

# Photographing and Measuring Double Stars with Unconventional Imagers

Rod Mollise

Department of Physics  
University of South, Alabama  
Mobile, Alabama  
rmollise@hotmail.com

**Abstract:** This is the first article in a 3 part series about using electronic imagers for double star observations.

Over the last forty years since astrophotography became a popular pastime for rank and file amateur astronomers, observers bitten by the imaging bug have challenged and conquered subjects as difficult and diverse as microfine detail on Jupiter and gravitationally lensed quasars. There is one type of object that's seldom been photographed, though, double and multiple stars. Strange as it seems, here at the dawn of the 21<sup>st</sup> century, it's still more common to see a pencil drawing of, say, Albireo, than a photo or an electronic image.

Why? A couple of reasons. Most importantly, imaging double stars, even fairly widely separated double stars, is not easy. "Not easy?" you ask. "What could be simpler than taking a picture of a *star*?" Actually, getting a good image of even a bright single star is not as simple as you'd think, and making a recognizable portrait of a fairly close double is orders of magnitude more difficult.

There's also no denying that the lack of double star images has something to do with a lack of interest in double stars. Even those of us who've been wild about multiples since Mizar was first pointed out to us must admit most of our brother and sister amateur (and professional) observers consider doubles a ho-hum part of the astronomy game. There is definitely a trend back to observing doubles now, however. The continuing growth of light pollution has seen to that. The easy availability of high quality, reasonably priced optics hasn't hurt either.

The large growth in interest in doubles over the last few years has brought some experienced deep sky astrophotographers into our little fold, and, naturally, some of these talented amateurs have started thinking about taking pictures of the special stars that are their new passion. Even accomplished astrophotogra-

phers, however, are often surprised to find that producing a good image of a double is considerably harder than getting a good shot of a dim NGC galaxy.

The first challenge for the aspiring double star imager is tracking. Most low – medium cost equatorial mounts must be painstakingly guided if an exposure is to be longer than about 30 seconds. Otherwise, stars trail. This makes for an unattractive image of a single star and an often valueless image of a double. If the trailing is so bad that you can't make out a dim comes, you've wasted your time.

The unavoidable tracking errors of equatorial mounts are further exacerbated by another fact of double star imaging life: you usually can't shoot at prime focus, even with fairly long focal length instruments. At  $f/10$ , few close doubles will be well split on 35mm film. Be prepared to deal with very slow focal ratios from  $f/20$  up to  $f/35$  and beyond. You'll need to increase the focal ratio of a 2000mm  $f/10$  Schmidt Cassegrain, for example, to at least twice its value by means of eyepiece projection. This large image scale does help split stars, but also, unfortunately, magnifies the smallest mount/drive/guiding errors.

As if things weren't difficult enough, there's also the seeing problem. When you increase the "magnification" of your telescope by extending its focal ratio to  $f/20$ ,  $f/30$ , or higher, you also increase problems with seeing. At 2000mm of focal length, a star may look pretty good. Run that up to 6500mm and it looks more like a blob than a star. The obvious way to keep stars looking like stars in turbulent conditions is to reduce exposure time as much as possible to minimize the seeing induced "dancing" and "wavering" of star disks. Unfortunately, a short enough exposure to minimize seeing problems (and tracking errors), may yield an underexposed frame at large focal ratios.

## Photographing and Measuring Double Stars with Unconventional Imagers

When you're ready to move on to imaging dim pairs, this becomes a brick-wall type of limitation unless you can throw considerable aperture at the problem.

What would be the characteristics of the perfect "double star camera?" It would deliver large scale images without the need for vibration inducing eyepiece projection adapters. It would be sensitive enough to allow short exposures at high focal ratios. Color would be nice, too. And it would also be wonderful if this imager were equipped with adaptive optics to keep seeing problems under control when the atmosphere doesn't want to cooperate.

It would seem that all these requirements are met by the integrating CCD cameras now easily available to amateurs. Indeed, most amateur cameras fulfill our first two requirements. Except for top of the line models, the chips in most SBIG and Starlight Xpress cameras (the two most popular vendors of amateur CCD cams) are small enough to produce a large image scale without recourse to eyepiece projection. Usually a 3x Barlow or TeleVue Powermate in the image train is more than sufficient.

Integrating CCD cameras are sensitive, too, with equivalent ISO values running into the tens of thousands. This sensitivity means the double star imager can easily remain below the "30 second limit" of less expensive mounts, with a second or two of exposure—at most—being sufficient to reveal surprisingly dim stars.

So the multiple star imager should choose an ST7 or an MX516? *Not necessarily.* Conventional CCD cameras do not meet *all* our needs well or cheaply. One fly in the ointment is expense. Even the reasonably priced cameras command substantially more than 1000 US\$. Color? While there are some "one shot" color cameras on the market, they are fairly expensive and often less sensitive than cheaper monochrome cams. The usual avenue for obtaining color images from a standard CCD camera is with tri-color imaging—one filtered exposure for red, one for green, one for blue, and often a luminance image, to boot. That's a real problem for multiple star picture-taking, where it's often necessary to image quickly in hopes of overcoming poor seeing. Adaptive optics? Forget *that* unless you have *very* deep pockets.

What if I told you you could put together a nearly perfect multiple star imaging system for as little as 100 – 150 US\$? One that not only delivers a perfect image scale for doubles, but one which features built-in adaptive optics, one shot color, and good sensitivity? Would you get excited? A hundred bucks still too

steep? How about an imaging camera for 50 US\$ from Ebay?

No, I'm not kidding. I'm talking webcams (see Figure 1), of course. Webcams, those little video conferencing devices that connect to your PC via a USB connection, have been used in astronomy for nearly a decade now. Webcams have taken excellent pictures of everything from Neptune to the Crab Nebula, and they are simply wonderful on double stars.

Believe it or not, a Toucam or a Quickcam is not simply a compromise for those of us who can't afford an SBIG ST10. Webcams are actually better for double imaging than the fanciest and most expensive "astronomy cameras." They have some characteristics that make them ideal for our use. Webcams possess very small chips, in the ¼ inch range usually, that produce nice, large image scales just right for resolving doubles. You want color? You want to see Admiral Smyth's "emeralds" and "lilacs" in your pictures? No problem. All current webcams are one-shot color imag-



Figure 1: Three different webcams.

ers. Adaptive optics? Gotcha covered. The way amateurs use their webcams for celestial imaging—taking many (sometimes thousands) of frames of an object and picking and stacking the best of these frames to form a final still image—means that for all intents and purposes the humble webcam has *built-in adaptive optics*.

So you should run to the Wal-Mart or ASDA and grab a webcam, any webcam? Slow down just a minute. Some cams are better for astronomical purposes than others. The biggest difference among the numerous webcams sitting on the shelves is their sensors.

## Photographing and Measuring Double Stars with Unconventional Imagers

Many now have CMOS chips rather than CCDs. CCDs are much more desirable for astronomical use because they are more sensitive and noise free. Currently, the most popular and best webcams for astronomical use are the Toucam Pro from Phillips and the Quickcam Pro 4000 from Logitech, both of which are equipped with CCD chips. The Toucam is a particularly good choice, but until recently was not easy to obtain in the U.S. Luckily, it is now available from many astronomy dealers, often as a package deal with a 1.25" eyepiece adapter in place of its standard lens (webcams are always inserted directly into a telescope focuser without their lenses by means a commercial or homemade 1.25" adapter).

Unlike a digital SLR or a video camera, a webcam *must* be used with a computer. What kind of computer? In order to run a webcam at the recommended (for astronomy) speed of 10 video frames per second, you'll need a computer with a Pentium processor with a speed of about 500mhz, quite modest by today's standards. The computer will connect to the webcam via USB. If you are using an older machine without USB capability, add-on USB ports are dirt cheap for desktop PCs and relatively inexpensive for laptops. Don't bother to invest in USB 2.0. Every webcam currently for sale uses USB 1.1. Hard drive? The bigger the better. The .avi files that webcams produce take up lots of disk space.

Do you have to own a laptop computer to do webcam imaging? This is an important question. While laptops are dropping in price, they are still more expensive than desktops. The answer? Absolutely not. I used an older desktop for all my webcamming for years. Since you can image doubles from the most badly light polluted areas, there's no need to haul everything to a remote dark site, so a laptop, while convenient, is not a necessity. Set your desktop on a sturdy table in the backyard or on the deck or patio and image away. The only hassle is carrying a processor, monitor, and keyboard outside in addition to the telescope.

Naturally, you'll need software to run on this PC. All webcams come with a CD (sometimes CDs) full of imaging software. In addition to the drivers needed to allow your computer to talk to the camera, you'll find camera control and image processing programs on these disks. Unfortunately, you will also find that these applications aren't really optimum for astronomy use. They're pretty barebones and are designed to help you shoot well-lit moving images of your Aunt Petunia, not Gamma Virginis. Luckily, thanks to the

efforts of the amateur astronomy webcam community, there is plenty of excellent astronomy-oriented software available to operate your camera.

If you're using a PC, the preeminent camera control software is *K3CCD Tools*. This program, shown in Figure 2, will operate almost any webcam using the drivers provided with the camera. While "K3" is suitable for anything from planetary imaging to deep sky picture taking, it is particularly nice for double star shooting. In addition to such niceties as brightness level indicators, automatic image stacking, and basic image processing tools, it includes the ability to accurately measure position angles and separations of double stars, something I'll talk about in Part III of this series. *K3CCD Tools* is available in both shareware and freeware versions. The shareware version has many more features than the freeware edition, and, at the modest price of about 40 US\$, is highly recommended.

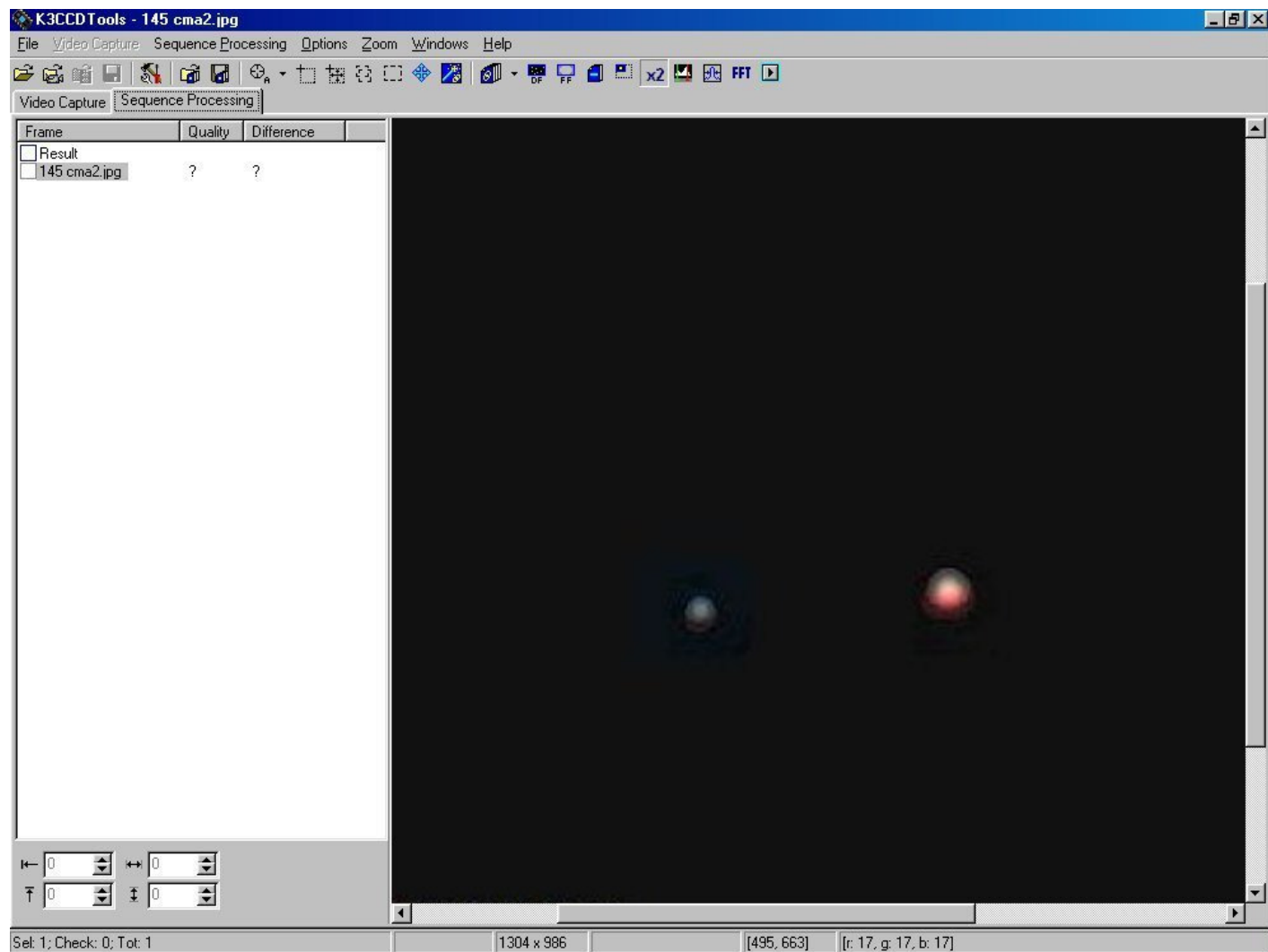
Don't like PCs? Apple all the way? There are now several astronomy-oriented Apple apps available. One of the best is the freeware *Keith's Astroimager*. This OS X program will do most of the things for Apple users that K3 can do for the Windows crew.

Once you've got a camera, a computer and some software, you're ready to go equipment-wise? Well, maybe. Let's set up for a double imaging run and see what else suggests itself. The first thing you'll notice, I guarantee, is that I'm not kidding when I say that the small chips of webcams produce highly magnified images that cover a very small area of the sky. Even if you use a goto scope, you may find it extremely difficult to get even a prominent star centered on the screen of your monitor.

You can deal with this "framing problem" the hard way or the easy way. "The hard way" is carefully centering the target star in the field of a high power eyepiece (a crosshair reticle eyepiece for best results), gently removing the eyepiece, and replacing the camera. If you can make the eyepiece parfocal with the camera by means of a "parfocal ring" (available from most astrophotography equipment vendors) or eyepiece extension tubes, your task will be easier, but still quite difficult at first.

The best solution? In my opinion, a *flip mirror*. As the name indicates, the main feature of this device is a mirror that can be "flipped" up or down with a knob or lever. The flip mirror is placed in the imaging train just ahead of the camera. With the mirror flipped "down," light from the scope goes to the camera. In the "up" position, light goes to an eyepiece inserted into a

## Photographing and Measuring Double Stars with Unconventional Imagers



**Figure 2:** Screen shot from K3CCDTools showing image of Beta Cygnii

focuser on the top of the flip mirror (if you've used an off axis guider, the arrangement is similar). Center a double star in the flip mirror eyepiece, flip the mirror down, and the double is "automatically" in the webcam's field. A new Meade 644 flip mirror for Schmidt Cassegrains can be had for 150 US\$ new, money well spent. These devices are also available for Newtonians, though they may cause problems there due to back-focus requirements.

One telescope related question I'm sometimes asked is, "Can an undriven Dobsonian telescope be used for webcam imaging?" The answer is a highly qualified "yes." People have done it, but it is generally an exercise in frustration. That small webcam chip makes it horribly difficult to find and track objects.

With PC, software, scope, camera, flip mirror, and telescope ready, let's shoot a double. This time of year, there are many pleasing candidates, but choose an easy one to start with. How about the afore-mentioned Albireo? It's easy to find and frame even with a non-computerized "manual" telescope. Not that *I'd* use one of these manual scopes for imaging these days. Yes, I'm spoiled. Goto makes finding and framing much faster, and your imaging sessions much more productive.

If you're using a flip mirror and have adjusted it according to the manufacturers instructions to ensure that the camera and eyepiece both reach focus at the same point, Beta is likely pretty sharp on-screen, but probably not perfect. The sharper/smaller the star im-

## Photographing and Measuring Double Stars with Unconventional Imagers

ages are, the more attractive (and useful for making measurements) your final images will be. Be obsessive about focusing. I often spend as much as half an hour getting things just right.

With perfect focus attained, you can now worry about exposure. How should your star images look on the monitor? What you want is an exposure value that produces stars that are bright and obvious on-screen, but not at the expense of sharpness. Too long an exposure “burns out” stars, making their disks larger than they should be, and exaggerates seeing, often producing star disks that look like bloated amoebas. Exposure should, naturally, be long enough to show both stars of a pair. How do you adjust exposure? For just about every camera and control program combination there are three basic ways: shutter speed, gain, and frame rate.

Shutter speed is your normal control. If an image is underexposed, decrease shutter speed. If  $1/10^{\text{th}}$  of a second produces dim stars, decrease the shutter speed to  $1/5^{\text{th}}$  second. Keep in mind that you’ll be stacking multiple images, and you probably *want* the single frames you’re seeing on your software’s pre-view screen to look a *little* underexposed. If setting the shutter speed to its longest value doesn’t result in a well-exposed image, you can adjust the gain control, but normally try to leave gain close to minimum, as moving it much off zero will add a *lot* of noise to your pictures. Reducing frame rate will also increase exposure, but 10 frames per second (fps) is generally recommended for noise free images that minimize seeing problems.

With focus and exposure set, you’re ready to shoot a sequence. When you push the “take sequence” button on the K3 toolbar, the camera will begin sending a video composed of many frames to your computer where it will be saved on the hard drive as a .avi format video file. How long should you allow these exposure sequences to run? That depends on two factors: seeing and hard drive capacity.

If seeing is not good, take long sequences, 90 seconds to two minutes, perhaps, rather than the more typical (for doubles) 30 seconds. This will yield about a thousand frames, and you (or your software) should be able to find plenty of good ones among these for stacking. “How long” also depends on your PC’s drive. A 90 second .avi file can consume as much as 700 megabytes. Be sure your computer’s disk can handle that. When its primary hard drive begins to fill up, a computer will begin to act decidedly weird. Luckily, K3CCD Tools has an indicator for disk space remain-

ing at the bottom of the screen.

Once you’ve taken as many sequences of Beta Cygni as you desire, it’s time to move inside and start producing still pictures. As indicated above, what we will do is take these video files, these .avis, examine their frames for quality, and stack the best ones into one sharp, noise free image. There are two ways to do this. You can go through a video sequence frame by frame, marking the best for inclusion in the final still image. Or you can let your software do the work. K3CCD Tools is quite capable of deciding which of your frames meet the quality standard you set (you or it can choose a “reference frame”) and doing all the work for you.

Many users of K3, however much they love the program, don’t use it for image stacking. There is one piece of software above all others that has allowed webcam users to produce great images. That program is *Registax* (see Figure 3), now in its third release. This freeware offering will allow you to easily stack good frames and, once stacked, process the result into a wonderful image (via its amazing “wavelet” filters). Using *Registax* is a subject for a whole journal article or series of articles, but great results can be produced by the novice by simply using the program in its “auto” mode.

Macaddict? *Astrostack* is one image stacking program for the Macintosh (and Linux, too) that’s very highly regarded.

When you’re done stacking and processing, whether with *K3CCD* or *Registax* or *Astrostack*, you may want to do some final tweaking with a program like *Adobe Photoshop*. When it comes to doubles, I find that a little playing with color balance results in something closer to what I think is “natural” than what I usually see in “raw” images.

Now is the time to evaluate your finished pictures, and decide what you can do to improve them “next time.” Does Albireo look well-resolved? If not, you may want to increase the focal length of your scope further with a higher-powered Barlow. How about color? My webcam images often look much too pinkish. This can be dealt with in image post-processing, but it’s easier to reduce “color shift” at the time of exposure. Adding an inexpensive IR blocking filter to a webcam will improve its color rendition by reducing IR “bleed.” CCD chips are overly sensitive to infrared, and render this “color” as an excess of magenta. An IR filter can also make stars sharper looking and less bloated. How about focus? Were you satisfied with that? And exposure? If you’re like me, the

## Photographing and Measuring Double Stars with Unconventional Imagers

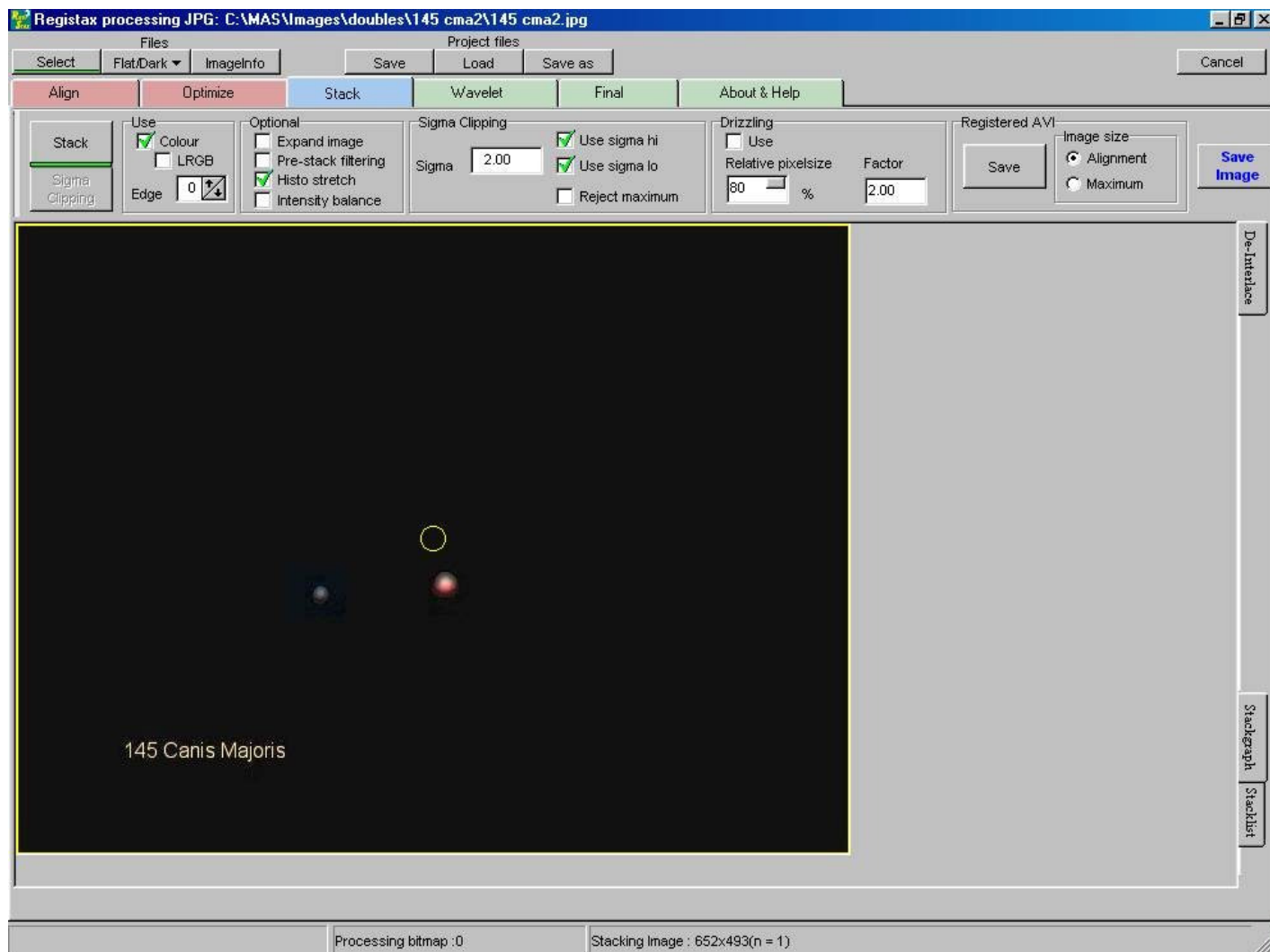


Figure 3: Screen shot from Registax

pictures you think are “perfect” will be few and far between.

Our last topic for this installment is “dimmer.” All off-the-shelf webcams are limited to exposures of less than one second. With a scope in the 8 inch aperture class, this may get you down to about magnitude 7 – 8 with some judicious tweaking of exposure controls and post-processing. But what if you want to shoot longer exposures to capture dimmer stars? When amateurs first began using webcams, the answer was, “you can’t.” Never discount the resourcefulness of a knowledgeable amateur astronomer equipped with a soldering iron, though.

Steve Chambers, one of the folks responsible for the webcam astronomy explosion, developed a me-

thod of modifying Toucam, Quickcam, and similar webcams for long exposure. With a few circuit modifications and the addition of a parallel port line for long exposure shutter control, an “SC” modified webcam can expose for as long as desired. While the required modifications are not difficult, a couple of manufacturers have realized that there’s a market for commercially modified webcams—not everybody has the time or skill to do electronic work. SAC Imaging (who produced the rightmost camera, a SAC7, in Figure 1) and ATIK both sell SC modified webcams in sturdy professionally made housings. These cameras can even be purchased with built-in Peltier coolers to keep thermal noise at bay.

*The webcam is the king of double star imaging?*



## Photographing and Measuring Double Stars with Unconventional Imagers

*Yes, in many ways it is. Or has been. Next issue I'll examine the Meade DSI, the Deep Sky Imager, a webcam-like camera designed for astronomy that has some special advantages of its own.*

### Resources

#### Software

*Astrostack*

<http://www.astrostack.com/info/features.html>

*K3CCD Tools*

<http://www.pk3.org/Astro/k3ccdtools.htm>

*Keith's Astroimager*

<http://www.unm.edu/~keithw/software/keithsAstroImager.html>

*Registax 3*

<http://registax.astronomy.net/>

#### Hardware

ATIK Cameras

<http://www.modernastronomy.com/atik.html>

IR Blocking Filters

<http://www.alpineastro.com/filters/filters.htm>

SAC Cameras

<http://www.sac-imaging.com>

SC Long Exposure Mods

<http://www.astrosurf.com/benschop/LXWebcam.htm>

Toucam Pro

<http://www.scopetronix.com/>

*Mr. Mollise is an editor of this journal and teaches astronomy laboratories at the University of South Alabama. He is the author of the book Choosing and Using a Schmidt-Cassegrain Telescope: A Guide to Commercial SCTs and Maksutovs.*

