SkyEye45AC-plus User Manual

Version 1.0
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Please download the latest version from touptek-astro.com.

Contents

1 Description and Features

The SkyEye45AC-plus has a full-frame image sensor, precise temperature regulation and ultra-low readout noise, and is mainly used for deep sky photo shooting. Its extraordinary performance and extensive usage will give you great astrophotography experience.

The features of SkyEye45AC-plus are listed below:

- IMX 366 Color CMOS Sensor
- Resolution: 8192 x 5460
- 4.40 um Square Pixels
- Full Frame (Diagonal 43.3mm)
- 14-bit ADC
- 512 Mbyte Memory
- Precise Temperature Regulation
- G Sensitivity: 356.40mV with 1/30s
- Ultra-Low Noise: 0.88 to 4.46 e- (Low Noise Mode)
- Support Low Noise Mode/ High Frame Rate Mode (15.2 FPS at all Pixel Readout 8 bit)
- Support HCG/LCG mode
- SNR Max: 48.6 dB (Low Noise Mode)
- Dynamic Range: 81.66 dB (Low Noise Mode)
- -32°C below ambient under short exposure/ -38°C under long exposure time(> 1s)

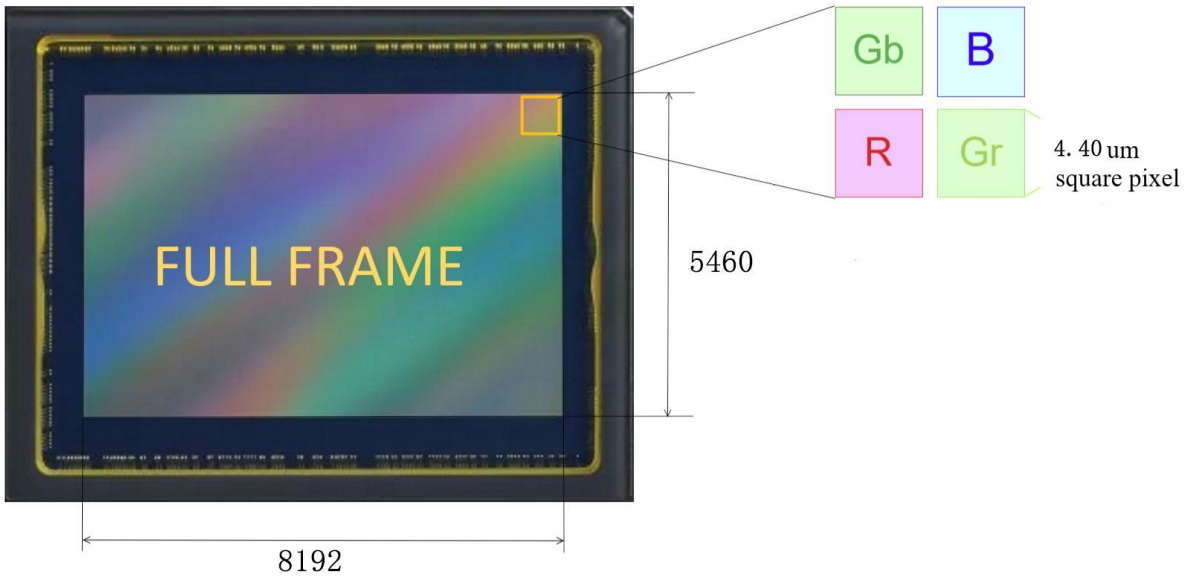

Figure 1 IMX366 Sensor and Its Pixel Structure

2 SkyEye45AC-plus Specifications and Performance

2.1 Camera Specifications

Table 1 SkyEye45AC-plus Technique Specifications.

Item	Specification	
Sensor	Sony IMX366 color sensor	
Diagonal	43.3 mm	
Image Resolution	44.72 mega pixels, 8192 x 5460	
Pixel Size	4.40μm × 4.40μm	
Image Area	36.045mm × 24.024mm	
Max FPS at Resolution (USB 3.0)	14bit	8bit
	4.3 FPS @ 8192*5460 21.2 FPS @ 4096*2160 37.3 FPS @ 2720*1818	8.2 FPS @ 6064*4040 42.2 FPS @ 3024*2012 74.0 FPS @ 2016*1342
Max FPS at Resolution (Low Noise, USB 3.0)	14bit	8bit
	4.1 FPS @ 8192*5460	8.2 FPS @ 8192*5460
Max FPS at Resolution (USB 2.0)	14bit	8bit
	0.2 FPS @ 8192*5460 2.0 FPS @ 4096*2160 4.2 FPS @ 2720*1818	0.5 FPS @ 8192*5460 5.3 FPS @ 4096*2160 8.2 FPS @ 2720*1818
Max FPS at Resolution (Low Noise, USB 2.0)	14bit	8bit
	0.2 FPS @ 8192*5460	0.5 FPS @ 8192*5460
Shutter Type	Rolling shutter	
Exposure Time	0.1ms – 3600s	
Gain	1x – 100x	
SNR	48.6 dB	
Dynamic Range	81.66 dB (Low Noise Mode)	
Read Noise (LCG)	6.03 – 3.57 e-	
Read Noise (HCG)	1.35 - 0.88 e-	
QE Peak	>80%	
Full Well	73ke- (14.9ke- @HCG)	
ADC	14bit	
DDR3 Buffer	512MB (4Gb)	
Connection Port	USB3.0/USB2.0	
Camera Adaptor	M54 × 0.75	
Protect Windows	IR-cut filter	
Spectral Range	380-690nm (with IR-cut filter)	
Capture/Control SDK	Windows/Linux/macOS/Android Multiple Platform SDK(Native C/C++, C#/VB.NET, Python, Java, DirectShow, Twain, etc.);	
Recording System	Still picture and movie	
Camera Dimensions	Diameter 89mm * height 117mm	
Camera Weight	0.785kg	
Back Focus Distance	17.5/12.5mm	
Cooling	Two stage TEC	
Effective Cooling Temp	-32°C below ambient under short exposure/ -38°C under long exposure(> 1s)	
Supported OS	Microsoft® Windows® XP / Vista / 7 / 8 /10 /11(32 & 64 bit) OSx (Mac OS X)	

	Linux

2.2 Sony IMX366 Sensitivity

The sensor G Sensitivity of SkyEye45AC-plus is 356.40mV with 1/30s. Its spectral sensitivity is shown in Figure 2.

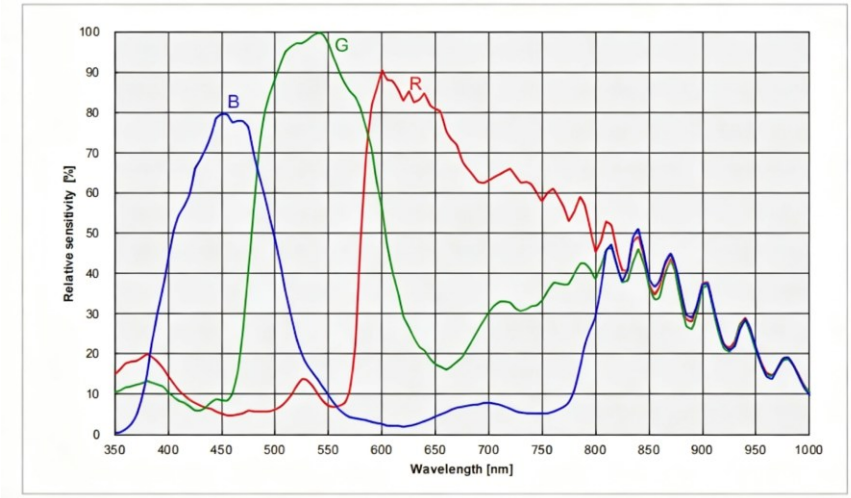

Figure 2 IMX366 Spectral Sensitivity Characteristic

2.3 14bit ADC and ROI

The SkyEye45AC-plus has built in 14bit ADC. It also has 12bit output mode for hardware binning and smaller resolution. The camera also supports hardware ROI, and the smaller the ROI size is, the higher the frame rate is.

Table 2 SkyEye45AC-plus Frame Rate at Different Resolution/Data Bit/Data Transfer (USB3.0/ USB2.0)

Bit & Interface / FPS / Resolution	14Bit ADC		8Bit ADC	
	USB3.0	USB2.0	USB 3.0	USB 2.0
8192*5460	4.3	0.2	8.2	0.5
4096*2160	21.2	2.0	42.2	5.3
2720*1818	37.3	4.2	74.0	8.2
8192*5460 (Low Noise Mode)	4.1	0.2	8.2	0.5

2.4 DDR3 Buffer

SkyEye45AC-plus camera has a 512MB (4Gb) DDR3 buffer, which helps maintain the stability of data transmission, and effectively reduce the amp-glow because image data can be temporarily buffered without being sent hastily to the receiver.

2.5 Binning

The SkyEye45AC-plus supports digital binning from 1x1 to 8x8 in either stacking or averaging method, and hardware binning from 1x1 to 3x3 in averaging method. Hardware pixel binning is much faster than software binning.

2.6 Conversion Gain Switch

SkyEye45AC-plus support HCG and LCG mode switch. With HCG mode on, the read noise can be as low as 0.8 e- at the maximum gain setting.

2.7 Power and Cooling System for Precise Temperature Regulation

The cooling system of SkyEye45AC-plus is two-stage Thermoelectric Cooling (TEC) with controllable electric fan assisting heat dissipation. The working temperature can be regulated to specific number, and effective temperature drop can be -38°C from ambient temperature. Such efficient cooling system guarantees the stability of ultra-low noise mode and quality of the camera image.

The TEC system is controlled by PID algorithm, which allows the TEC to be precisely regulated towards the target temperature with 0.1°C deviation.°

2.8 Camera Performance Analysis

Camera performance can be evaluated with e-/ADU, Read Noise, Full Well and Dynamic Range.

e-/ADU: The sensors found in cameras used for vision applications have pixels that convert incoming photons into electrons. Gain on a CCD/CMOS camera represents the conversion factor from electrons (e-) into digital counts, or Analog-Digital Units (ADUs). Gain is expressed as the number of electrons that get converted into a digital number, or electrons per ADU (e-/ADU).

Read Noise: Read Noise is the most important reference to measure the performance of a camera. Lower read noise usually means better SNR and better quality of image. Read Noise is created within the camera electronics during the readout process as the electrons are subjected to the analog to digital conversion, amplification and processing steps that enable an image to be produced.

Full Well: The electrons are held in each pixel and are converted into electrical charge which can be measured to show the amount of light that has fallen on each pixel. The maximum electrical charge possible is termed "full well capacity". Under the same conditions such as noise and A/D converter quality, the greater full well capacity a sensor has, the wider dynamic range the sensor has. As there is a limit to the depth to which pixels can be made, the full well capacity is often proportional to the frontal area of the light gathering element of the pixel.

Dynamic Range is the ratio between the maximum output signal level and the noise floor at minimum signal amplification (noise floor which is the RMS (root mean square) noise level in a black image). The noise floor of the camera contains sensor readout noise, camera processing noise and the dark current shot noise. Dynamic range represents the camera's ability to display/reproduce the brightest and darkest portions of the image and how many variations in between. This is technically intra-scene dynamic range. Within one image there may be a portion that is in complete black and a portion that is completely saturated.

For the SkyEye series camera, the Gain Value is in xxx% mode. Here xxx is used as the x axis (Gain Value) for the description of the camera performance

$$Rel\ Gain(dB) = 20 * log_{10}[xxx(Gain\ Value)/100]$$

$$xxx(Gain\ Value) = 100 \times 10^{(Rel\ Gain(dB)/20}$$

The read noise of SkyEye45AC-plus is as low as 6.03 - 0.88 e-. It is more impressive that SkyEye45AC-plus comes with Low Noise Mode, which means users could get even lower readout noise by selecting Low Noise Mode.

Camera setting used for HCG performance analysis is shown below:

- Full resolution
- RAW 14-bit mode
- Temperature: -10°C

Table 3 Sensor Analysis Data in HCG Mode

Gain Value	100	177	316	562	1000	1778	3162	5623
Rel Gain (dB)	0.00	4.82	9.93	14.81	19.87	24.77	29.67	34.93
e-/ADU	0.91	0.52	0.29	0.17	0.09	0.05	0.03	0.02
Read Noise (e-)	1.35	1.22	1.13	1.07	1.00	0.98	0.95	0.88
Full Well (ke-)	14.942	8.550	4.761	2.717	1.517	0.862	0.490	0.267
Dynamic Range (stop)	13.43	12.78	12.05	11.32	10.56	9.78	9.02	8.25

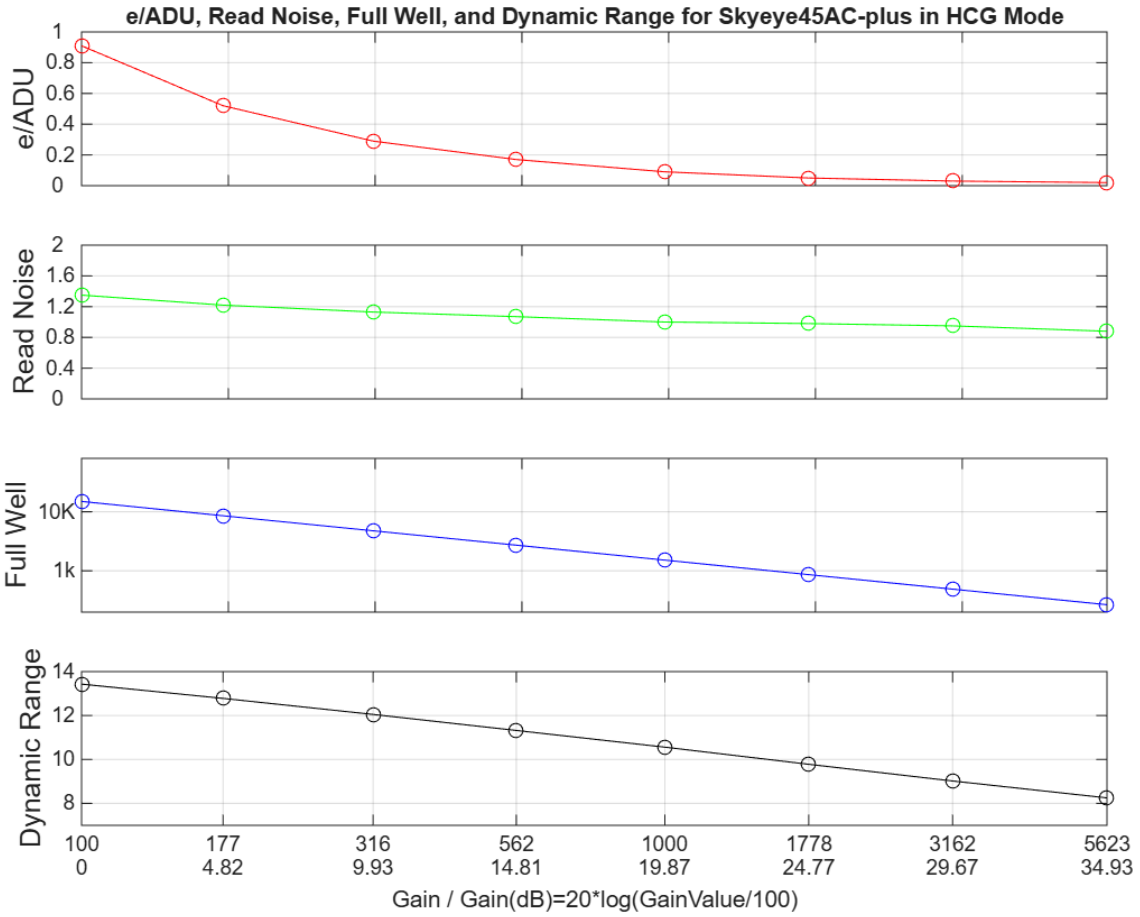

Figure 3 e/ADU, Read Noise, Full Well and Dynamic Range for SkyEye45AC-plus

Camera setting used for LCG performance analysis is shown below:

- Full resolution
- RAW 14-bit mode
- Temperature: -10°C

Table 4 Sensor Analysis Data in LCG Mode

Gain Value	100	177	316	562	1000	1778	3162	5623
Rel Gain (dB)	0.00	4.98	9.92	14.99	19.88	24.97	29.92	35.97
e-/ADU	4.46	2.51	1.42	0.79	0.45	0.25	0.14	0.08
Read Noise (e-)	6.03	5.24	4.82	4.43	4.17	3.94	3.77	3.57
Full Well (ke-)	73.019	41.139	23.292	13.000	7.404	4.118	2.330	1.303
Dynamic Range (stop)	13.56	12.94	12.24	11.52	10.79	10.03	9.27	8.51

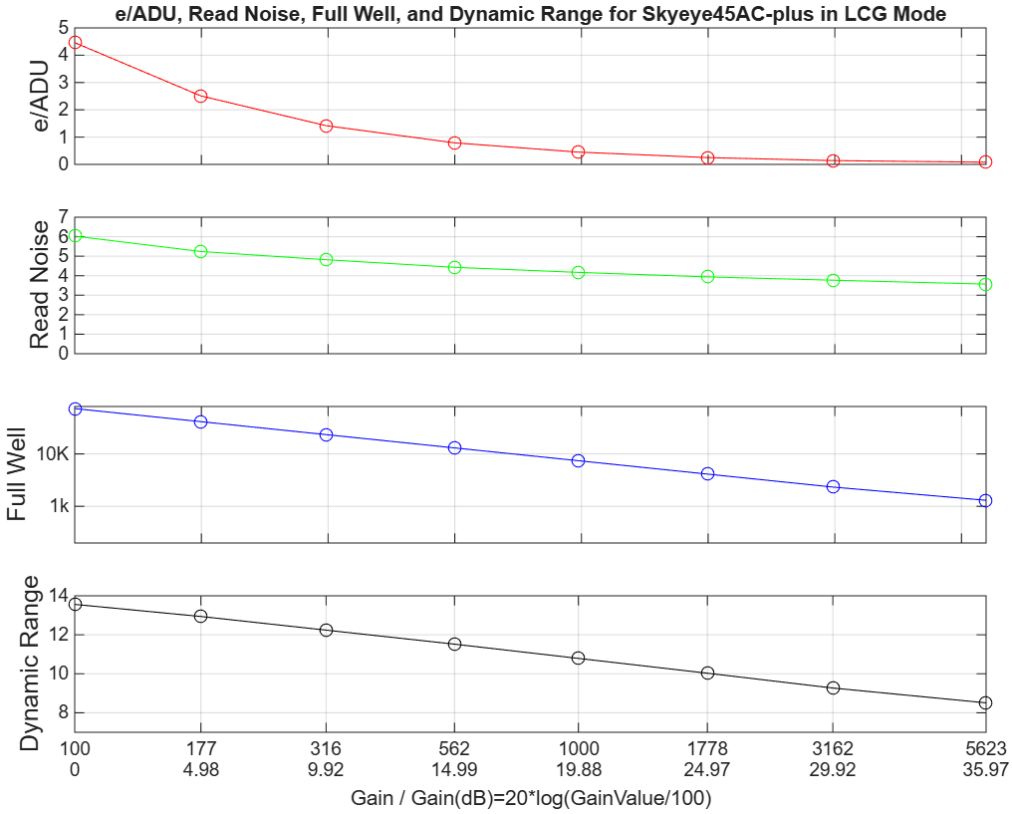

Figure 4 e/ADU, Read Noise, Full Well and Dynamic Range for SkyEye45AC-plus

3 Product Package and Connections

3.1 Packing List

Figure 5 Packing Information of SkyEye45AC-plus

Table 5 SkyEye45AC-plus Packing List

Standard Package	
A	3-A safety equipment case: L:26.2cm W:24.0cm H:12.4cm (1pcs, 3.9Kg/box)
B	SkyEye series camera (M54Fx0.75 mount)
C	Power adapter: input: AC 100~240V 50Hz/60Hz, output: DC 12V 3A
D	High-Speed USB3.0 A male to B male gold-plated connectors cable (1.5m)
E	CD (driver and utility software, Ø12cm)
F	Hex wrench H 2.0
G	M54M-M48F 21mm extender
H	M48M-M48F 16.5mm extender
I	M48M-M42F adapter

3.2 Camera Dimension and Its Mount

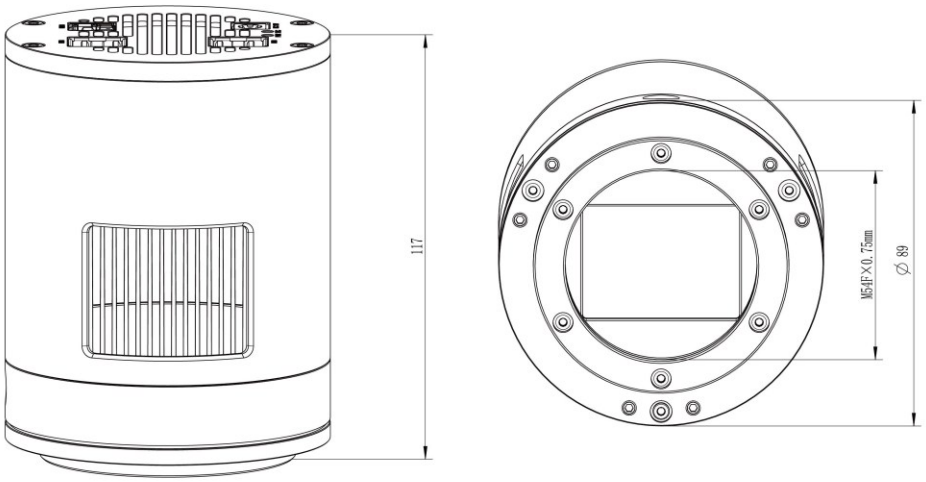

Figure 6 Dimension and Mount of SkyEye45AC-plus

Table 6 Dimension and Mount of SkyEye45AC-plus

Item	Specification
Diameter	∅89mm
Height	117mm
Mount	M54Fx0.75mm

3.3 Camera Outline and Interface

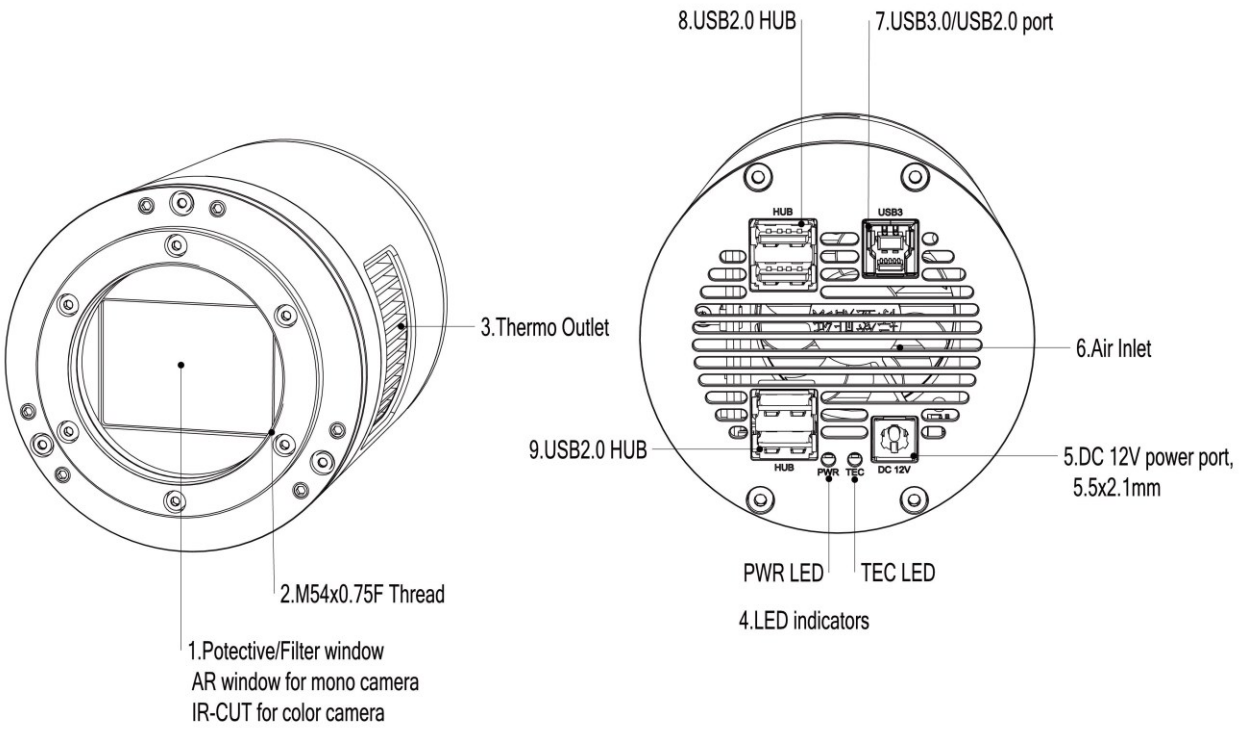

Figure 7 Camera Outline and Interface.

Table 7 Camera Outline and Interface List

Item	Specification
1	Protective window: 43 * 31 * 1.1mm, AR window for mono camera, IR-cut filter for color camera
2	M54F x 0.75 thread×
3	Thermo outlet or radiator
4	LED indicators: 1) Power LED. 2) TEC LED.
5	DC 12V 5A power port, 5.5 x 2.1mm
6	Air inlet
7	USB 3.0/ USB 2.0 port (for connecting to a computer or astronomy smart controller)
8	USB HUB (includes two USB2.0 ports)
9	USB HUB (includes two USB2.0 ports)

3.4 Camera Mechanical Connection with Adapter

The SkyEye45AC-plus can be connected to a telescope with a proper adapter, or the camera lens. The most common adapters are already included in the package, but we also provide some specific adapters based on the requirement.

The M54 internal-thread flange has a double-layer structure with thicknesses of 4.5mm/5mm respectively, i.e. the back focus distance occupied by the camera body is 8mm; with only the base M54 internal-thread flange installed, the camera occupies 12.5mm of back focus distance; with the double-layer M54 internal-thread flange installed, the camera occupies 17.5mm of back focus distance. With the double-layer flange connected, users can use the 21mm and 16.5mm extenders included in the package to reach a back focus distance of 55mm. Please refer to Figure 10 for more details.

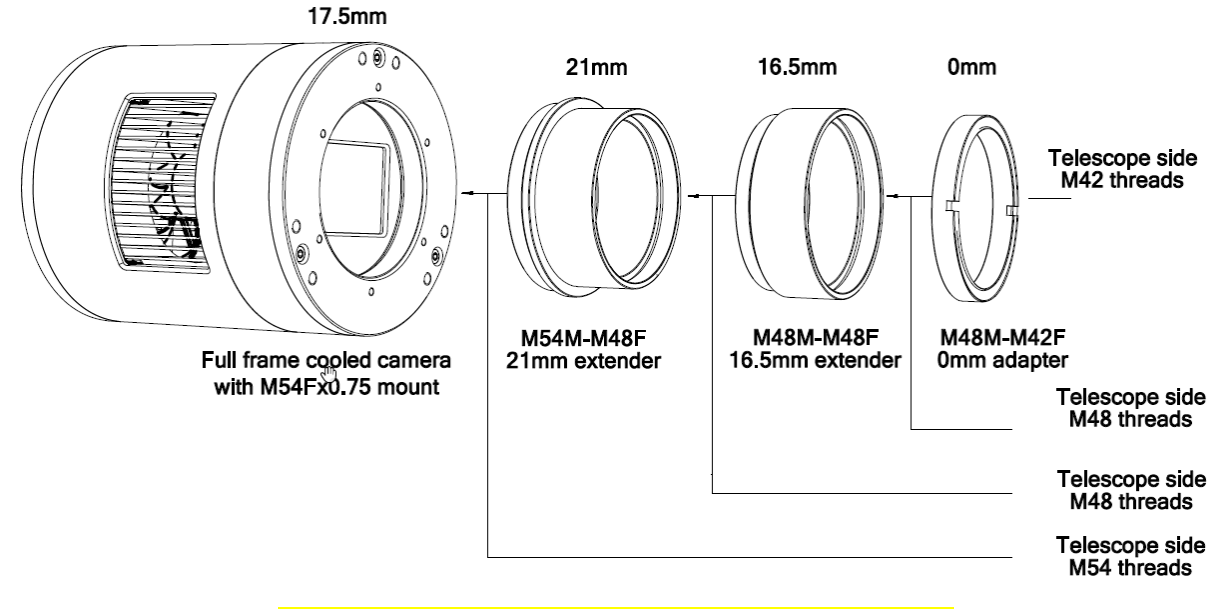

Figure 8 The Connection of the SkyEye Camera and Adapter

Table 8 Camera and Its Adapter Connections

Item	Specification
Back focus distance occupied by camera body	8mm
Back focus distance with the base M54 internal-thread flange installed	8+4.5=12.5mm
Back focus distance with the double-layer M54 internal-thread flange installed	8+4.5+5=17.5mm
M54M-M54F 21mm extender	For telescope with M54M x 0.75 thread
M54M-M54F 16.5mm extender	For telescope with M54M x 0.75 thread
M54M-M48F 0mm adapter	For telescope with M48M x 0.75 thread

3.5 Camera Mechanical Connection with Lens

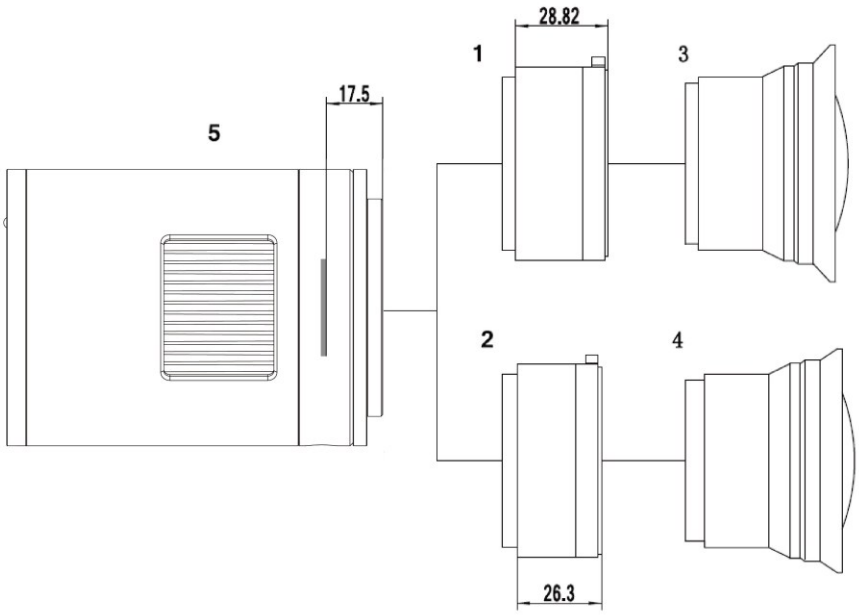

Figure 9 Nikon /Canon Lens with SkyEye Camera

Table 9 Camera and Lens Connection

Item	Specification
1	Nikon F-M54 adapter
2	EOS EF-M54 adapter
3	Nikon F-mount lens
4	Canon EF-mount lens
5	SkyEye camera with M54Fx0.75 mount

3.6 Camera Tilt Adjustment

The SkyEye45AC-plus is able to adjust the tilt of the sensor plane. There are three sets of screws for adjusting the image sensor tilt so that it is parallel to the telescope's primary mirror; each set has one screw for pulling back and one for pushing forward.

Please refer to the following:

Table 10 Camera Tilt Adjustment

Step	Operation
1	Capture an image with stars and analyze it with professional software such as Siril, CCDInspector or ASTAP. Users can easily find the tilted part of the sensor plane in the image and then adjust one or more sets of screws on the camera flange according to the analysis results to complete the tilt adjustment of the image sensor.
2	After one tilt adjustment, capture another image and compare it with the previously captured image in the corresponding software. If the tilt is reduced, the previous adjustment was correct; otherwise, the previous adjustment was wrong.
3	Repeat the operation in Step 2 until the star shape at the edge of the image reaches its best condition.

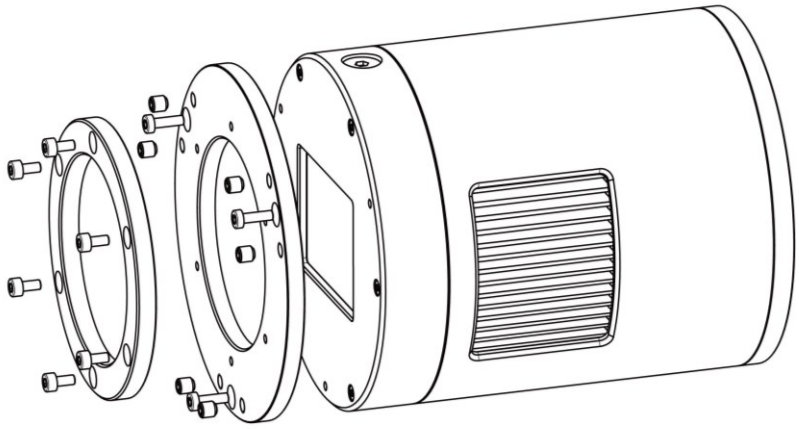

Figure 10 Tilt Adjustment

3.7 Camera Electric Connection with Accessories

On the back side of SkyEye45AC-plus, there are 3 connection ports: DC 12V/5A power port, USB3.0/ USB2.0 port and USB-HUB.

Due to the significantly larger power consumption of IMX366, SkyEye45AC-plus (including the cooling system) is now booted up only by 12V/5A power supply. USB3.0 no longer works as a power source but only as a data communication method. The USB-HUB provides connection with other devices, which allows user to avoid the mess of cable management. Once another device is connected through the USB-HUB, it will be connected to PC device through the USB3.0/USB2.0 port.

Table 11 Camera Electric Connection

Item	Specification
USB3.0/USB2.0 Port	To computer with USB3.0/USB2.0 cable
USB HUB for Accessories	To filter wheel with USB2.0 cable
	To guiding camera with USB 2.0 cable
	To electronic focuser with USB 2.0 cable
	To other devices with USB 2.0 cable
Power Port	DC12V/5A

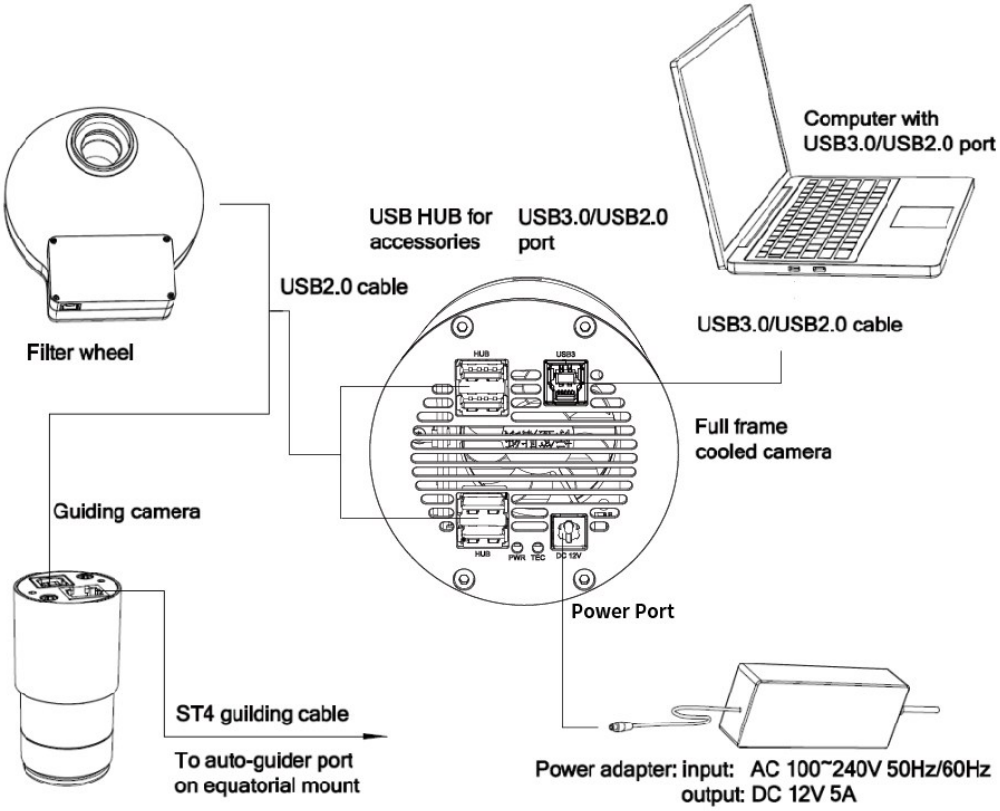

Figure 11 Camera Electric Connection

4 SkyEye45AC-plus and Its Software

4.1 Application Installation

For software, customers are welcomed to go to our software website: https://touptek-astro.com/downloads/, to download the latest ToupSky. The SkyEye series camera can also be used with ASCOM, DirectShow SDK. If the third-party software is compatible with these SDK, customers can also download the software driver from our website and install the drivers into the third-party software.

ToupSky is ToupTek astronomy camera's Windows application. ToupSky is a professional software integrated with camera control, image capture & process, image browse, and analysis functions. ToupSky is born with the following features:

Windows:

- x86: XP SP3 or above; CPU supports SSE2 instruction set or above
- x64: Win7 or above

Features

- Full control of the camera
- Trigger mode and video mode support (raw format or RGB format)
- Automatic capture and quick record function
- Multi-language support
- Hardware ROI and digital binning function
- Extensive image processing functions, like image stitching, live stacking, flat field correction, dark field correction, etc.

Supported Camera:

- All ToupTek astronomy cameras

4.1.1 User-friendly UI Design

- Well-arranged menus and toolbars ensure quick operating;
- The unique design of 3 sidebars -- Camera, Folders, Undo/Redo are orderly classified;
- Convenient operating method (Double click or right-click context menu) as much as possible;
- Detailed help manual;

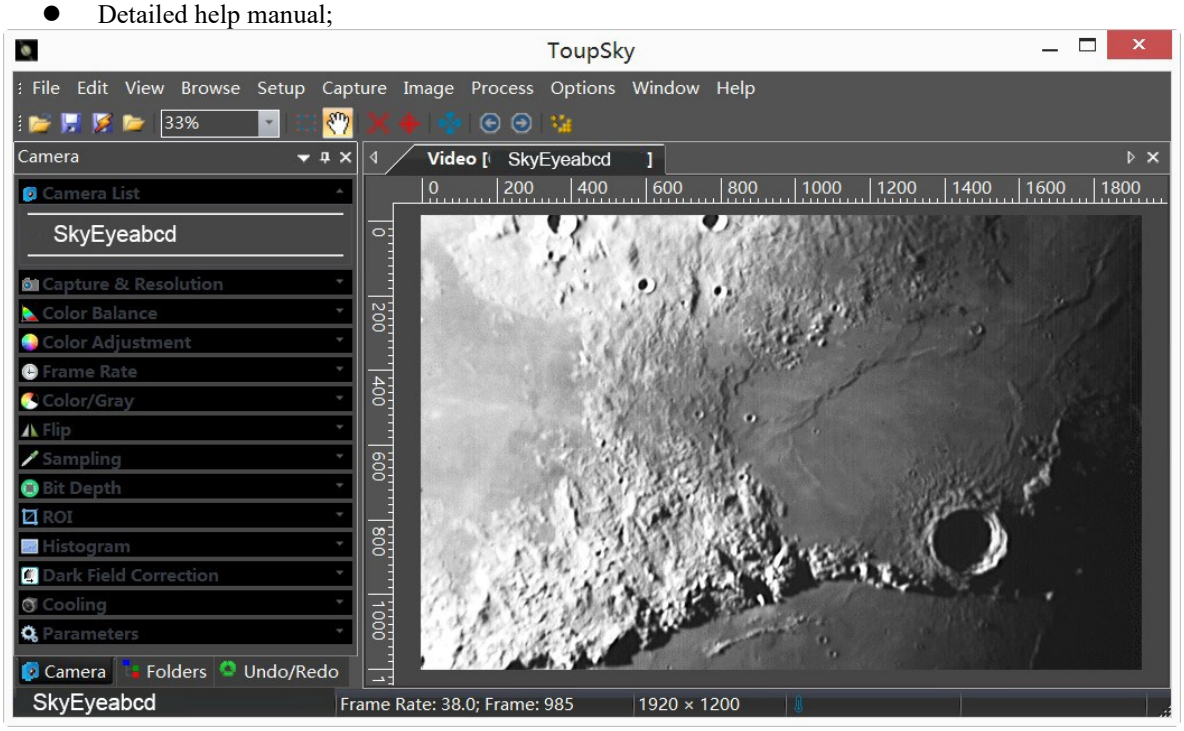

Figure 12 ToupSky and Its Video Window

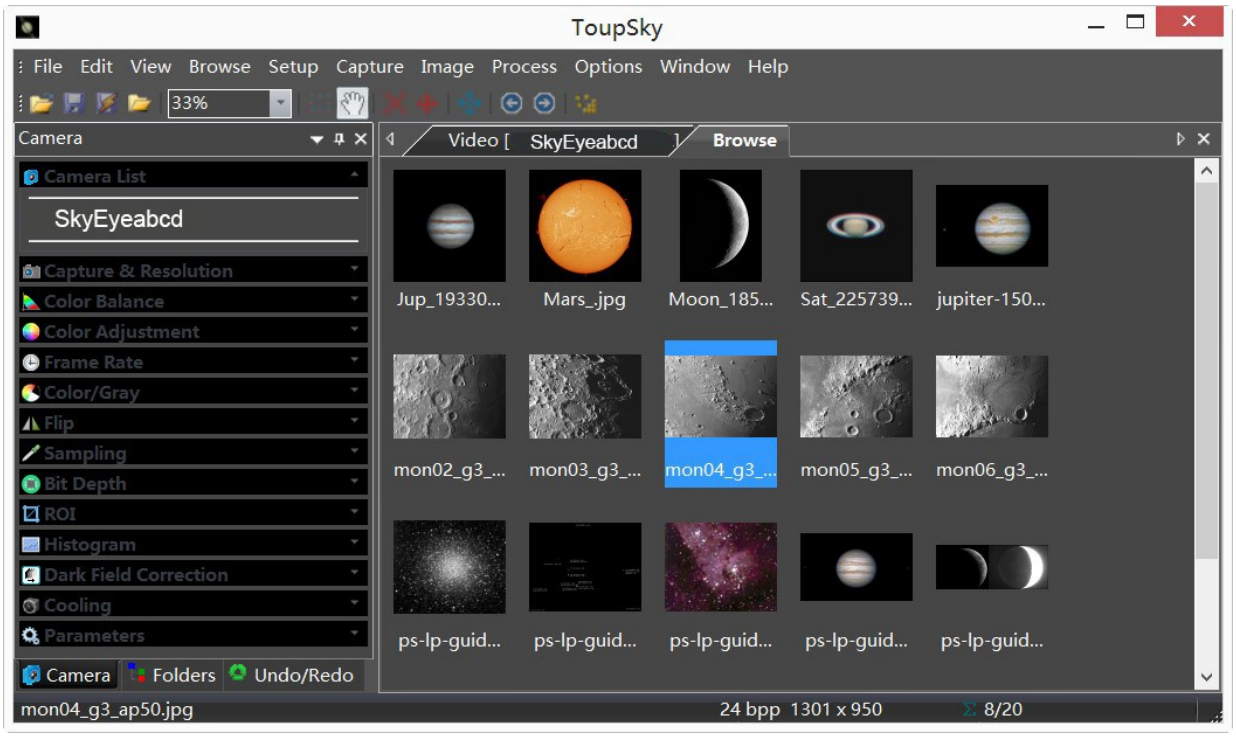

Figure 13 ToupSky and Its Browse Window

4.1.2 Professional Camera Control Panel

Capture & Resolution	Set the live and snap resolution and snap the image or record video;
Exposure & Gain	Auto exposure (exposure target preset) and manual exposure (exposure time can be inputted manually); Up to 5 times gain;
Color Balance	Advanced single-click intelligent white balance setting, temperature and tint can be manually adjusted;
Color Adjustment	Hue, saturation, brightness, contrast, gamma initialization adjustment;
Frame Rate	Adjustment of frame rate available for different computer configurations;
Flip	Check the "horizontal" or "vertical" option to correct the sample direction;
Sampling	Bin mode can obtain low noise video stream; Skip mode obtains sharper and smoother video stream. Support video stream histogram extension, Negative and positive switching, Gray calibration, Clarity factor for focusing etc.
Bit Depth	Switch between 8 bits and 12 bits. 8 bits is the basic Windows image format. 12bits will have higher image quality but moderate FPS.
ROI	ROI, Region of interest. This function can set the ROI on the video window. When the ROI group was expanded, a dotted rectangle with "Handles" will appear around the video window that will let you alter the ROI. Use mouse button to adjust the ROI size. If ROI is ok, click Apply will set the video to ROI size, Defaults will return to the original size.
Dark Field Correction	To Enable the Dark Field Correction, one should capture the dark field image first. After the images are captured, the Enable button will be clickable. Checking the Enable button will enable the Dark Field correction. Unchecking it will disable the Dark Field Correction.
Cooling	Set the TE-Cooling target temperature and set the fan On/Off;
Parameters	Load, save, overwrite, import, export self-defined parameters of camera control panel (including calibration information, exposure and color setting information);

4.1.3 Practical Functions with Good Results

Video functions	Various professional functions: Video broadcast; Time lapse capture; Video record; Video stream grid; Image stitch; Video scale bar, date etc.
Image Processing and Enhancement	Control and adjust image by denoise, sharpen, color toning deinterlace, all kinds of filtering algorithm and mathematical morphology algorithm, range, binary, pseudo color, surface plot and line profile ital..
Image Stacking	Image stacking adopts advanced image matching technology. With the recorded video, regardless of shifting, rotation, scaling, the high-fidelity image can be stacked to decrease the image noise.

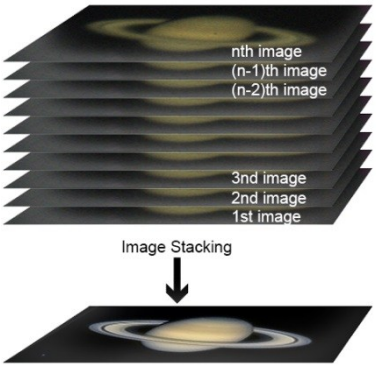

Figure 14 Image Stacking

4.1.4 Powerful Compatibility

Video Interface	Support Twain, DirectShow, SDK Package (Native C++、C#/VB.NET)
Operating System	Compatible with Microsoft® Windows® XP / Vista / 7 / 8 /10 (32 & 64 bit), Mac OSX, Linux
Language Support	Unlimited language support, currently available in Simplified Chinese, Traditional Chinese, English, Russian, German, French, Polish and Turkish

4.1.5 Hardware Requirement

PC Requirements	CPU: Intel Core 2 2.8GHz or higher
	Memory: 2GB or more
	USB port: USB3.0/USB2.0 port
	Display: 17" or larger
	CD-ROM

4.2 SkyEye45AC-plus and Dshow

ToupTekDshowAstroSetup (Click the left blue link to download)

DshowAstro is an interface driver providing Dshow standard support for ToupTek USB astronomy camera

Supported OS: Windows:

- x86: XP SP3 or above; CPU supports SSE2 instruction set or above
- x64: Win7 or above

Supported Camera:

- All ToupTek astronomy cameras

4.3 SkyEye45AC-plus and the 3rd Party Software

4.3.1 Support Software

No.	Software	Version	WDM	ASCOM	Native
1	PHD Guiding	2.3.0(2014)	√	√	√
2	Nebulosity	3.2.2(2014)	√	×	/
3	MaxIm DL	5.23(2013)	√	×	/
4	SharpCap	2.1(2014)	√	×	/
5	MetaGuide	5.2.0(2014)	√	/	/
6	FireCapture	2.4.05(2014)	√	/	/
7	Astroart	5.0(2014)	√	×	/

4.3.2 ASCOM Platform

All AstroCam telescope camera drivers request to install ASCOM platform, free.

http://www.ascom-standards.org/index.htm

You can download the ASCOM package from: http://ascom-standards.org/Downloads/Index.htm

4.3.3 PHD Guiding

A popular free guide software: http://openphdguiding.org/

ToupTek's telescope camera support Native/ASCOM/WDM driver to run the video.

4.3.4 Nebulosity

A popular cooled camera control/image process software directly supported via ASCOM.

4.3.5 MetaGuide

Autoguiding software with novel method to avoid the atmospheric agitation. The latest version support GCMOS01200KPB and the guide port: http://www.astrogeeks.com/Bliss/MetaGuide/

4.3.6 MAXIMDL

Famous full functional CCD Control/Image Process software. Popular used in US.

4.3.7 AstroArt

Famous full functional CCD Control/Image Process software. Popular used in Europe.

4.3.8 FireCapture

Great free planetary capture software. Support part of AstroCam series telescope camera.

4.3.9 SharpCAP

A nice free planetary capture software support WDM cameras includes AstroCam series telescope camera.

4.3.10 Registax

A popular free planetary stacking and processing software.

4.3.11 AstroStack

A planetary stacking and process software.

4.3.12 DeepSky Stacker

A free deep sky image stack and process software.

5 FAQ

The IMX366 image sensor may show uneven, horizontally decreasing shading in the image. Sony states that the IMX366 image sensor can keep the horizontal dark shading below 4.5 LSB. This characteristic may have three causes:

First, due to the full-frame sensor size, its internal circuit logic is more complex, which makes it more difficult to supply the same amount of power. In this case, based on the large size of the full-frame sensor, Sony has determined after evaluation that this characteristic, within the range of 4.5 LSB, does not affect image quality. Therefore, the yield of the image sensor and mass production on the assembly line can be guaranteed.

Second, due to the limitations of semiconductor manufacturing equipment, image sensors larger than APS-C format are divided into two or more regions for the exposure process, which inevitably causes a step difference in pin positions between the two differently exposed regions, and this is the main reason why horizontal dark shading is more obvious on large-format sensors.

Third, due to different production batches, although the parameters of the image sensors are all within the preset range, there will still be certain differences.

6 Service

For software upgrades, please refer to "Download" on our official website: https://touptek-astro.com//

For customers who purchase the cameras from local dealer, please contact your dealer for more inquiry.

For technical support, please contact e-mail address: astro@touptek.com.