



Reading and Resources

Further Reading

Telescopes and Astronomical Equipment

The following are books that offer particularly sage advice on selecting and using astronomical equipment. While many astronomy books include short accounts of the basic types of telescope and useful type of accessories to look out for, the authors of these books name the good and shame the bad, which makes them invaluable companions when shopping.

- *Choosing and Using the Schmidt-Cassegrain Telescope*. R. Mollise, Springer-Verlag, 2002, London, UK.
- *How to Use a Computerized Telescope: Practical Amateur Astronomy Volume 1*. M. A. Covington, Cambridge University Press, 2002, Cambridge, UK.
- *Star Ware (3rd Edition)*. P. S. Harrington, John Wiley & Sons, 2002, USA.
- *Stargazing with a Telescope*. R. Scagell, Philips, 2000, London, UK.
- *The Backyard Astronomer's Guide (2nd Edition)*. T. Dickinson and A. Dyer, Firefly Books, 2002, USA.
- *Using the Meade ETX*. M. Weasner, Springer-Verlag, 2002, London, UK.

Star-Hopping Techniques

Star hopping is a great way to combine your planetarium program with your telescope; use them to produce charts that are either viewed on the computer screen or printed off to use

away from the computer. Here are two of great books for learning star-hopping techniques and expanding the range of things you observe each evening.

- *Star-Hopping: Your Visa to Viewing the Universe*. R. Garfinkle, Cambridge University Press, 1997, UK.
- *Turn Left at Orion*. G. Consolmagno and D. Davis, Cambridge University Press, 2000, UK.

Catalogs of Deep Sky Objects

If you want to put together an observing program based on a certain type of object, you'll need a source book to get ideas from. The two star hopping books mentioned above are a good place to start, and the following will provide thousands more objects for more experienced observers.

- *Burnham's Celestial Handbook*. R. Burnham, Dover Books, 1978, USA.
- *Field Guide to the Deep Sky Objects*. M. Inglis, Springer-Verlag, 2001, London, UK.

CCD and Advanced Imaging Methods

The details and methods involved in advanced electronic imaging using specially designed astronomical CCD cameras instead of webcams and digital cameras falls outside the scope of this book. Fortunately, a good number of books already exist on the topic, to which the reader is referred.

- *CCD Astronomy: Construction and Use of an Astronomical CCD Camera*. C. Buil, 1991, Willman-Bell, USA.
- *Choosing And Using A CCD Camera*. R. Berry, Cambridge University Press, 1992, UK.
- *Handbook of Astronomical Image Processing (includes Astronomical Image Processing for Windows)*. R. Berry and J. Burnell, Willman-Bell, 2001, USA.
- *Practical Astrophotography*. J. R. Charles, Springer-Verlag, 2000, London, UK.
- *A Practical Guide to CCD Astronomy*. P. Martinez and A. Klotz, 1997, Cambridge University Press, UK.

Charting and Utility Software

Planetarium and Moon-Mapping Software

Star charting software is among the most useful available to astronomers, and there are applications available for all budgets and levels of observing skill. Such applications can be used either to produce tailor-made star charts for printing, or in the field alongside the telescope, in which case some sort of night vision mode is essential. Moon-mapping software produces much more detailed charts of the lunar surface, allowing the user to identify craters and other features much more easily than with traditional books and maps.

- *2sky* (<http://in2space.com>) for Palm OS. Basic version includes stars down to 6th magnitude plus five hundred deep sky objects. Additional databases can be purchased for ten dollars a throw, including the full NGC/IC catalogs. Commercial.

- *Alpha Centaure* (<http://astrosurf.com/alphacentaure/english/index1.htm>) for Windows. Lightweight, easy to use planetarium including a good selection of bright stars, Messier and NGC objects, comets and so on. Includes a night vision mode and a user-configurable sunspot plotter. Freeware.
- *Cartes du Ciel* (<http://www.stargazing.net/astropc/index.html>) for Windows. Full-featured, easy to use planetarium program. Freeware.
- *Deep Sky 2003* (<http://www.deepsky2000.com>) for Windows. Big, comprehensive planetarium with hundreds of thousands of deep sky objects and millions of stars and advanced features like telescope control and CCD image processing. Commercial.
- *Equinox* (<http://www.microprojects.ca>) for the Mac. Impressively appointed but low-cost planetarium program including such luxuries as go-to telescope control and observing lists. Shareware.
- *KStars* (<http://edu.kde.org/kstars>) for Linux. Powerful, Internet-savvy open source planetarium, and probably the easiest to use for Linux or UNIX generally. Can be modified to run on the Mac as well. Freeware.
- *Lunar Map Pro* (<http://www.riti.com>) for Windows. Powerful lunar atlas for serious observers. Commercial.
- *MegaStar* (<http://www.willbell.com>) for Windows. Widely considered to be the best planetarium program for advanced deep sky observers. Includes huge catalogs of deep sky objects, support for most go-to telescopes and mounts, CCD camera utilities and more. Commercial.
- *Palm Planetarium* (<http://www.aho.ch/pilotplanets>) for Palm OS. Includes features such as telescope control (via the serial port) and a night vision mode (on color systems). Shareware.
- *RedShift* (<http://www.maris.com>) for Windows and Mac. Primarily devised as an educational tool but includes a planetarium as well. Commercial.
- *SkyChart* (<http://skychart.sourceforge.net>) for Windows and Linux. Still being developed and based on the popular Windows application *Cartes du Ciel*, this is currently a usable if simple planetarium program. Freeware.
- *SkyChart 3* (<http://www.southernstars.com>) for Windows and Mac. Low cost but sophisticated planetarium program. Sky Sight, a Mac CCD program, is also available for free.
- *SkyMap Pro* (<http://www.skymap.com>) for Windows. Heavyweight program for advanced amateurs containing just about every feature imaginable. Commercial.
- *Stargazer's Delight* (<http://www.stargazersoft.com>) for the Mac. Simple and fun lightweight planetarium including some neat tutorials and animations, as well as useful tools such as plots of Jupiter's moons. Shareware.
- *Starry Night* (<http://www.starrynight.com>) for Windows and Mac. Photorealistic planetarium program available in basic *Backyard* and advanced *Pro* versions. The *Pro* version includes much larger object catalogs, telescope control and a planning tool for creating and optimizing observing programs. Commercial.
- *Stellarium* (<http://stellarium.free.fr>) for Windows, Mac and Linux. Beautiful if somewhat limited "eye-candy" planetarium offering some of the best virtual stargazing around. Freeware.
- *The Digital Universe* (<http://www.syz.com>) for Windows, Mac and Amiga. Intuitive and attractive planetarium program including a very fine astronomical encyclopaedia with hundreds of pictures and long, well-researched and very detailed articles. Comes bundled with a 3-D star simulation called *3DStars* and red/blue spectacles for getting the full effect with. Commercial.
- *TheSky* (<http://www.bisque.com/>) for Windows, Mac and Windows CE. Sophisticated and easy to use planetarium with many useful features. Available in various editions,

from the basic *Student* edition through to the powerful *Level IV* version that including telescope control, image manipulation and editing, and large deep sky object catalogs. Commercial.

- *Virtual Moon Atlas* (http://astrosurf.com/avl/UK_index.html) for Windows. Useful and easy to use lunar atlas. Freeware.
- *Voyager* (<http://www.carinasoft.com>) for the Mac. Full-featured planetarium program although lacking integrated go-to telescope control. A lightweight version of this application for Windows and Mac is also available, called *SkyGazer*. Commercial.
- *XEphem* (<http://www.clearskyinstitute.com>) for Windows, Mac and Linux. Very powerful astronomical ephemeris including a planetarium mode as well as maps of Mars and the Moon, satellite imagery of the Earth, FITS image views and more. CSI also produce a star-charting program for the Sharp Zaurus series of palmtop computers. Commercial.

Telescope Control, Logging and Utility Software

Various utilities exist to improve the lot of the amateur astronomer, including electronic guidebooks to the night sky, software for creating observing lists and stepping go-to telescopes through them and utilities for changing the colors on a laptop to a more night-vision friendly mode.

- *AstroPlanner* (<http://www.ilangainc.com/astroplanner>) for Windows and Mac. This is a multi-purpose tool that includes deep sky observing list generation, calculations of the “best pair” of stars to use for aligning go-to telescopes, and go-to telescopes control (via a serial cable). Shareware.
- *David Paul Green’s Free Software* (<http://www.davidpaulgreen.com/software.html>) for Windows and Mac. A great suite of tools for logging observations, including ones for the Messier and Caldwell lists. Freeware.
- *Night Vision* (<http://www.adpartnership.net/NightVision/index.html>) for Windows and Mac. A night vision utility that darkens and tints the screen allowing a laptop to be used in the field without ruining dark adaptation. Freeware.
- *NightMaster* (<http://www.ilangainc.com/nightmaster>) for the Mac. Another night vision utility. Includes red, green and blue sliders that allow some very funky display configurations! Freeware.
- *Scope Driver* (<http://www.adpartnership.net/ScopeDriver>) for Windows and Mac. Fast, lean and easy to use list-based observing utility. Shareware.

X Windows and Professional Astronomical Software

Many serious astronomical programs are available for download and use from the Internet, and though of limited practical value, can be fun and educational. In some cases they will run in the traditional Windows or Mac operating system but often they require the presence of an X Windows server of some sort.

- *Apple X11* (<http://www.apple.com/macosx/x11>) for the Mac. The simplest X Windows server to install on a modern Mac computer. Runs UNIX software alongside traditional Mac programs. Freeware.
- *DS9* (<http://hea-www.harvard.edu/rd/ds9>) for X Windows. An image analysis program designed for use by professional astronomers, but amateurs will find the ability to

view FITS files (as well as a variety of other graphics file formats) useful as well. Freeware.

- *Cygwin* (<http://cygwin.com>) for Windows. A popular Linux emulator, not as easy to install as the commercial alternatives, but effective nonetheless. Freeware.
- *Fink* (<http://fink.sourceforge.net>) for Mac. Fink is a project consisting of ported versions of UNIX applications adapted to run on X Windows on Mac hardware, including versions of *KStars*, *StarPlot* and *Nightfall*.
- *GeoVirgil* (<http://www.siliconspaceships.com>) for Windows and Mac. A Java-based application that accesses and displays NASA images of Mars, Venus and other solar system bodies. A companion program called *AstroVirgil* does the same thing for x-ray images from the Chandra space telescope. Freeware.
- *Nightfall* (<http://www.lsw.uni-heidelberg.de/~rwichman/Nightfall.html>) for X Windows. The program simulates the orbits of binary stars and shows things like the way the shape of each star distorts under the gravitational influence of its companion. Freeware.
- *OroborOSX* (<http://oroborosx.sourceforge.net>) for the Mac. Augments *XFree86* by integrating it more completely with the Mac operating system, for example adding the ability to copy and paste between programs. Freeware.
- *Partiview* (<http://www.haydenplanetarium.org/hp/vo/du/index.html>) for Windows, Mac and UNIX. A three-dimensional atlas of the Milky Way and beyond; very pretty and ideal for educators as well as curious amateur astronomers. Freeware.
- *SETI@Home* (<http://setiathome.ssl.berkeley.edu>) for Windows, Mac and UNIX. Various applications that allow computers with a connection to the Internet to download and process SETI data. Freeware.
- *StarPlot* (<http://starplot.org/index.html>) for X Windows. Simple and attractive stellar cartography program designed to show the relative positions of stars to one another in three dimensions. Freeware.
- *Virtual PC* (<http://www.microsoft.com/windowsxp/virtualpc>) for Windows and Mac. Because it emulates the hardware that can run a Linux operating system, it is relatively straightforward to install and run a full-blown Linux operating system onto Virtual PC instead of some version of Microsoft Windows. Commercial.
- *WinaXe* (<http://labf.com/index.html>) for Windows. A sophisticated but relatively easy to install and use X Windows emulation package that installs onto computers from Windows 95 to XP. Commercial.
- *XFree86* (<http://mrcla.com/XonX>) for the Mac. A basic X Windows server that runs UNIX programs but lacks some of the niceties of the usual Macintosh front end; these can be added using *OroborOSX*. Runs UNIX software ported to the Mac. Freeware.

Go-To Telescopes and Accessories

All-in-One Go-To Telescope Manufacturers

Only two companies mass-produce all-in-one go-to telescopes, and which is the better of the two is a popular topic for discussion among astronomy hobbyists! Catadioptric telescopes of one sort or another dominate the computerized telescope ranges of both companies.

- *Celestron* (<http://www.celestron.com>). Major manufacturer of consumer level telescopes and accessories. NexStar series of all-in-one go-to telescopes include refractor, reflector and catadioptric designs. Links to worldwide dealers.

- *Meade* (<http://www.meade.com>). Major manufacturer of consumer level telescopes and accessories. Autostar series of all-in-one go-to telescopes include refractor, reflector and catadioptric designs. Links to worldwide dealers.

Go-To Mounts and Mount Upgrades

Go-to mounts offer much more flexibility in terms of what optical tube assembly is used, which is ideal if you want to use a high-quality apochromatic refractor or short focal length Newtonian sold as an optical tube alone.

- *Alpine Astro* (<http://www.alpineastro.com>). US distributor of Baader Planetarium products, including the adapters for fixing optical tubes to the smaller Celestron go-to telescope mounts.
- *Astro-Physics* (<http://www.astro-physics.com>). Manufacturer of top-quality telescopes and mounts, including the GTO series of go-to mounts. Links to worldwide dealers.
- *Baader Planetarium* (<http://www.baader-planetarium.de>). Manufacturer and distributor of various astronomical accessories including a repackaged NexStar go-to mount suitable for use with small refractors and catadioptric telescopes, including Leica and Zeiss spotter scopes. In German; some online ordering available, plus links to worldwide dealers.
- *Jim's Mobile* (<http://jimsmobile.com>). Manufacturer and distributor of a wide range of useful accessories for astronomers, including the NGC-MAX DSC system and flight cases for go-to telescopes.
- *Losmandy* (<http://www.losmandy.com>). Manufacturers of high-quality telescope tripods and mounts including a go-to system known as Gemini. Losmandy also produce the mounting rings and counterweights needed to attach small telescopes to larger ones. Online ordering available.
- *Lumicon* (<http://www.lumicon.com>). A division of Parks International, the Lumicon range includes the Sky Vector DSC system as well as various optical and light pollution filters, illuminated reticule eyepieces and astrophotography equipment. Online ordering available.
- *Orion* (<http://www.oriontelescope.com>). Major distributor of mass-market astronomical equipment in the US, including the IntelliScope DSC system for their XT-series of Dobsonian telescopes. Online ordering available.
- *Sky Engineering* (<http://skyeng.com>). Manufacturer of DSC systems for equatorially mounted and Dobsonian telescopes.
- *StarMaster* (<http://www.starmastertelescopes.com>). Top-quality Dobsonian manufacturer. One upgrade available is the Sky Tracker go-to system.
- *Takahashi* (<http://www.takahashiamerica.com>). Manufacturers of very high-quality Japanese-made refracting telescopes and mounts, including a go-to system known as Temma II. Links to US dealers.
- *Tech2000* (<http://homepages.accnorwalk.com/tddi/tech2000>). Manufacturer of various astronomical accessories including motorization kits compatible with Dobsonians and DSC systems. Online ordering available.
- *Vixen* (<http://www.vixen-global.com>). Japanese manufacturer of good quality telescopes and mounts, plus accessories such as the versatile SkySensor 2000 go-to upgrade package for their equatorial mounts. Links to worldwide dealers.

Manufacturers and Distributors of Useful Accessories

The following suppliers provide equipment that can be used for expanding a go-to telescope, as described in this book.

- *Apogee* (<http://www.apogeeinc.com>). Distributors of various telescope accessories including replacement star diagonals and focusers for SCT and Maksutov telescopes, camera adapters and collimators. Online ordering available.
- *Broadhurst, Clarkson and Fuller* (<http://www.telescopehouse.co.uk>). Distributors of their own line of Meade ETX and LX 200 series telescope accessories, as well as others, though primarily Meade and Tele Vue.
- *Kendrick Astro Instruments* (<http://www.kendrick-ai.com>). Distributors of their own line of accessories for telescopes as well as others, including computerized mounts from Losmandy, Takahashi, Tele Vue and Vixen. Online ordering available.
- *ScopeStuff* (<http://www.scopestuff.com>). Manufacturers of telescope various accessories including mounting rings and counterweights for attaching small telescopes and cameras to large go-to telescopes such 200-mm (8 inch) SCTs. Online ordering available.
- *ScopeTronix* (<http://www.scopetronix.com>). Distributors of a wide variety of ETX, LX and NexStar upgrades and accessories, including tripods, counterweights, solar filters, external battery packs and replacement finders. Online ordering available.
- *SkyPointer* (<http://www.skypointer.net>). Manufacturers of a pen-sized laser pointer that can also be used as a finder device. Online ordering available.

Go-To Telescope Support and Commentaries

There are several web sites devoted to go-to telescopes of various sorts, some of which have become real focal points for mutual support and discussion between amateurs using specific designs of instrument.

- *Jan's LX 90 Pages* (<http://m1.aol.com/kewtasheck/lx90.html>). A rich seam of information on using and expanding the LX 90 SCT, including sections on updating the handset and improving pointing accuracy.
- *LXD55.com* (<http://www.lxd55.com>). Reviews, upgrades, astrophotography and more make this an essential read for owners of Meade's LXD 55 family of reflectors and refractors.
- *Meade Advanced Products Users Group* (<http://www.mapug.com>). Eclectic collection of opinions and e-mails rather than articles, this web site offers some useful information for owners of ETX and LX series telescopes.
- *NexStar Resource Site* (<http://www.nexstarsite.com/NUG.htm>). Arranged as a companion to a forthcoming book covering all aspects of NexStar use, this site includes many useful articles and downloads.
- *NexStar Web site* (<http://home.att.net/~nexstar/index.html>). Not regularly updated but still useful site with reviews and commentaries on the first generation of NexStar telescopes.
- *Weasner's ETX Home Page* (<http://www.weasner.com>). Exceptionally valuable resource for Meade ETX telescope users covering every imaginable aspect of their use from troubleshooting go-to reliability through to astrophotography.

Webcam and Digital Astrophotography

Cameras and Adapters

Webcams can be used as they are out of the box, or modified to extend the exposure lengths and reduce the noise apparent on the images. The following links include web sites detailing their use and modification or sell useful accessories.

- *Ash's Astronomy Pages* (<http://astro.ai-software.com>). Descriptions of various webcam modifications together with some nice galleries, including a Messier object album!
- *Astrocam.org* (<http://www.astrocam.org>). Webcam modifications, galleries and help files; very useful web site.
- *Kendrick Astro Instruments* (<http://www.kendrick-ai.com>). Distributors and manufacturers of various telescope accessories including the "Kwik Focus" Hartman mask. Online ordering available.
- *Long exposure webcams* (<http://home.clara.net/smunch/wintro.htm>). Includes schematics and explanations of various builds and comments on which cameras they work with.
- *QUCAIG* (<http://www.qcuiag.co.uk>). QUCAIG is short for the Quick Cam and Unconventional Imaging Astronomy Group, and is a useful site for image processing and descriptions of webcam modifications.
- *SAC Imaging* (<http://www.sac-imaging.com/main.html>). Manufacturer and distributor of low-cost CCD cameras, a significant step up from a regular webcam in performance and a fine alternative to a do-it-yourself webcam modification. Online ordering available.
- *Sarawak Skies* (<http://www.angelfire.com/space2/tgtan>). Nice tutorials on image processing, the fundamental step to getting satisfying images from webcam movies.
- *ScopeTronix* (<http://www.scopetronix.com>). Besides the telescope accessories mentioned above, ScopeTronix also produce adapters for connecting a large number of digital cameras and camcorders to telescopes. Online ordering available.
- *Steven Mogg's Webcam Adapters* (<http://webcaddy.com.au/astro/adapter.htm>). These adapters provide an easy way to connect a webcam to a telescope, and the range includes adapters for most webcam models. Adapters also available for SLR and digital cameras. Online ordering available.
- *William Optics* (<http://www.william-optics.com>). A wide variety of adapters for fitting Fuji, Nikon, Sony and other popular digital cameras to telescopes. Online ordering available.

Astrophotography and Image Processing

Webcam astrophotography has become very popular, not least of all because the cameras are inexpensive and compatible with most computers and telescopes. Registering, stacking and processing webcam images does require specialized software though, but fortunately most of this is available on the Internet for free.

- *Adobe Photoshop* (<http://www.adobe.com>) for Windows and Mac. Powerful, surprisingly easy to use image editing software. Good, but expensive. Commercial.

- *AstroStack* (<http://www.astrostack.com>) for Windows. Very powerful and rightly popular application for combining frames from a webcam movie into a single high-resolution image. Shareware.
- *AstroYacker* (<http://home.iprimus.com.au/rodkenedy/Astro/Jerra.html>) for Mac. AstroYacker manipulates webcam movies prior to stacking, for example rotating frames to compensate for field rotation so that they align better.
- *The GIMP* (<http://www.gimp.org>) for Windows, Mac and Linux. Open-source image editing software; a great zero-cost alternative to *Adobe Photoshop*. Freeware.
- *GIMP for Windows* (<http://www.gimp.org/~tml/gimp/win32/>) for Windows. Windows-native port of *The GIMP*. Freeware.
- *JImage* (<http://rsb.info.nih.gov/ij>) for Windows, Mac and Linux. Java-based image processing application. Fast, relatively easy to use and comes with built-in image stacking tools. Freeware.
- *Jasc Software* (<http://www.jasc.com>) for Windows. A popular consumer-level application that accomplishes many of the things possible with *Adobe Photoshop* but at a significantly lower cost. Commercial.
- *Keith's Image Stacker* (<http://www.unm.edu/~keithw/software.html>) for the Mac. Broadly equivalent to *AstroStack*. Shareware.
- *Macam* (<http://webcam-osx.sourceforge.net>) for the Mac. Image capturing software for USB webcams including many designs that are not otherwise Mac compatible. Freeware.
- *Photoshop for Astrophotographers* (<http://www.astropix.com/pfa/pfa.htm>) for Windows and Mac, an electronic book on a CD including tips and tutorials for using this application with both traditional film and electronic images. Commercial.
- *Qastrocam* (<http://3demi.net/astro/qastrocam>) for Linux. Source code for building webcam capturing and stacking software for Linux computers. Compatible with a wide variety of webcam models. Freeware.
- *Registax* (<http://aberrator.astronomy.net/registax/index.html>) for Windows. Sophisticated software for aligning frames from webcam movies precisely and including a great many tools for processing the resulting images. Freeware.

Web Sites: Reviews and Resources

Amateur Astronomical Societies

- *American Association of Amateur Astronomers* (<http://www.corvus.com/index.html>). A very rich resource with articles on all manner of topics, from quantifying seeing conditions through to detailed descriptions of the constellations. Also plenty of links to other resources, an astronomy store, and of course membership information. Highly recommended even for amateurs outside the US.
- *Astronomical Society of Australia* (http://www.atnf.csiro.au/asa_www/astro.html). The web address given here isn't to the main site of the ASA, which is primarily a professional body, but to their comprehensive list of amateur astronomy societies in the southern hemisphere.
- *British Astronomical Association* (<http://www.britastro.org/main/index.html>). Home page of the BAA, which is divided up into various observing sections covering topics like Saturn and Aurorae.

Astronomy Resources and Information

- *Clear Sky Clock* (<http://cleardarksky.com/csk>). Home page for the Clear Sky Clocks used by many amateurs to predict observing conditions for a few nights in advance. The data comes from the Canadian Meteorological Centre, and there are links on this page to clocks that cover most of North America. Very useful.
- *Digitized Sky Survey* (http://www-gsss.stsci.edu/DSS/dss_home.htm). Put together by the Space Telescope Science Institute using the Oschin Schmidt Telescope on Mt. Palomar and the UK Schmidt Telescope in New South Wales, Australia. Several programs (such as *XEphem*) allow users to access these images easily.
- *Ken's Telescope Calculator* (<http://www.klhess.com/telecalc.html>). Determines aspects of telescope performance such as magnification as well as more tricky measurements like true field and exit pupil using JavaScript. Easy to use, and very useful, and comes complete with some of the most popular eyepieces built-in!
- *FAQ About Collimating a Newtonian Telescope* (<http://zebu.uoregon.edu/~mbartels/kolli/kolli.html>). Another good collimation site, including information on the available tools, such as laser collimators.
- *Seeing Forecast for Astronomical Purposes* (http://www.cmc.ec.gc.ca/cmc/htmls/seeing_e.html). A useful explanation of the five-point seeing scale used by many amateur astronomers and by online "Clear Sky Clocks". Complete with a very useful animation that shows what a star under each point along the seeing scale would look like.
- *Sky & Telescope: Saving Dark Skies* (<http://skyandtelescope.com/resources/darksky>). Includes discussions of light pollution and how to minimize its effect, plus a detailed explanation of the Bortle Dark Sky scale.
- *Sky Transparency Forecast for Astronomical Purposes* (http://www.cmc.ec.gc.ca/cmc/htmls/transparence_e.html). As above, for transparency.
- *Thierry Legault's "The Collimation" page* (<http://perso.club-internet.fr/legault/collim.html>). A very detailed and helpful site describing what collimation is, how it affects astronomical images, and the ways to correctly collimate a telescope. Essential reading for owners and users of reflecting telescopes.

Equipment Reviews

Astronomical equipment reviews are extremely popular, and many amateurs put up notes on their equipment up on their web sites to share with others. Review sites like the ones listed below take this further in one of two ways: either *compiled* from reviews undertaken by a single author, or *edited* from submitted reviews written by many different authors. Single-author web sites are more consistent in quality and methods, making the comparisons between telescopes and accessories more meaningful, but the workload on one person does mean the site expands only slowly. On the other hand multi-author sites are much more dependent on the quality of the submissions made to them; at their best, with a peer-review process, a constant level of quality can be maintained as well as a much broader and faster evolving range of reviews. The following include some of the most popular and respected review sites.

- *Affordable Astronomical Equipment Reviews* (<http://members.tripod.com/irwincur>) edited by Curt Irwin. A review sites focused on low-cost astronomical equipment, such as telescopes costing \$1500 or less. The quality of the reviews is variable, but there is a

good range and plenty of useful information. There is also a spin-off mailing list that complements the site giving amateurs on a budget a forum for discussing equipment and techniques.

- *AppleLust* (<http://www.applelust.com/scitech>) edited by David Schultz. The science and technology section of AppleLust includes the largest collection astronomy program reviews on the Internet, primarily for the Mac OS but including some for Linux and Windows.
- *Cloudy Nights Telescope Reviews* (<http://www.cloudynights.com>) edited by Allister St. Claire. One of the best multi-author sites and the only one with a formal peer-review process. A team of experts reads the reviews first, and then they discuss their conclusions with the author. This works to improve consistency and objectivity, and helps authors to elucidate their observations and opinions more clearly.
- *Excelsis* (<http://www.excelsis.com>) edited by Excelsis Consulting. The great variations in the quality of the reviews at this site is balanced by the enormous breadth they cover, and this site is a useful first stop for information on a wide range of topics including telescopes, eyepieces, retailers and books. Although visitors are able to submit reviews freely, a form of weighting does exist to mark out good reviews from unreliable and poorly written reviews ones.
- *Heretics Guide to Choosing and Buying Your First Telescope* (<http://www.findascope.com>) compiled by Michael Edelman. Very detailed explanation of the factors to consider before purchasing a telescope. Somewhat partial and idiosyncratic, but useful nevertheless.
- *Scope Reviews* (<http://www.scopereviews.com>) compiled by Ed Ting. This is one of the oldest and most respected review sites and probably the one against which all the others are compared. Ed Ting's reviews are objective and balanced, taking into account factors like price and ease of use as well as optical quality, and cover a good range of equipment from small aperture reflectors through to top of the range apochromatic refractors. *Scope Reviews* is divided up into sections some of which are logical enough (e.g., reviews of all the Radian eyepieces) but others are simply chronological admixtures of whatever was being reviewed at that time.
- *Todd Gross' Weather and Astronomy Site* (<http://www.weatherman.com>) compiled by Todd Gross. Like *Scope Reviews* this is a single author site and as such there are logical and detailed comparisons between the various telescopes and accessories discussed. The various reviews are generally balanced and well written, and although not laid out as clearly as some, this is still one of the best review sites out there.

Observing

There are many different web sites devoted to particular aspects of astronomical observing on the Internet, and only a few can be listed here. Some are straightforward lists of things like double stars or deep sky objects, but more interesting perhaps are those web sites that combine text, images, sound and video.

- *33 Doubles* (<http://www.carbonar.es/s33/33.html>). Observing projects and commentaries based around double and multiple stars. Aimed at amateurs using equipment ranging from binoculars through to large aperture telescopes.
- *Antonio Cidadão's Home Page* (<http://astrosurf.com/cidadao>). Truly spectacular images of the Moon and planets combined with detailed notes and diagrams make this web site an essential stop for those interested in solar system observing.

- *Hitchhiker's Guide to the Moon* (<http://shallowsky.com/moon>). A reference guide for lunar observers by Akkana Peck and others. The prime attraction is a map of the Moon that is illuminated according to its phase and divided up into small sections. Click on any one of these to find out about interesting features in that region. Based on the highly praised but out-of-print guidebook to the Moon by Anton Rühl.
- *Inconstant Moon* (<http://www.inconstantmoon.com>). An unusual multi-media astronomical web site that nicely shows off the potential of the Internet for mixing different sorts of educational and entertainment approaches. Moon-themed music plays in the background (this can be switched off easily enough) while the visitor uses interactive tools like a lunar calendar and an illustrated, hyperlinked encyclopaedia of lunar features. A selection of the sights best seen on the Moon that day is offered together with lists of events such as lunar eclipses.
- *Invitation to the Moon* (<http://mo.atz.jp/index-e.htm>). Morio Higashida's web site describes many of the most interesting features on the Moon and is particularly inspirational for those observers looking for ideas of things to image using a webcam or digital camera.
- *Observing With A 6" Reflector* (http://www.geocities.com/the_150mm_reflector/). Alistair Thomson's web site includes observing ideas and reports submitted by amateurs using a wide variety of telescopes, not just the 6-inch reflector suggested by the title.
- *Royal Astronomical Society of Canada's Finest NGC observing list* (<http://www.seds.org/messier/xtra/similar/rasc-ngc.html>). Although the deep sky objects that make up the NGC tend to be overlooked by beginners in favor of the Messier Catalog, there are some nice objects hidden among the hundreds of faint and commonly rather unimpressive entries. This page lists many of them, and has them arranged by season to help you see them at their best.



Seeing, Transparency and Darkness

Estimating Seeing Conditions

Many beginners find it difficult to judge seeing objectively. Basically the seeing depends on thermal currents and other movements in the air. By looking at a star at high magnification (30–50 times per inch of aperture) and then taking the image out of focus, it is really quite easily to spot these air currents. Under good seeing conditions the image, though now blurred, will be steady and the Airy disc and the diffraction rings will be clear, but if the seeing is bad the Airy disc and diffraction rings will be rapidly scintillating and difficult to distinguish. Of course this assumes the telescope is properly collimated and that it has been allowed time to cool down. In fact warm air currents inside a telescope that has just been brought outside essentially mimic bad seeing, and that is why telescopes need to reach thermal equilibrium with the night air before they can deliver good images. Many astronomers simply talk about “poor” or “good” seeing to describe the conditions they find themselves observing under, but more neatly divided scales do exist. The American Association of Amateur Astronomers (AAAA) and the popular online Clear Sky Clocks use a five-point scale based on that developed by a planetary astronomer by the name of E. M. Antoniadi, as follows:

- (I) Star image appears to be a “boiling” blob with no differentiation between the Airy disc and diffraction rings. This is the poorest seeing, described as “severely disturbed” by the AAAA, and even at low power stars looks blurry. No detail on planets, and views of the Moon are disappointing and difficult to focus as the craters and seas seem to bubble and move.
- (II) Star still boiling and difficult to focus, but at low powers at least images are acceptable if not sharp. Some differentiation between the brighter central part of the star and the fainter edge, but with no sign of the Airy disc or diffraction rings as such. The AAAA calls this “poor seeing”.

- (III) Star now divides clearly into the Airy disc and the diffraction rings, although the rings are more incomplete arcs than complete rings, and will seem to move about a bit under the influence of the slight air currents. The Airy disc will be approximately circular, though again there may be constant changes to its shape as well. This is the sort of night where it becomes worth staying out and looking at the planets and Moon with a reasonable expectation of seeing some detail at moderate powers, what the AAAAA calls a night of “good seeing”.
- (IV) Star with clear and sharp Airy disc and diffraction rings. The central disc is uniformly bright and fairly steady, and the rings will be more or less complete with only small gaps here and there. The AAAAA calls this “excellent seeing” and you can expect good images of the Moon, planets and double stars at moderate powers, though at high magnifications detail, though evident, will appear a little blurry.
- (V) Star displays textbook-quality Airy disc and diffraction rings: the disc is circular and steady, and the rings around it are perfect circles. Described by the AAAAA as “perfect seeing” this is the sort of night amateur astronomers dream about. Magnification can be ramped up to the theoretical limits of the instrument without noticeable image breakdown, and views of all objects will be steady, crisp and detailed.

Estimating Transparency

By day at least it is easy enough to appraise transparency; the clearer the sky of clouds, and the deeper the shade of blue the sky is, the better the transparency. On really good days the sky will be a deep blue right above your head, almost violet. These promise dark nights when you hope the Moon isn't above the horizon and you can get some real deep sky observing done. Transparency is how much light gets from the object being viewed to the observer without being scattered by haze, dust, pollen and other things in the air. Although many beginners confuse transparency with seeing, the two things are quite different, and in fact they aren't usually good at the same time: steady seeing tends to be associated with low transparency, and vice versa. The reason for this is the clear, cold air that is most transparent is also the most mobile, and will, for example, be agitated by heat radiating off the ground after sunset. In contrast the steady air of summer will often be humid, and its very stillness means that particulate matter can just hang there messing up your images. It is a rare night indeed that is both still and clear! There are various scales used for transparency, the following is based on that used by the AAAAA:

- (0) The sky is overcast or raining, and no observing is possible. Entirely normal if you have just bought a new telescope.
- (1) More or less completely overcast with only a few poor patches of thinner cloud or hazy open sky though which the Moon, bright planets and perhaps a few of the brightest stars (like Sirius or Capella) can be glimpsed. Not worth going outside to observe, what the AAAAA calls “very poor” transparency.
- (2) Incomplete cloud cover or approximately open skies but with thick haze. Visibility of Moon will be okay for naked eye or binocular views, where craters and seas can be seen easily, albeit with streaks of cloud or haze passing in front of the Moon continuously. Bright stars and a few medium-bright stars (down to about second magnitude, such as Polaris and Kochab in Ursa Minor) will be visible as well. For the AAAAA this is “poor” transparency and not really worth bothering with (except in the UK where this is often as good as it gets for weeks on end).
- (3) Sky essentially devoid of low-level fluffy clouds but substantial haze apparent, or else thin, wispy cirrus clouds at high altitude. “Somewhat clear” using the AAAAA scale, the

planets and bright stars are easily visible and some fainter stars as well, down to about magnitude. A popular benchmark is the visibility of three or four stars in the Little Dipper asterism, besides Polaris and Kochab, Pherkad and perhaps Epsilon Ursae Minoris should be apparent as well.

- (4) Fairly clear with only a little haze and fainter stars, below fourth magnitude, should be easily visible. In the Little Dipper, expect to see four or five stars, the four mentioned so far plus Zeta Ursae Minoris. Close by Kochab, 5 Ursae Minoris will be visible as well. By the AAAA scale this is termed a “partly clear” night. This, and the preceding category, is typical of the warm, humid summer nights that offer excellent seeing but poor transparency.
- (5) An AAAA “clear” night, with no clouds and very little haze. With averted (indirect) vision the Milky Way should be easy enough to detect, and all the stars in the Little Dipper asterism except the faintest, Eta Ursae Minoris, can be seen.
- (6) Cloudless and almost entirely haze-free skies under which the Milky Way is easily seen with direct vision. Deep sky objects like M31 and the Double Cluster in Perseus should be visible as distinct blurs to the naked eye. All seven stars in the Little Dipper can be seen. Termed a “very clear” night by the AAAA.
- (7) Completely cloudless, haze-free skies that are exceptionally clean of dust and other particulate matter liable to scatter light. Considered “extremely clear” by the AAAA these are the sorts of nights under which objects like the globular clusters the Great Hercules Cluster M13 and M15 in Pegasus are obvious if blurred points of light, and galaxies like the Triangulum Galaxy M33, and M 81 can be seen with the naked eye. For keen deep sky observers, the very rare nights like these are the stuff of dreams!

Estimating Sky Darkness and Light Pollution

The final set of conditions that need to be included in an observing report is the ambient sky darkness, or as far as many people observing in suburban areas, the amount of light pollution. Dust and haze reflect natural sources of light like the Sun or Moon, even after that light source has slipped below the horizon, and even in the deep desert the night sky is never truly black. But it is near human habitation that light pollution becomes a real problem. At their worst, artificial light sources such as street lamps, billboards, houses and playing fields floodlighting produce so much unwanted light that can make the night sky not black or even dark, but a sickly orange glow. Dealing with this sort of light pollution is tricky and in general its effect can at best be diminished rather than nullified. Light pollution filters can cut out some wavelengths particular to artificial sources but absent from certain deep sky objects, primarily planetary and diffuse nebulae. Using these filters reduces overall brightness though, and so they are only worth using if you have light to spare, demanding a moderately large telescope in most cases. The least demanding of these filters in this regard are the “broadband” filters, and these can be used with even small telescopes but they have only a marginal effect. “Narrowband” filters work much better but generally need a 150-mm (6 inch) telescope or larger to be worthwhile. In addition to this limitation, none of these light pollution filters has much effect on stars or anything made up of them like galaxies or clusters. The wavelengths of light given off by stars are too similar to that of artificial light sources, and screening out the light pollution invariably dims stars as well.

John Bortle produced a “dark sky scale” for the US astronomy magazine *Sky & Telescope* that has become quite popular among amateur astronomers as a simple benchmark to use for estimating sky darkness. The full thing is rather long and involves lots of criteria for each point on the scale and is best viewed at the *Sky & Telescope* web site (the link is in Appendix 1, under Astronomy Resources and Information); what follows is a summary with some of the key things to look out for.

- Class 1 Excellent dark-sky site with very faint astronomical features like the Zodiacal Light being apparent. Milky Way obvious and may even cast a shadow. Faint naked eye deep sky objects like M33 is obvious, and the naked eye should be able to spot stars down to eighth magnitude. The sky is dark right down to the horizon.
- Class 2 A typical truly dark site, dark enough for M33 to be glimpsed with averted vision, and the structure of the Milky Way, such as the dark patches through Scorpio and Sagittarius, to be seen clearly. The bright globular clusters like M13 are obvious bright spots, and stars down to magnitude 7.5 should be visible.
- Class 3 A good rural sky, with artificial light pollution only visible at the horizon. Bright globular clusters should be visible, and it is possible to see stars as faint as seventh magnitude.
- Class 4 Rural/suburban transition with obvious regions of light pollution extending above the horizon in the direction of towns and cities. The Milky Way is obvious but not structured when overhead. Naked eye limit of star visibility is about magnitude 6.5.
- Class 5 Suburban skies typical of areas even 60 km (35 miles) from big cities, with obvious light pollution along the entire horizon plus some diffuse glow to the rest of the sky. The Milky Way is weakly visible if at all along the horizon and rather pale even overhead. Stars down to about magnitude six can be seen with the naked eye.
- Class 6 A bright suburban sky with the Milky Way visible only directly overhead and no structure can be made out at all. Sky glow extends a significant way above the horizon, its color depending on local conditions but enough to hide all but the brightest stars and planets. Stars down to about magnitude 5.5 can be made out.
- Class 7 Suburban to urban transition with substantial light pollution evident. The sky is entirely grey rather than blue or black, with bright patches on the horizon. The Milky Way is difficult to impossible to see even directly overhead. Even bright deep sky objects like M31 can only be glimpsed, and even through a telescope they are unimpressive. The limiting magnitude for naked eye stars is around five.
- Class 8 City skies; more or less uniformly grey tending towards orange, and not really dark at all. Though some of the stars making up M45, the Pleiades, can be seen, M44, the Praesepe, is invisible. Some of the stars of the fainter constellations and asterisms such as Cancer and the Little Dipper are not apparent without binoculars, indicating a limiting magnitude of around 4.5
- Class 9 Inner-city skies offering nothing for deep sky observers. The sky is bright, and only the brightest stars are visible, and even then not particularly outstanding. Depending on the conditions stars as dim as magnitude four might be glimpsed.

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