PRODUCT REVIEW

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THE CONTENDERS Compared with dedicated astronomical CCD cameras, DSLRs provide the most megapixels per dollar. From left to right, the Pentax K10D, Canon Digital Rebel XTi and Nikon D80 each offer 10 megapixels for about $1,000—amazing value thanks to the mass production of these cameras for the amateur photography market.

Cameras in head-to-head showdown

Three of the latest digital SLRs compete for the title of best $1,000 camera for astrophotography

SINCE THEIR INTRODUCTION TO THE market some five years ago, digital single-lens reflex (DSLR) cameras have become the most popular models for astronomical photography. Intended for serious amateur photographers and all types of shooting, DSLRs have several key features that make them particularly desirable for nighttime photography. First and most important, their large sensors offer *much* lower noise and cleaner images than do compact point-and-shoot digital cameras, especially at ISO 400 and higher. DSLRs feature interchangeable lenses—or direct attachment to a telescope's focuser—making them by far the most versatile cameras for all forms of astrophotography, from panoramas of the Milky Way with wide-angle lenses to deep-sky close-ups through a telescope.

Starting with the price-breakthrough 300D Digital Rebel in 2003, Canon's DSLR cameras have been the most popular choices among backyard astronomers. But what about other brands? Many people are heavily invested in suites of lenses for their faithful Nikon and Pentax film cameras and would like to buy a digital model compatible with their existing gear. Do you stay loyal or switch brands?

COMPETING CAMERAS

To answer the question of how Nikon and Pentax cameras compare with Canon for astronomical photography, we acquired an off-the-shelf sample of the latest DSLR from each of the three manufacturers: Canon's Digital Rebel XTi, Nikon's D80 and Pentax's K10D. All are 10-megapixel models, competitive with one another in price and features. Very thorough reviews of their performance for daytime shooting can be found at digital-camera websites, such as the excellent www.dpreview.com. However, astronomical long-exposure performance information for these models is virtually nonexistent, so we concentrated on this aspect. Taking a long exposure of the night sky is a task that pushes any camera to its limit, revealing quirks and inadequacies missed in normal testing.

The bane of all digital cameras is noise—electronic "grain" that builds up during

	FEATURES	PROS	CONS
 **Canon Digital Rebel XTi (400D)**	10.1 megapixels / 3,888 x 2,592 pixels 22.2mm x 14.8mm sensor size; 5.7-micron pixel size Media: Compact Flash (CF) memory card Weight: 750 grams (with battery) Typical price: $950 (body only)	• Lowest noise of the trio • Lack of amplifier glow • Lightest camera body • Dust-removal feature	• Bright white single LCD screen (see photo, page 37) • Remote jack not compatible with Canon TC-80N3 interval timer
 **Nikon D80**	10.2 megapixels / 3,872 x 2,592 pixels 23.6mm x 15.6mm sensor size; 6-micron pixel size Media: SD memory card Weight: 850 grams (with battery) Typical price: $1,100 (body only)	• Good noise performance • 1/3-stop ISO increments	• Poor image quality at ISOs below 800 in long exposures • Flawed dark-frame subtraction at ISO 400 and lower • Prominent amplifier glow in long exposures • Coloured "de-Bayering" artifacts on some stars
 **Pentax K10D**	10.2 megapixels / 3,872 x 2,592 pixels 23.5mm x 15.7mm sensor size; 6-micron pixel size Media: SD memory card Weight: 1,000 grams (with battery) Typical price: $1,100 (body only)	• Dust-removal feature • Can save RAW images in standard DNG format • Excellent battery life	• Highest noise of trio tested • Some amplifier glow visible

long exposures, potentially ruining the photo. Our prime concern, therefore, was determining which of the trio had the lowest noise during the 5-to-10-minute exposures typical of deep-sky imaging.

To test them, we equipped each camera with a lens of the same focal length, ganged them on a single mount tracking the sky and fired off simultaneous shots at identical combinations of ISO sensitivity, aperture and shutter speed. Testing was done on winter nights, with temperatures at or just below freezing—an aid to camera performance, as cold suppresses some forms of imaging noise.

NOISE AND ARTIFACTS

When comparing noise levels, the Canon Digital Rebel XTi (also known as the 400D) showed the smoothest sky background with the least graininess and coloured speckling. The Nikon and Pentax both fared quite well, evidence that these manufacturers have addressed the issue of noise in their new models. For example, we had the chance to use an older Pentax, the 6-megapixel K100D, as part of our testing. This economy model exhibited so much noise, it proved unsuitable for long exposures.

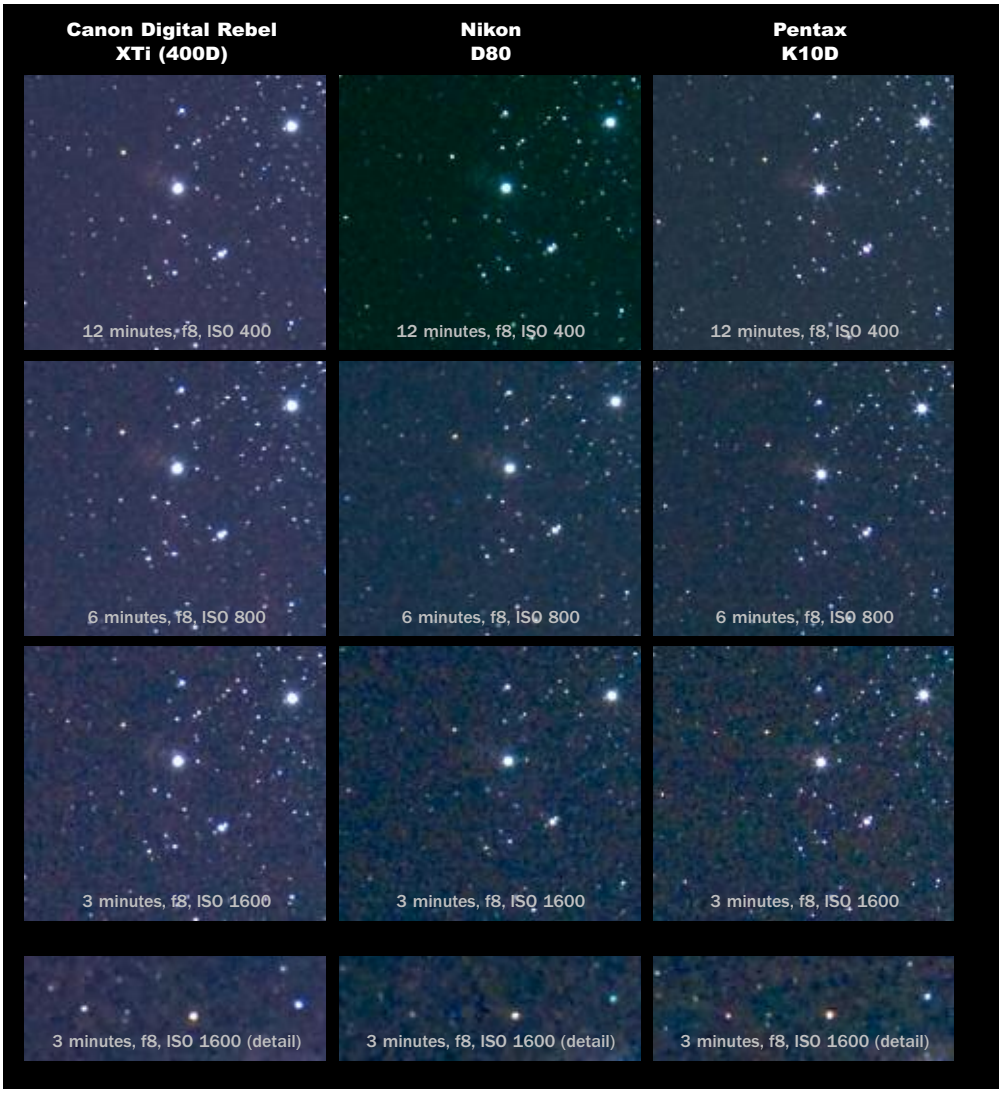
But the Nikon and Pentax noise levels, while respectable at lower ISO 400 and 800 settings, became quite severe at their top settings of ISO 1600 (increasing the ISO speed boosts a camera's sensitivity but also increases noise). By comparison, the Canon was still usable at ISO 1600.

Even after upgrading the Nikon D80's firmware to version 1.01, images had the odd characteristic of turning green and lacking faint detail when taken at ISO settings of 640 or lower for longer than about 5 minutes. The slower ISO settings simply weren't usable for long exposures. Yet at ISO 800, the Nikon worked just fine. Colour was normal, and image quality was good, though with noise inevitably higher than it would be at lower ISOs. In addition, the Nikon and, to a much lesser extent, the Pentax exhibited "amplifier glow"—an intrusive glow along one edge of the frame caused by heat from the internal electronics.

During testing, each camera's "long exposure noise reduction" option was turned on, forcing the camera to take an additional exposure of equal length with the shutter closed. This "dark frame" records nothing but noise and artifacts, such as

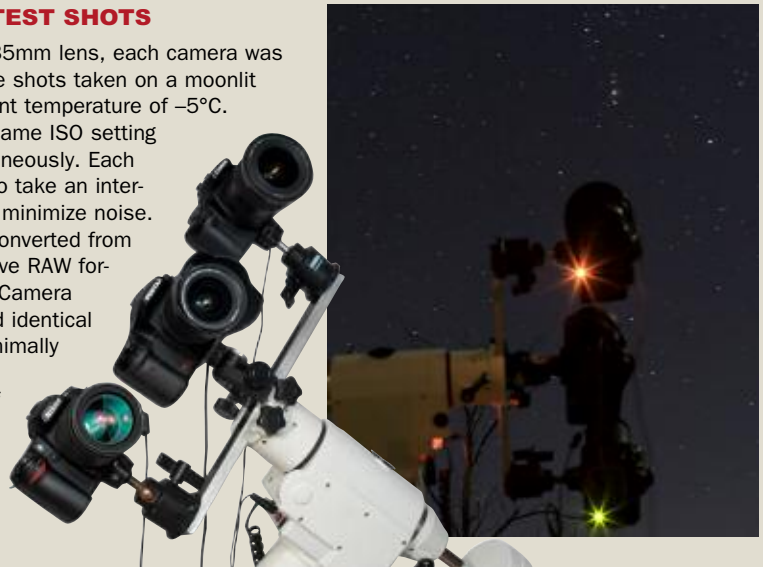
COMPARING IMAGES

This array shows small sections (for clarity) from each frame in a series of exposures taken with the setup shown at bottom. Simultaneous exposures were taken at ISO 400 for 12 minutes, ISO 800 for 6 minutes and ISO 1600 for 3 minutes. Notice the green colour cast of the Nikon ISO 400 image. The blowups reveal visible differences in noise levels, as well as artifacts, such as the oddly coloured stars present in the Nikon images.



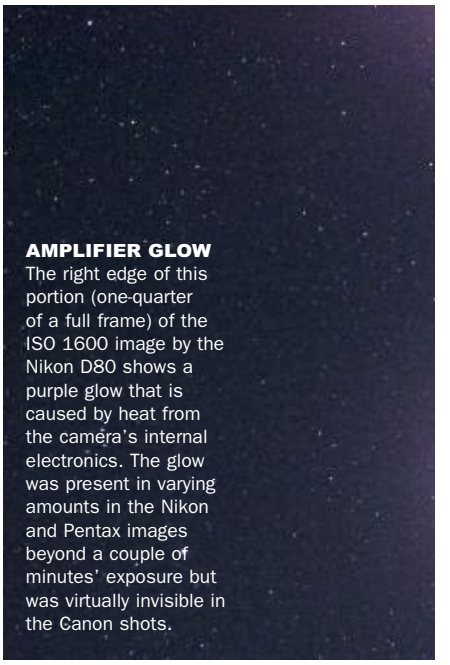
ABOUT THE TEST SHOTS

Equipped with a 35mm lens, each camera was set to f8 for these shots taken on a moonlit night at an ambient temperature of –5°C. Images with the same ISO setting were shot simultaneously. Each camera was set to take an internal dark frame to minimize noise. All images were converted from the camera's native RAW format using Adobe Camera RAW software and identical settings, then minimally processed with identical boosts of brightness and contrast. No colour correction was applied.



TWILIGHT ASTROPHOTOGRAPHY
Some of the most impressive celestial events —comets, groupings of the crescent Moon and bright planets—are visible during morning and evening twilight. All three of the cameras tested are superb performers for this type of shooting.

TODD CARLSON



AMPLIFIER GLOW
The right edge of this portion (one-quarter of a full frame) of the ISO 1600 image by the Nikon D80 shows a purple glow that is caused by heat from the camera's internal electronics. The glow was present in varying amounts in the Nikon and Pentax images beyond a couple of minutes' exposure but was virtually invisible in the Canon shots.

hot pixels and amplifier glow. The camera then automatically subtracts this frame internally from the deep-sky exposure, in theory leaving an exposure free of such artifacts. However, this proved to be the case only with the Canon. Curiously, with the Nikon D80 at ISO settings of 400 and lower, the internal dark frame lasted for only half the length of the main exposure.

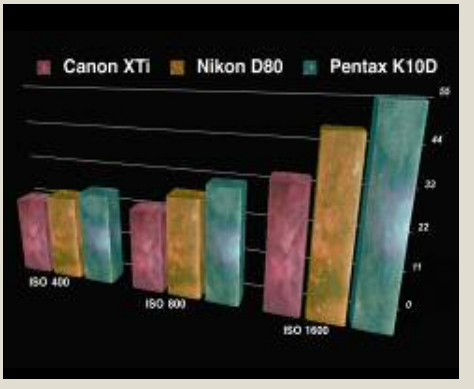
The Pentax K10D behaved oddly at first as well. When the camera was cold (as is inevitable on most nights in Canada), it consistently shut down just a few seconds into a time exposure, indicating a dead battery, despite its having been freshly charged. Clearly, something was wrong. Sure enough, upgrading the camera's firmware to version 1.1 resolved the issue, enabling the camera to take exposures of any length desired, with excellent battery life, even on chilly nights.

The Nikon D80 showed no sign of stars being blurred or wiped out as a side effect of the camera smoothing noise. This undesirable effect was reported by users of earlier Nikon models, prompting odd work-arounds to ensure the sharpest images. But blurring of stars became apparent after switching on the Nikon D80's "High ISO Noise Reduction" mode, a feature not recommended for astronomical subjects.

The Nikon did, however, record some stars as vividly coloured green or blue dots, even in frames converted from RAW-format originals using Adobe Camera RAW, a standard file converter. This is likely due to an imperfect translation of each pixel's raw monochrome data into a colour image, a process known as "de-Bayering." The Pentax showed a few de-Bayering artifacts, while in the Canon,

COMPARING CANONS
Here, we compare the 10-megapixel Canon Rebel XTi, right, with the 8-megapixel Canon 20Da, far right, in blowups of two exposures of the Pleiades, taken the same night at ISO 800 with a 200mm telephoto lens. While the XTi does well for noise, it looks somewhat grainier than the now discontinued 20Da, still the benchmark camera for low-noise performance in a DSLR.

GRAPHING THE NOISE The noise-reduction software Noise Ninja was used to measure the relative noise levels, in arbitrary units, in astronomical images taken simultaneously for identical exposure times. The Canon presented the lowest noise, with the difference greatest at ISO 1600, the most sensitive setting.



stars looked as they should, in their natural colours.

When shooting under dark skies, none of the cameras led the pack in picking up red nebulosity. All performed acceptably but cannot match the performance of DSLR cameras modified for extended red response by third-party suppliers, such as KW Telescope in Canada (www.kwtelescope.com) and Hutech in the United States (www.sciencecenter.net/hutech).

CHOOSING A CAMERA

At the end of the testing, Canon emerged victorious. Its low noise and lack of other artifacts make it the most suitable for long exposures. Nevertheless, the Nikon and Pentax put up a good fight. Both produce fine results at ISO 400 and 800 settings if exposures are kept short. If you're looking for a camera that's compatible with existing hardware and planning to use it for only casual short-exposure astrophotography, the Pentax K10D and Nikon D80 will work very well.

But for someone serious about deep-sky imaging through a telescope, where, for the best results, exposures should last several minutes, the Canon Digital Rebel XTi is the best choice of the trio. There are better cameras for astrophotography, but not at this price. As of early 2007, this is the lowest-cost Canon DSLR and has a higher megapixel rating than some of the more costly models.

How important is the higher pixel count? Surprisingly, in this case, the jump from 8 to 10 megapixels barely makes a difference. In same-object, same-night comparison shots with an 8-megapixel Canon 20Da, the Rebel XTi's extra two megapixels produced virtually no noticeable advantage. Far more important is the camera's excellent balance between low noise and high sensitivity to low-light subjects in long exposures. This is now, and will remain for some time to come, the main battleground for future DSLR cameras competing for the astronomical crown.

BRIGHT SCREEN AT NIGHT

The primary downside to the Canon Digital Rebel XTi is the single LCD screen that displays the images and all settings. The Nikon D80 and Pentax K10D, as well as other Canon models, have a second dimly lit top-mounted screen for displaying camera settings—a much better arrangement for night use at the telescope. The Canon XTi's rear screen is glaring white, which, even at its lowest brightness, was too bright for use at a dark site. Fortunately, the screen can be turned off when not needed. Too bad an optional "night-vision" red-screen mode is not available.