

Cambridge University Press
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Part I

Basics

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Chapter 1

The DSLR revolution

A few years ago, I said that if somebody would manufacture a digital SLR camera (DSLR) that would sell for under \$1000 and would work as well as film for astrophotography, I'd have to buy one.

That happened in 2004. The Canon Digital Rebel and Nikon D70 took the world by storm, not only for daytime photography but also for astronomy. Within two years, many other low-cost DSLRs appeared on the market, and film astrophotographers switched to DSLRs en masse.

There had been DSLRs since 1995 or so, but Canon's and Nikon's 2004 models were the first that worked well for astronomical photography. Earlier digital cameras produced noisy, speckled images in long exposures of celestial objects. Current DSLRs work so well that, for non-critical work, you almost don't need any digital image processing at all – just use the picture as it comes out of the camera (Figure 1.1). The results aren't perfect, but they're better than we often got with film.

As you move past the beginner stage, you can do just as much computer control and image enhancement with a DSLR as with an astronomical CCD camera. Some hobbyists bring a laptop computer into the field and run their DSLR under continuous computer control. Others, including me, prefer to use the camera without a computer and do all the computer work indoors later.

1.1 What is a DSLR?

A DSLR is a digital camera that is built like a film SLR (single-lens reflex) and has the same ability to interchange lenses. You can attach a DSLR to anything that will form an image, whether it's a modern camera lens, an old lens you have adapted, or a telescope, microscope, or other instrument.

Unlike other digital cameras, a DSLR does not normally show you a continuous electronic preview of the image. Instead, the viewfinder of a DSLR uses a mirror and a focusing screen to capture the image optically so that you can view

The DSLR revolution

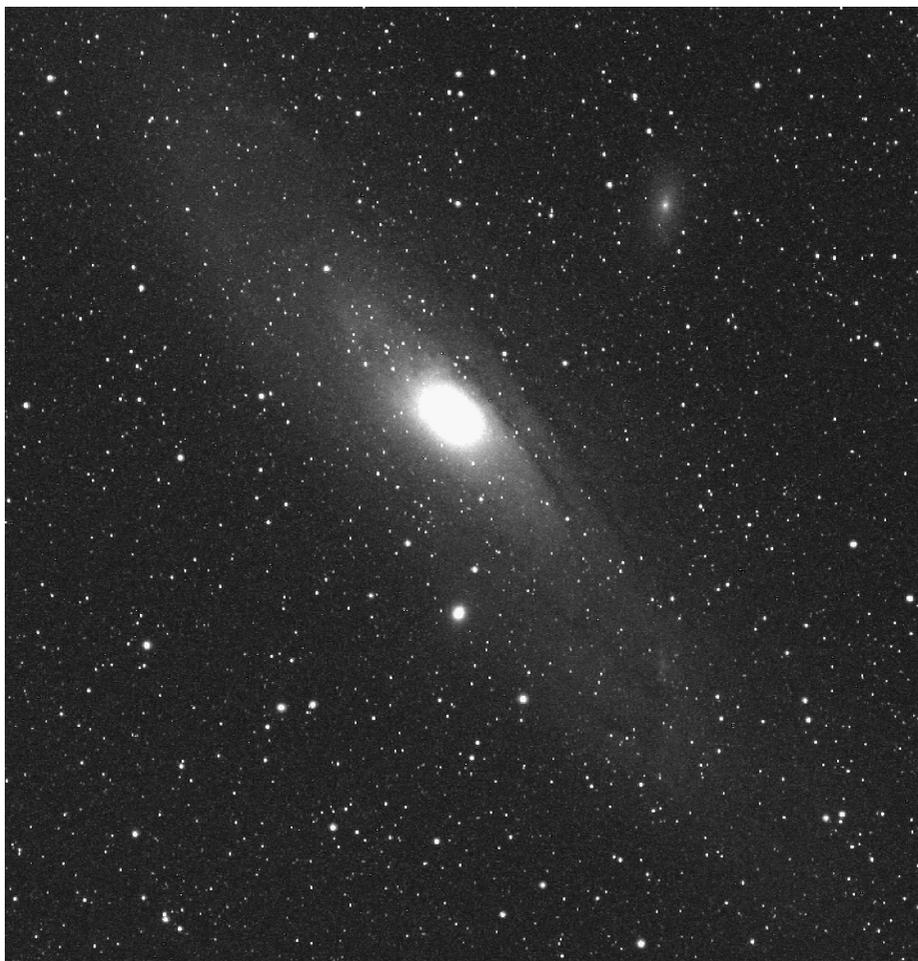


Figure 1.1. The galaxy M31 as the image came from the camera, with no processing except adjustment of brightness and contrast. Canon Digital Rebel (300D); single 6-minute exposure through a 300-mm lens at $f/5.6$, captured as JPEG. Some noise specks are present which newer cameras would eliminate with automatic dark-frame subtraction.

and focus through an eyepiece. When you take the picture, the mirror flips up, the image sensor is turned on, and the shutter opens.

The reason a DSLR doesn't show the electronic image continuously is that its sensor is much larger than the one in a compact digital camera. Big sensors are good because they produce much less noise (speckle), especially in long exposures, but operating a big sensor all the time would run down the battery. It would also cause the sensor to warm up, raising its noise level. That's why you normally view through the mirror, focusing screen, and eyepiece.

Some DSLRs *do* offer "live focusing" or "live previewing" for up to 30 seconds at a time. The Canon EOS 20Da, marketed to astronomers in 2005, was the first. Live previewing enables you to focus much more precisely than by looking

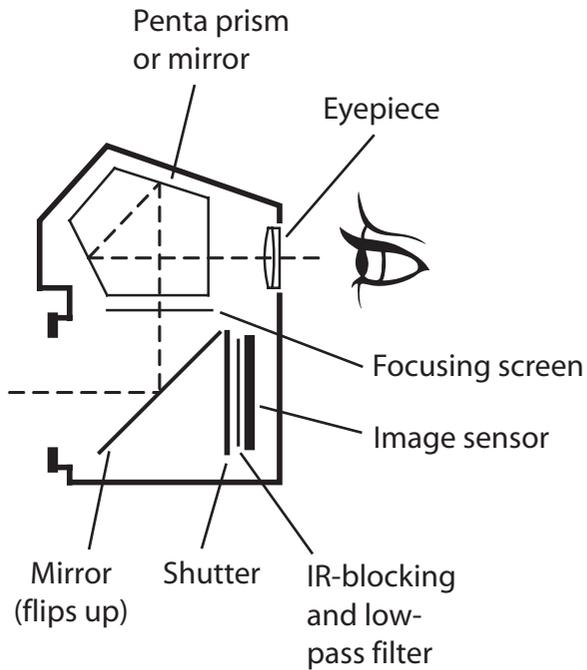


Figure 1.2. A DSLR is a single-lens reflex with a digital image sensor. Mirror and eyepiece allow you to view the image that will fall on the sensor when the mirror flips up and the shutter opens.



Figure 1.3. A more elaborate view of what's inside a DSLR. Note computer circuitry ("DIGIC II") at right. (Canon USA.)

The DSLR revolution

through the eyepiece, especially since you can magnify the view. Note that some cameras, such as the Olympus E330, offer a live preview from a secondary small sensor, not the main sensor; that kind of live preview is much less useful.

It's hard to guess what the role of DSLRs will be in the history of photography. Future photographers may look back on them as an awkward transitional form, like a fish with legs, soon to be replaced by cameras that don't require mirrors. But at present, DSLRs are the best digital cameras you can get, and they are revolutionizing low-budget astrophotography.

1.2 Choosing a DSLR

1.2.1 Major manufacturers

Canon

Many astrophotographers have settled on the Canon Digital Rebel, XT, XTi (EOS 300D, 350D, and 400D) and their successors. These are low-priced, high-performance cameras. One reason Canon leads the market is that Canon is the only DSLR maker that has specifically addressed astrophotography, first with tutorials published in Japan¹ and then, briefly, by marketing a special DSLR for astrophotography (the EOS 20Da).

Also, because Canon SLR bodies are relatively compact, you can use other brands of lenses on them, including Nikon, Olympus OM, Leicaflex, Contax/Yashica, and Pentax-Praktica M42 screw mount. For more about lens adapters, see p. 80. Of course, with an adapter, there is no autofocus, but with Canon DSLRs, you can use the exposure meter and aperture-priority auto exposure (useful for eclipses) with any lens or telescope.

So far, there have been three generations of Canon DSLRs suitable for astrophotography. The EOS 10D and Digital Rebel (300D) used the original Canon DIGIC image processor and CRW raw file format. With the EOS 20D, Canon moved to a new system, DIGIC II, with the CR2 raw file format; this is used in the Digital Rebel XT (350D), XTi (400D), 20D, 20Da, 30D, and their successors. The third generation, DIGIC III, began with the EOS 1D Mark III in 2007. Each of these has its own raw file format, and software that supports one will not necessarily support another.

Canon's nomenclature can confuse you. The EOS Digital Rebel, EOS Kiss, and EOS 300D are the same camera, but the EOS 300 and EOS Rebel are film cameras from an earlier era. The EOS 30D is an excellent recent-model DSLR, but the EOS D30 is an early DSLR from before Canon developed sensors suitable for astronomy. And so on. If you want to buy a secondhand camera, study the nomenclature carefully.

¹ Formerly on the Web at <http://web.canon.jp/Imaging/astro/index-e.html>.

1.2 Choosing a DSLR

Nikon

Nikon also has a loyal following. At present, Nikon DSLRs are a bit awkward to use for astronomy because of a quirk called the “star eater” (p. 17). This is a problem that could disappear at any moment if Nikon made a change in the firmware, but so far, the D40, D50, D70, D70s, D80, and D200 (among others) are all afflicted. Also, it’s harder to build your own electrical accessories for Nikons because several models rely on an infrared remote control rather than a plug-in cable release.

Another Nikon drawback is that if the lens contains no electronics, the DSLR cannot use its exposure meter and cannot autoexpose. You can attach Nikon AI-mount manual-focus lenses to a Nikon DSLR, but the exposure meter is disabled. Of course, for astrophotography this is usually not a concern.

Nonetheless, Nikon cameras are easy to use for daytime photography, they are widely available, and some astrophotographers report that the sensor in the D40, D50, and D80 is more sensitive to stars than the competing Canon sensor – possibly because a Mode 3 image (p. 17) is “rawer” than Canon’s raw images. Nikon CCD sensors are reportedly made by Sony, but I cannot confirm this.

Others

Using modified Nikon bodies, Fuji makes DSLRs for general and scientific photography. The Fujifilm S3 Pro and S5 Pro have special sensors designed for high dynamic range; each pixel actually has two sensors, one for normal exposure and one to deal with overexposed highlights. Both cameras offer live focusing, and there is a version (the S3 Pro UVIR) that is not filtered to exclude infrared light. These cameras are relatively large and heavy.

Pentax, Sony, Olympus, and other DSLR makers are highly respected but have not achieved a large following among astrophotographers, and I have not tested their products. It is widely rumored that most other manufacturers use Sony CCD sensors similar to Nikon’s, although of course the firmware and internal image processing are different. Before buying any camera, you should search the Web and get astrophotographers’ opinions of it; also make sure its file formats are supported by astrophotography software.

1.2.2 Shopping strategy

Because of rapid technological progress, you generally want the *newest* DSLR that works well for astrophotography, not the most ruggedly built one. It’s better to buy a low-end DSLR today and another one in three years with a new, improved sensor, rather than sink all your money into a professional-grade camera that will commit you to using today’s technology for a decade.

Of course, if you can justify the expense for other reasons, go ahead and enjoy your Canon EOS 5D or Nikon D200; these cameras have big, bright viewfinders and are a joy to use. Apart from price, one disadvantage of pro-grade DSLRs

The DSLR revolution

is that they are heavy enough to unbalance a medium-sized amateur telescope. Another is that pro-grade cameras are more complicated to operate, and that can be a problem in the dark. Generally, professional cameras are designed for people who use them all the time and can easily remember a large number of controls. Entry-level cameras with simpler controls are easier to use, even for advanced work, as long as they have the features needed.

You don't have to have the best camera on the market in order to get good pictures. You just have to have a camera that is *good enough*. All astronomical instruments, including big observatory telescopes, have measurable limitations. We work so close to the limits of the laws of physics that perfection is unobtainable.

Also, buying the *very* newest camera has some drawbacks. This week's hot new DSLR may not yet be supported by your software, although updates usually come quickly. It also may not have fully debugged firmware (the software inside the camera); watch the manufacturer's Web site for firmware upgrades.

One last warning. Unreliable camera vendors are common on the Internet, and they often advertise impossibly low prices. Before dealing with a stranger, do some searching and find out whether others have had good experiences with the same merchant. You can find out the reputation of a vendor from www.epinions.com and www.resellerratings.com. Remember that even the best large-volume dealer has a few unsatisfied customers, and a "perfect" score may mean simply that not many customers have been surveyed.

Highly reliable camera dealers include B&H in New York (www.bhphotovideo.com), their neighbor Adorama (www.adorama.com), Samy's in Los Angeles (www.samys.com), KEH in Atlanta (www.keh.com), Wolf/Ritz all over the United States (www.wolfcamera.com), and Jessops in the UK (www.jessops.com). Their prices are a good indication of what you should expect to pay anywhere. You can also buy DSLRs from major computer dealers.

1.3 Choosing software

It's easy to get the impression that you need more software than you actually do. It's partly a matter of taste whether you accumulate a large set of special-purpose tools or just a couple of full-featured software packages. Don't buy anything unless you know what you will use it for.

At minimum, you'll need two software packages, a general-purpose photo editor to perform basic adjustments and make prints, and an astronomy-specific image processing program for stacking, dark frame subtraction, and other specialized operations.

You don't have to use the same software I do. Most of this book is software-neutral. For the concrete examples that I'm going to give, I've chosen two full-featured software packages, *MaxDSLr* and Adobe *Photoshop*, because they're well-established products that don't change much from version to version. But you can make do with much less expensive substitutes.

1.3 Choosing software

1.3.1 Photo editing

For general-purpose photo editing, the software that comes with your camera may be adequate, especially if you pair it up with relatively powerful astronomy software. What you need is the ability to crop and resize pictures, adjust contrast and color balance, and make prints.

The king of the photo editors is of course Adobe *Photoshop*, which is one of the basic tools of computer graphics; many scientific add-ons for it have been developed. But *Photoshop* isn't cheap. An alternative is *Photoshop Elements*, which may even come with your DSLR; this is a cut-down version of *Photoshop* that does not process 16-bit TIFFs but is otherwise satisfactory. Or you can use its leading competitor, Corel's *Paint Shop Pro* (www.corel.com). Note that there are often upgrade discounts for people moving to *Photoshop* from *Photoshop Elements* or from competitors' products.

1.3.2 Astronomical image processing

For specifically astronomical functions I use *MaxDSLR* (from www.cyanogen.com) because it is well-established and reliable, follows standard Windows practices, and is organized to make important concepts clear. Thus, when telling you how to process images, I can concentrate on what you're actually accomplishing rather than the quirks of the software. What's more, *MaxDSLR* doesn't just process images; it can also control the camera, run a webcam autoguider, and capture and process video planet images.

MaxDSLR has a big brother (*MaxIm DL*, from the same manufacturer) and a head-on competitor (*ImagesPlus*, from www.mlunsold.com), both of which offer even more features but are more complex to use. They work with astronomical CCD cameras as well as DSLRs and webcams.

As an alternative to *MaxDSLR* I also use *Nebulosity* (from www.stark-labs.com). This is a quick and simple image processing package for DSLR users, similar in overall design to *MaxDSLR* but much lower priced. (The two make a good pair.) Like *MaxDSLR*, *Nebulosity* not only processes images, but also controls the camera in the field. It runs on the Macintosh as well as the PC.

1.3.3 Freeware

Excellent free software also exists. One example is Christian Buil's *Iris*, a full-featured image processing program available from <http://astrosurf.com/buil>. Based on a command-line interface, *Iris* is radically different from other image editing programs, but it is reliable and well-documented, and the price is right.

Another highly respected free program is Cor Berrevoets' *RegiStax*, which has long been the standard tool for stacking and enhancing video planet images. *RegiStax* is gradually adding features useful for processing still pictures of deep-sky objects. You can download it from <http://registax.astronomy.net>.

The DSLR revolution

Also highly respected is *DeepSkyStacker* (<http://deepskystacker.free.fr>), and again the price is right – it’s free. *DeepSkyStacker* can rotate and stack images, subtract dark frames, and interconvert all major file formats, including Canon and Nikon raw. It’s not a complete image processor, but it works well with a general photo editor.

1.3.4 Judging software quality

I am an astrophotographer by night but a computer scientist by day, so I’m rather picky about software quality. My main concern is that *more features are not necessarily better*. “Creeping featurism” is the enemy of reliability and ease of use. Choose software on the basis of what it’s like to use it, not the length of the feature list.

Good software should cooperate with the operating system. It should not compromise the system’s security by requiring you to use administrator mode (root mode in UNIX), nor should it confuse you with non-standard menus, icons, and sounds. (One package annoyed me by making the Windows “error” beep every time it finished a *successful* computation.) Defaults matter, too; output files should go into your documents folder, not a program folder that you may not even have permission to write in.

It’s a good thing when software packages imitate each other’s user interfaces; similar things should look alike. A non-standard user interface is justifiable only if it is a work of genius.

1.4 Is a DSLR right for you?

All of this assumes that a DSLR is the best astrocamera for your purposes. Maybe it isn’t. Before taking the plunge, consider how DSLRs compare to other kinds of astronomical cameras (Table 1.4, Figure 1.4). Notice that the DSLR provides



Figure 1.4. Left to right: a film SLR, a DSLR, a webcam modified for astronomy, and an astronomical CCD camera.