \text{Dark frame} - \text{Bias frame}) / \text{Flat frame} = \text{Calibrated image}$$

The Flat frame needs to be calibrated as well. A Flat frame gets calibrated in the following way:

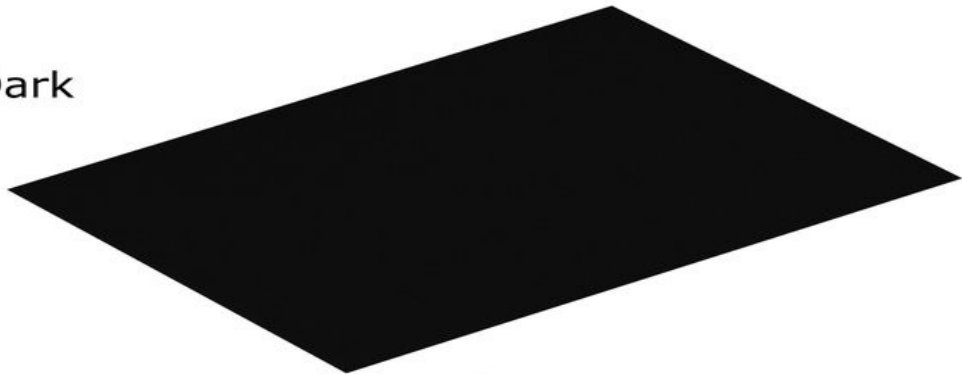
Flat frame – Dark frame (same exposure time as Flat frame) – Bias frame = calibrated Flat frame

The following picture doesn't show the Bias frame and nothing about the calibrated Flat frame.

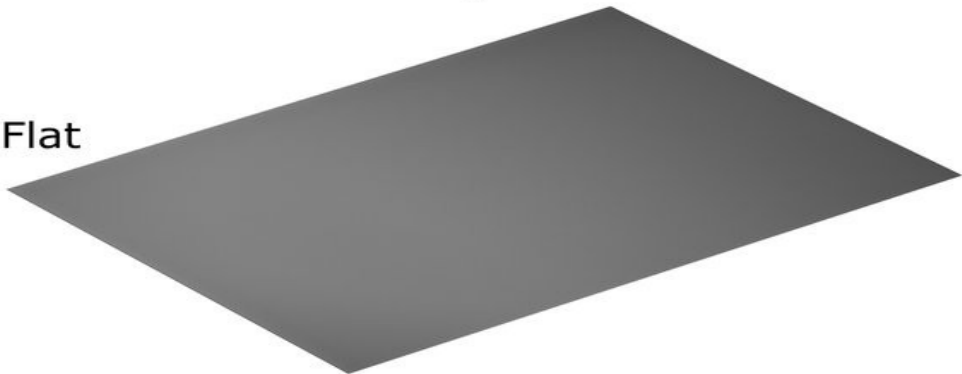
Image



Subtract Dark  
Frame

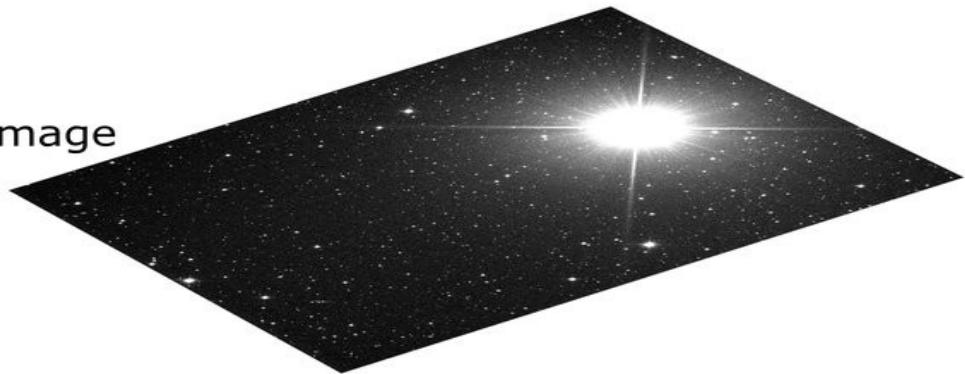


Division of Flat  
Frame



=

Calibrated image





## 4.2.2 Batch processing with Astroart including stacking the calibrated images

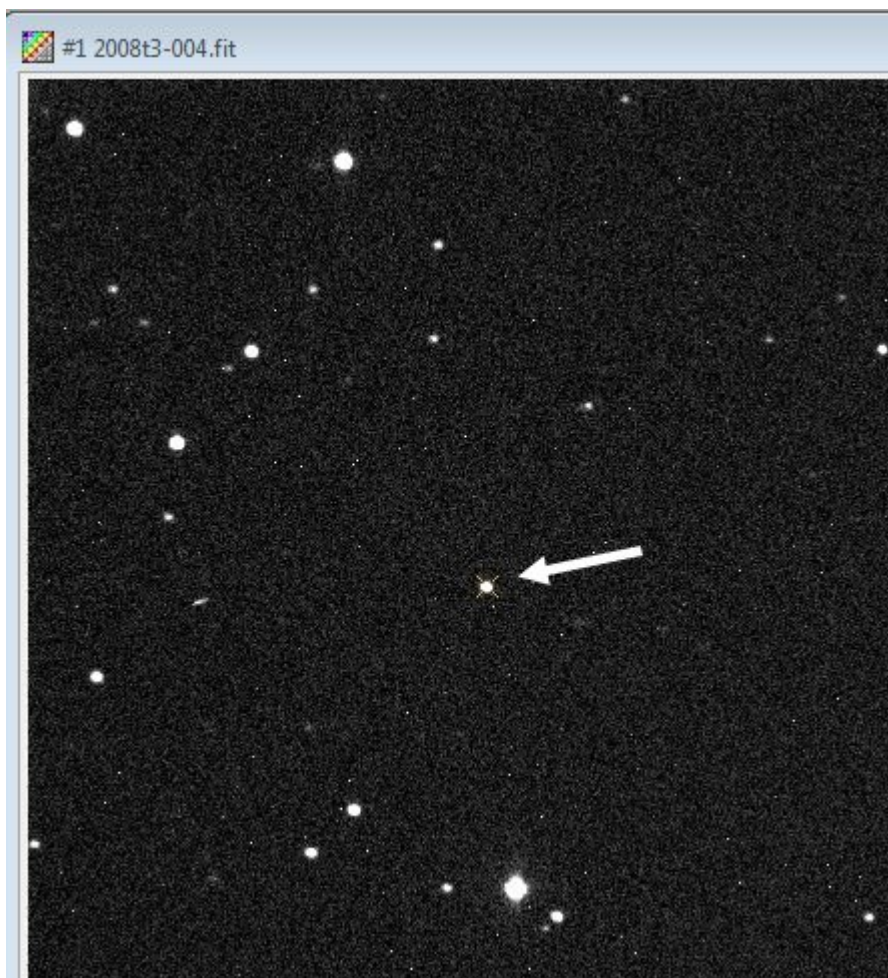
### 1. Preparations to use the Preprocessing

The files of the object, the Dark frames or Master Dark, the Flat frames or a Master Flat, the Bias frames, and a Master Bias are selected.

### 2. Option 1 – a slow comet

Load an image file of the object and highlight either the comet or a star with the mouse. The selected object gets marked with a yellow "X".

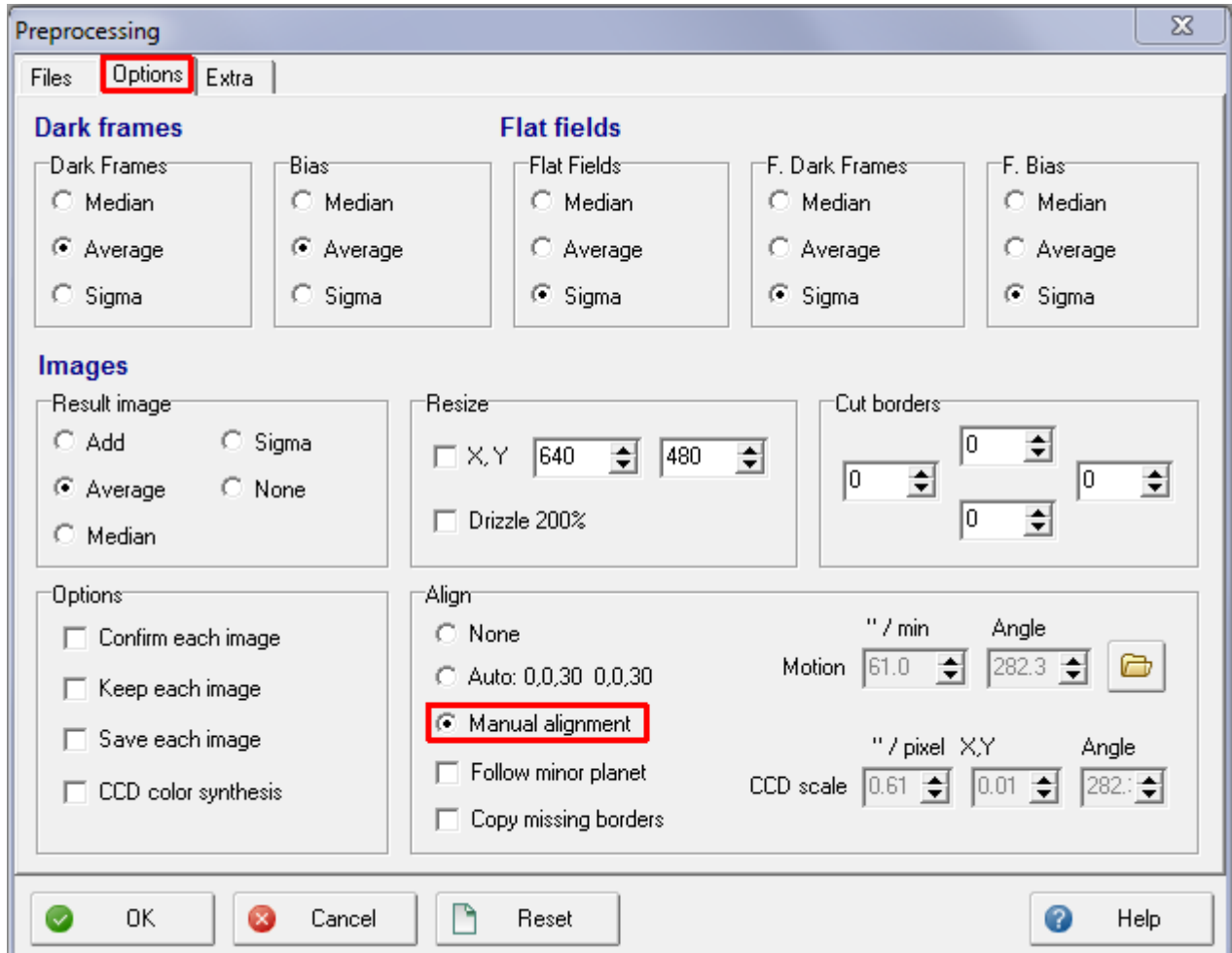
You can mark several objects / stars. Now close the loaded image, since Astroart stores these check marks.



A star is selected for automatic alignment.

### 3. Option 2 – a fast moving comet

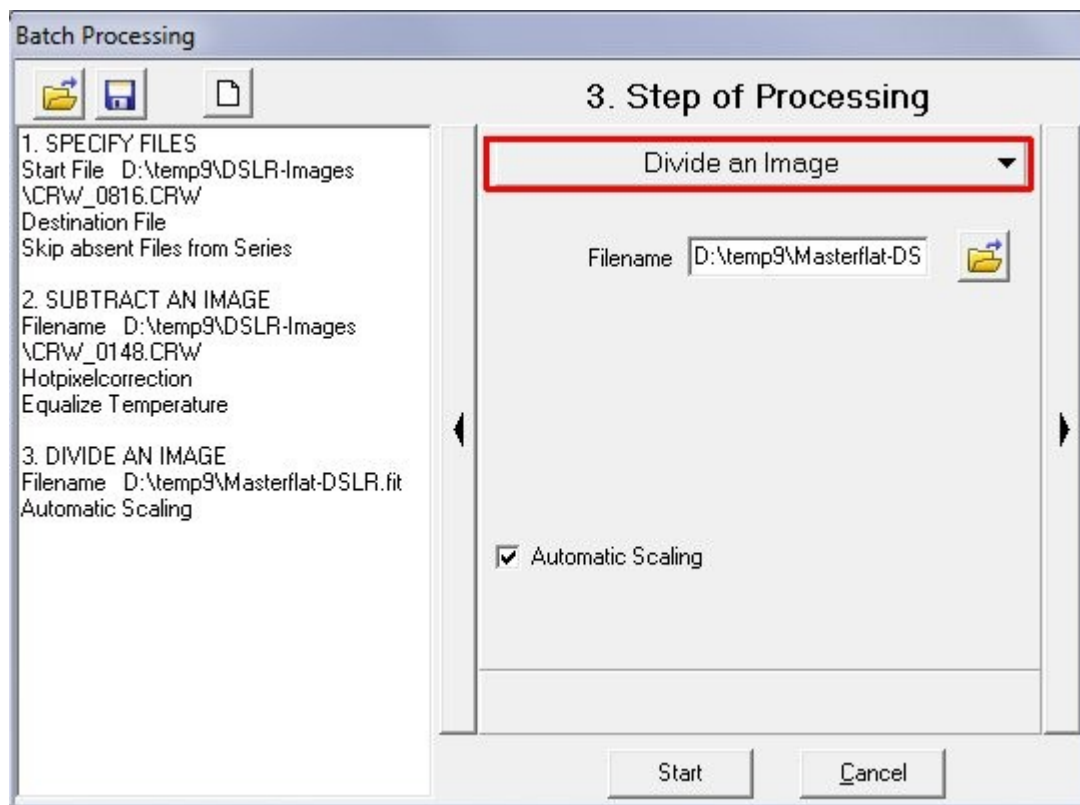
Steps 2.1 - 2.3 are carried out similarly. Only for the "**alignment**", select "**Manual alignment**". Based on the calculated motion of the comet, the pictures get stacked automatically or manual using the manual selection. The "**Manual alignment**" shows an additional selection box where the object must be marked manually on each frame.



Thus, virtually any number of images can be stacked. In any case, it is recommended to store the results as FITS or for further processing as a TIFF file (raw data).

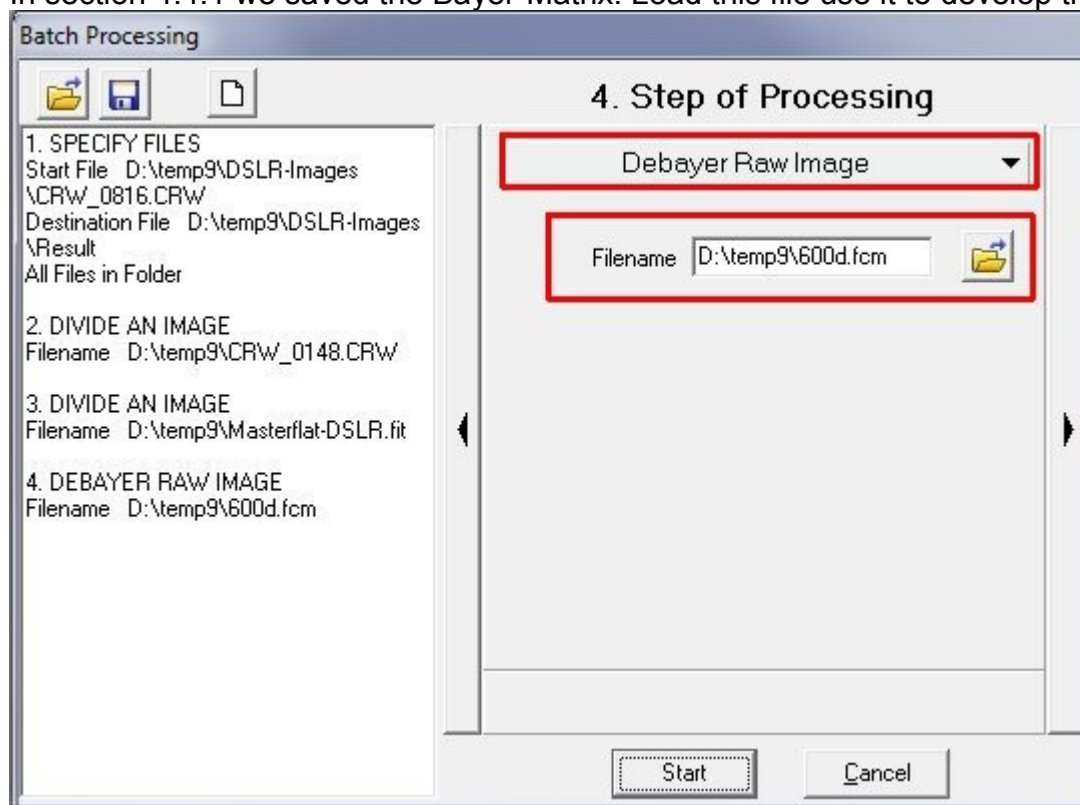
With the help of the functions outlined in red, the marquee can be moved or resized, the image section can be enlarged or the image brightness for the stack operation to be changed. Especially with faint comets it is recommended to change the brightness of the image for better selecting the object

### 3. Apply the Master Flat frame



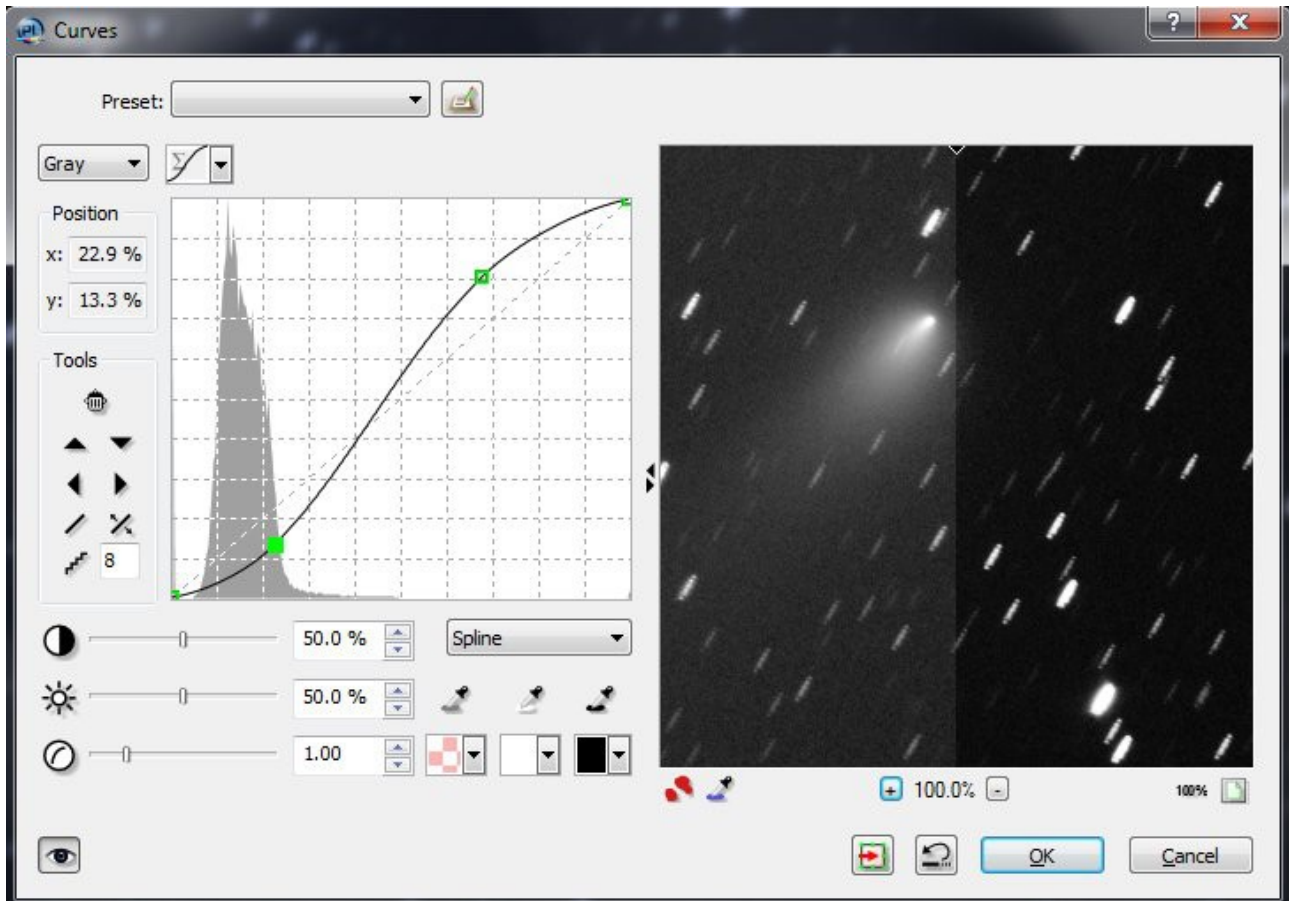
### 4. Develop the color image

In section 4.4.1 we saved the Bayer-Matrix. Load this file use it to develop the color image.



## 5.4 Digital Development Processing

Due to the short exposure times and therefore little image data, the processing of comet images often leads to an increased noise in the final image. This is also true for images of medium bright comets but some noise is sometimes acceptable. An image with a light gray background needs more sophisticated processing. Some image editing programs, call this method simply "DDP" and it provides a fast way to achieve this effect. The same effect can also be achieved with appropriate use of the tone curve. By making an S-shaped curve that DDP-effect is also achieved. Only with more control by simply changing the tone curve.



Again:

The optimal use of the S-shaped curve on each image must be determined by trial and error. With practice and more experience this is achieved very quickly.

More information can be found under <http://www.asahi-net.or.jp/~rt6k-okn/its98/ddp1.htm>

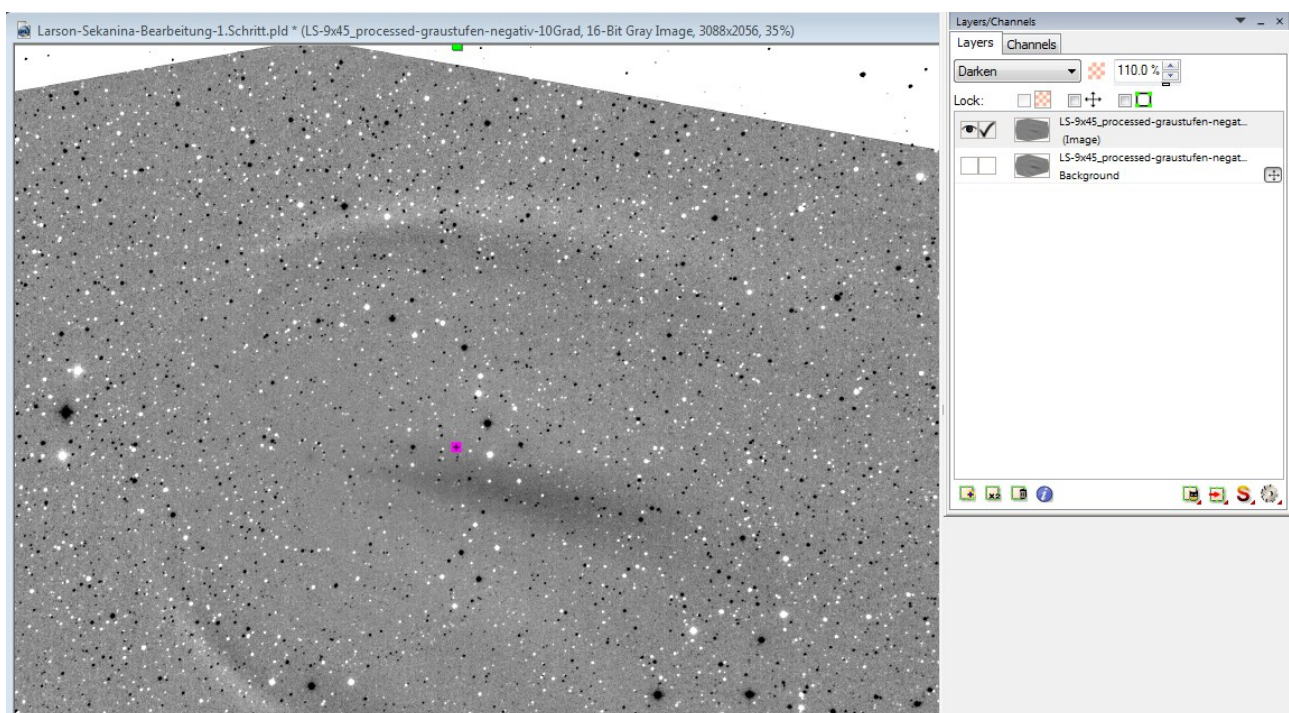


## Workflow:

1. Open a processed image
2. Apply the Larson-Sekanina filter
3. Create two images with different angle of rotation and save it
4. Open the image with the larger angle of rotation with your image processing program (e.g. Photoline, / Adobe Photoshop. etc.) this image is the background image
5. Copy the image with the smaller angle of rotation into the background image as a new layer
6. Select the layer that contains the image with the smaller angle of rotation
7. Apply the selected image with the function "darken". Increase the percent value until the "doubled" stars disappear.
8. Remaining "doubled" stars must be removed manually e.g. use the copy stamp

**Note:** The example uses an inverse image (black stars, white background). Therefore, the function "**darken**" is used as described in step 7 of the workflow. If a positive image is used, (white stars, black background), the function "**lighten**" must be used.

Both images are open as separate layers within Photoline. The layer with the smaller angle of rotation ( 10 degree ) is selected (marked with a hook).



## 9. CCD's, Cameras, Manufacturers, Software

The given data were collected from technical data sheets of the manufacturer and the manufacturer of the CCD cameras. Due to the many different camera models (Monochrome, Single-shot color, microlens, Anti-Blooming-Gate) not all kind of CCD's are listed. The manufacturers provide many data on their website. Feel free to browse the websites of the manufacturers.

If I wasn't able to determine the exact technical data, nothing is supplied in the table.

### Appendix and tables:

**Table of CCD's:**

Name	Type of CCD	Monochrome / Single-shot color	Number of pixels	Full-well capacity	CCD size in millimeters	Pixel size horizontal x vertical	Spectral response (with microlenses)	Spectral response (no microlenses)	ABG
KAF-0261	Full Frame	Monochrome	512 x 512		10,2 mm x 10,2 mm	20 µm x 20 µm		450 nm, 550 nm, 650 nm: 35%, 55%, 58%	No
KAF-402	Full Frame	Monochrome	768 x 512	100000	6,9 mm x 4,6 mm	9 µm x 9 µm	max: 77% 400 nm: 45%	max: 65% 400 nm: 30%	No
KAF-1001	Full Frame	Monochrome	1024 x 1024		24,6 mm x 24,6 mm	24 µm x 24 µm	450 nm, 550 nm, 650 nm: 40%, 55%, 65%		
KAF-1603	Full Frame	Monochrome	1536 x 1024	100000	13,8 mm x 9,2 mm	9 µm x 9 µm	max: 77% 400 nm: 45%	max: 65% 400 nm: 30%	No
KAF-3200	Full Frame	Monochrome	2184 x 1510	55000	14,85 mm x 10,26 mm	6.8 µm x 6.8 µm	blue=55%, green=70%, red=80%		No
KAF-4301	Full Frame	Monochrome	2048 x 2048			24 µm x 24 µm		450 nm, 550 nm, 650 nm: 40%, 55%, 65%	No
KAF-6303	Full Frame	Monochrome	3072 x 2048	100000	27,65 mm x 18,48 mm	9 µm x 9 µm		450 nm, 550 nm, 650nm: 40%, 52%, 65%	No