

## Optimizing Images of Comets

Bernhard Hubl, 2006-10-30

### 1. INTRODUCTION

One can reach very deep images of deep sky objects, if the telescope is guided onto the stars and if one chooses very long exposure times. The invested exposure time is only restricted by the patience of the photographer.

There are two reasons, why the situation is totally different when imaging comets:

1. Comet structures can severely change in short time intervals. The changes in the comet tail restrict the maximum time interval for images to typically 1 hour. A too long time interval would result in a 'washing out' of comet structures.
2. Comets move fast across the sky. A guiding onto the stars leads to washed out comet structures after a few minutes. It is possible to guide onto the comet. This results in a sharp comet, but at the same time in star trails.

This article describes my personal method of combining many images with short exposure time to create an image with a deep comet and sharp background stars. One example for this method is my image of comet Swan at 2006-10-26 ( [www.astrophoton.com/swan-2.htm](http://www.astrophoton.com/swan-2.htm) ).



Fig. 1 Comet Swan; 2006-10-26; NP101 with ST2000XM; 36 min exposure time

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## 2. CREATION OF RAW IMAGES

### 2.1. Observation Planning

A careful observation planning is the prerequisite for a successful image. The first step is the update of the comet ephemerides using a planetarium software. My personal favourite is Guide8. It is important to know the apparent velocity of the comet. This velocity can be found in the last rows of the info window of Guide8 for comet Swan (Fig. 2). Comet Swan is moving with a velocity of 5.9' per hour = 5.9" per minute. With my equipment (NP101 and ST2000XM) I get a resolution of 2.7" per pixel. I want to guide onto the stars and I allow a washing out of comet structures of 2 pixels. So, my single exposure time should not be longer than 1 minute.

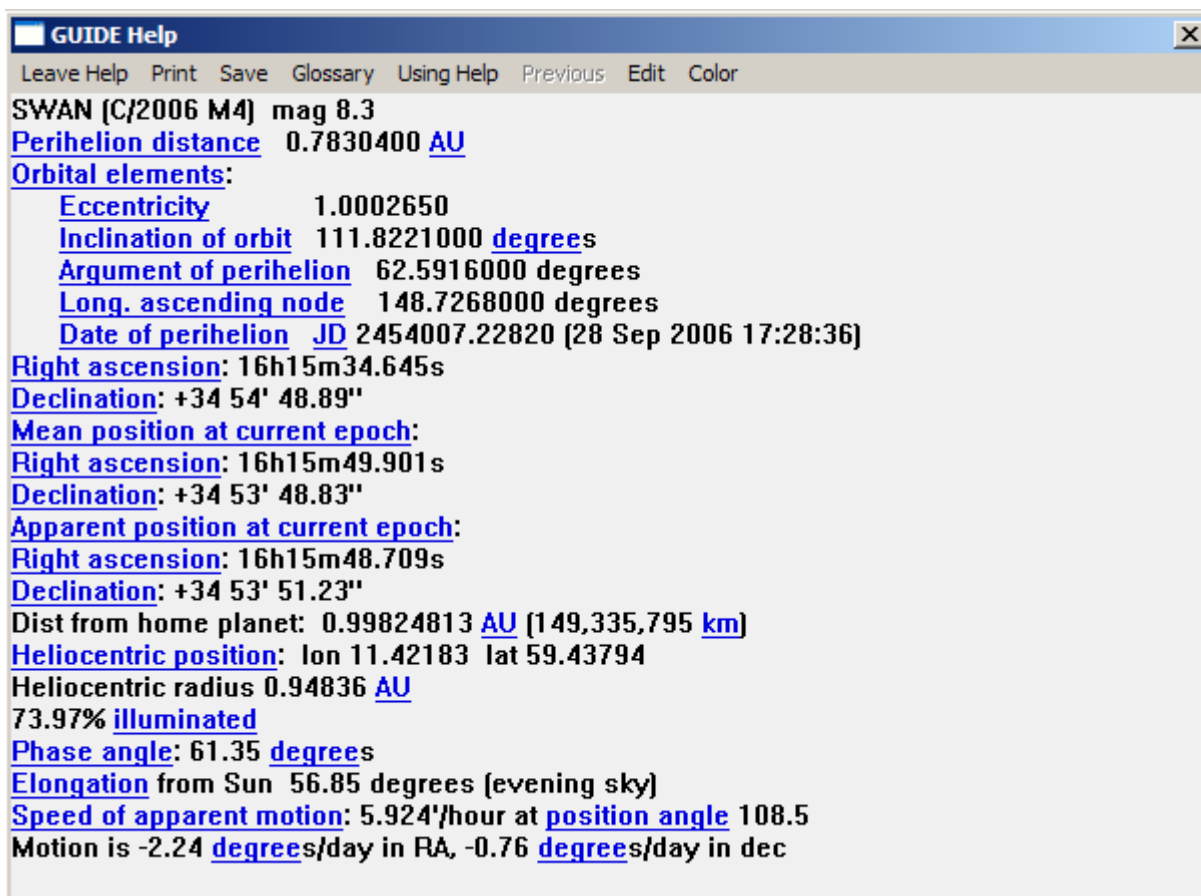


Fig. 2 Info window of Guide8 showing the data of comet Swan

The next step is to analyze the movement of comet Swan within a time interval of one hour. The optimal image framing is chosen (Fig. 3).

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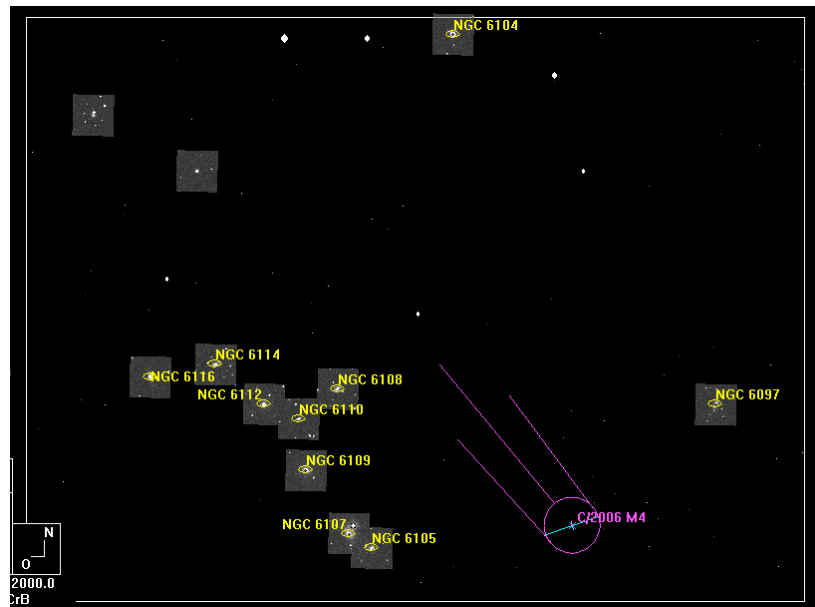


Fig. 3 Framing in Guide8: The white frame indicates the chip size of the ST2000XM camera and the blue line in the head of the comet shows the movement of the comet within one hour.

## 2.2. Determination of the Exposure Times

To get a minimum of washing out of comet details, short exposure times should be chosen. I used an exposure time of 60s with 1x1 binning for the luminance. 2x2 binning makes sense for colour. Because of the weak sensitivity of the ST2000XM chip in red wavelengths, I invested more exposure time in red than in green and blue: R 60s / G 30s / B 30s.

## 2.3. Exposure Sequence

It is very important, that the time interval between two single exposures through the same filter is long: If you register the single exposures to the comet core, then the stars must not overlap!

A monochrome camera with a filter wheel is a big advantage: One can change the filters continuously, so that the time interval between single exposures through the same filter is acceptable.

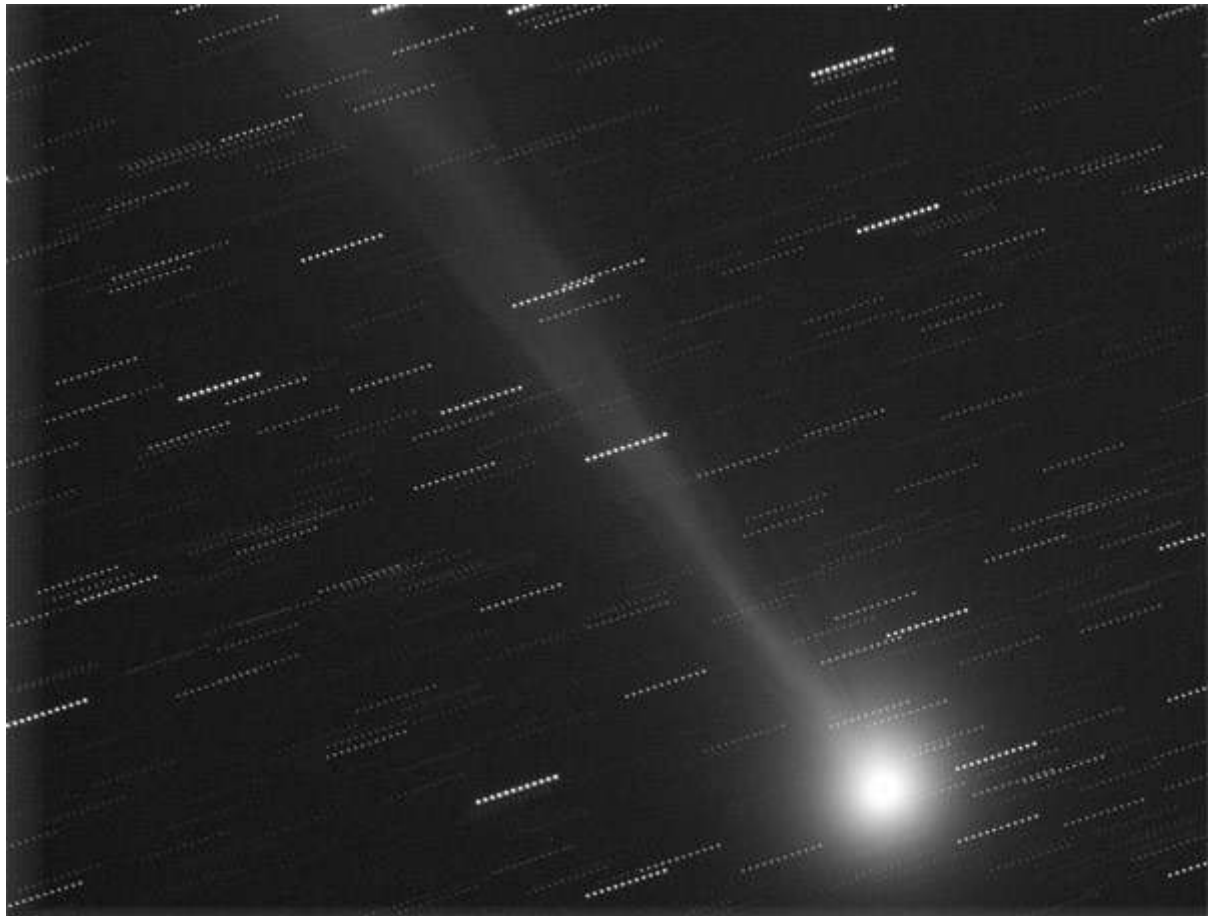
Table 1 shows the exposure sequence, which I had used for the image of comet Swan. The delay times are necessary for proper guiding after changing a filter. One exposure loop requires 4 minutes. A comet motion of 5.9" per minute leads to a shift of the comet between two exposures through the same filter of 24". This big shift results in no overlapping of stars (Fig. 4)

I suggest to do a minimum of 10 loops. The total time interval (starting from first image and ending at last image) should not be longer than 1 hour to prevent severe washing out of comet details because of real changes of the comet.

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**Table 1** Exposure Sequence

Delay	20 s
Exposure Clear	60s, 1x1 Binning
Delay	10 s
Exposure Red	60s, 2x2 Binning
Delay	10 s
Exposure Green	30s, 2x2 Binning
Delay	10 s
Exposure Blue	30 s, 2x2 Binning



**Fig. 4** Simple Mean of 12 Clear exposures; the images are registered to the comet core. The stars do not overlap.

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## 3. IMAGE PROCESSING

### 3.1. Basic Procedure

The raw data are calibrated similar to normal deep sky objects (dark, flat, hot/dark pixel correction).

The calibrated images are used to create two separate images:

1. image, which contains only the comet (no stars)
2. image, which contains only the background stars and the background galaxies (no comet)

Both images are colour weighted with the standard G2 star method:

[www.astrophoton.com/tips/color\\_balance.pdf](http://www.astrophoton.com/tips/color_balance.pdf)

The last step is to combine both images in Photoshop.

### 3.2. Image of the Comet

The single exposures are registered to the comet core. A simple mean combine would result in an image comparable to Fig. 4. The Sigma combine algorithm is necessary to suppress the stars. Sigma combine creates an average of the single images, but pixels, which differ severely from the average, are excluded before doing the average. This method works fine for eliminating satellites, airplanes and cosemics in normal deep sky images. In our case, we want to use Sigma to let the stars disappear. Now, it is clear, why it is so important that stars do not overlap.

My favourite software for sigma combine is CCDSTACK. If you do not use CCDSTACK, than you can use the very good freeware software Sigma, written by Ray Gralak.

After doing the sigma combine of L, R, G and B the LRGB can be built in the same way as for normal deep sky object images (Fig. 5).

### 3.3. Image of the Background Stars

The elimination of the comet is much more difficult. The first step is to register the single exposures to the stars. Sigma combine is no help for removing the comet. So, we use a standard mean combine and get an image with good stars, but a severely washed out comet (Fig. 6).

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Fig. 5 LRGB image, which contains only the comet.



Fig. 6 Image with sharp stars and washed out comet

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Now, we want to remove the washed out comet. This is possible, if we use a careful gradient removal approach.

Photoshop is the best tool for such an operation:

1. Duplicate Layer
2. Filter -> Noise -> Dust & Scratches
  - radius: 8 to 15
  - threshold: 6 to 12
3. Clone Stamp tool, to eliminate remnants of bright stars.
4. Gaussian blur
  - radius: 10 to 15
5. Make top layer invisible and select bottom layer
6. Image -> Apply Image: Subtract blurred image from untouched image



**Fig. 7** Image of background stars after eliminating of washed out comet

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## 3.4. Combine Comet and Background Stars

The best way to combine the comet image with the background stars image is to use the Lighten Mode of Photoshop layers.

Here is the result:

[www.astrophoton.com/swan-2.htm](http://www.astrophoton.com/swan-2.htm)



**Fig. 8 Combined Image**