THE BAA OBSERVERS' WORKSHOPS

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Dr Stewart Moore fascinated the Winchester audience with his deep sky drawings

Observing and drawing the deep sky

by Stewart Moore

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Introduction

Despite advances in photographic emulsions and the rapid evolution of CCD cameras, drawing is still a valid and enjoyable method of recording the appearance of deep-sky objects. It is cheap, simple and most importantly, you do not have to be a great artist to make a permanent record of what you observe.

The eye and brain combination is a very sophisticated light detector, with the ability to record detail over a wide range of intensity. This means that both faint and bright detail can be seen together – for example the bright core and faint outer arms of a spiral galaxy. This is something that other forms of imaging often struggle to achieve.

Of course, if you are observing under a light polluted sky, you cannot hope to see the faint detail that a CCD observer might record. But even urban observers will find there is much in the sky to keep them occupied and the use of special filters will often allow objects to be seen which otherwise might be invisible. Choice of objects is therefore important. While emission nebulae and star clusters make good targets for poor skies, large faint galaxies are best left to pristine skies and large telescopes.

Drawing techniques: initial considerations

There are few rules on how to draw deep-sky objects and the newcomer is advised to experiment with different styles and techniques and use those that are found most satisfactory. Probably the first decision to be made is whether to complete the drawing at the telescope, or whether to make rough sketches at the telescope and complete the drawing indoors.

This will depend to some extent on the observer's situation. If you have a nice comfortable observatory, well protected from the weather and with a driven telescope, then it would make sense to consider making the completed drawing at the telescope. However, if you are observing in the open with an undriven telescope, standing on a step ladder with the eyepiece at an awkward angle, it might be impossible to produce a finished drawing of any accuracy. In this case rough sketches and copious notes would be more sensible, with the drawing completed later.

Even if making a finished drawing at the eyepiece, notes should always be made – a hand held portable audio recorder is most useful for this – as it is often impossible to convey all the subtleties of an object on the drawing. However, be prepared for strange looks from your neighbours if they hear you talking to yourself in the middle of the night in your garden. The sort of things to consider when making notes will be discussed later.

Whatever technique is employed, the aim is to produce an accurate impression of what was seen through the eyepiece. If the completed sketch looks bland compared to photographs that you have seen this is of no concern, provided you are sure it is an accurate representation of what was visible.

Generally, objects are drawn in negative form using a soft lead pencil on white paper. Star clusters are drawn with the stars shown as circular black dots – the larger the dot the brighter the star. A diameter of 3mm for a first magnitude would be suitable, although this can, of course, be varied to suit the range of stars that are visible in the eyepiece. Any nebulosity is then drawn as grey or black shading. The darker the shading the brighter the object. This negative form of drawing is the opposite to that used on the planets, where, for example, the dark belts on Jupiter would be drawn as dark shaded areas and the polar caps of Mars left white.

Some people draw deep-sky objects as positive images, using white pencils on black paper and this can give a very realistic view. Nowadays, a negative drawing can be scanned and reversed using one of the many software packages available. Purists may regard this as cheating, but the results can be very effective. An example of this technique will be given later.

The eye: seeing detail

The human eye contains two sets of light detection devices, rods and cones. The cones are concentrated in the centre of the retina and are the light detection device we use to go about our every day business – such as buying telescopes. They also allow us to see colour. The rods are positioned off-axis and are much more sensitive than the cones, so it is the rods that we use under extremely low light levels when hunting for faint deep-sky objects. The trick therefore to seeing very faint objects is to look slightly to one side rather than straight at them. This is called using averted vision. As certain parts of the eye off-axis may be more sensitive than others, it is always worth scanning around the object to see if more detail can be seen in certain positions.

Some objects show interesting changes between direct and averted vision. One particularly nice object for this is the planetary nebula NGC 6826 in Cygnus, known as the blinking planetary. In a small telescope direct vision will show only the central star. Averted vision will make the surrounding nebula appear, while giving the impression of dimming the star.

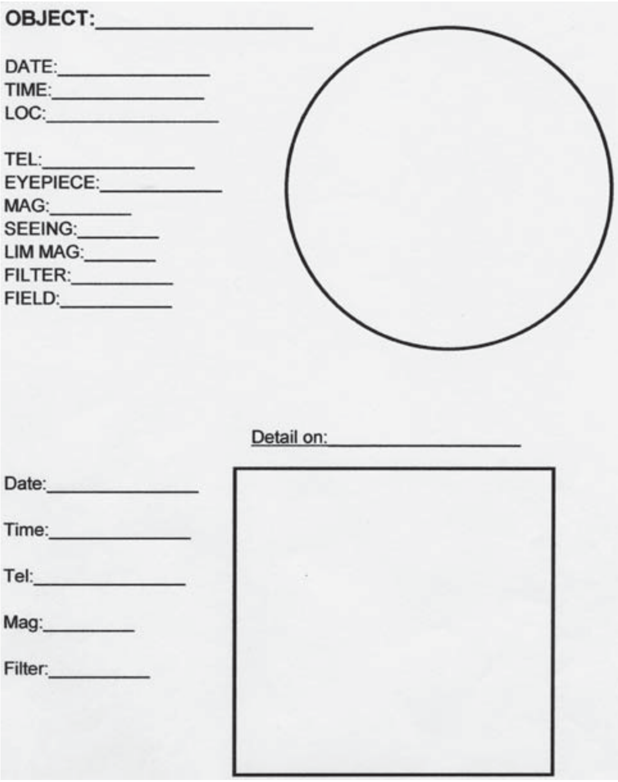


Figure 1. Field and detail drawing blanks as used by the author.

Switching back and forth between direct and averted vision can make the planetary appear to blink, hence its name.

When hunting for very faint objects it is essential that you are properly dark-adapted. There are two stages to this process. Within the first minute of going from light to dark the pupil of the eye opens and the eye becomes more sensitive. However a more gradual process, the building of a chemical in the eye called visual purple, also takes place. This takes much longer – up to an hour in some cases. This chemical build-up increases the sensitivity of the eye enormously and is the main reason why, once properly dark-adapted, you should avoid going back into a lighted room until the observing session is over.

A black cloth placed over the head to exclude all traces of light when at the eyepiece is another trick that can often help in snaring that elusive faint galaxy, although beware that covering your head while breathing will often cause the eyepiece to fog up. If this happens, the best solution is to take a very deep breath and then avoid breathing while you search. Clearly there is a limit to how long you can keep this up. Also be aware that if you are observing in a public place, someone with a black cloth over his or her head may well appear suspicious, especially when equipped with a telescope that looks like a rocket launcher....

Always use a dim light to illuminate sketchpads or charts. A red light is generally considered best for maintaining dark adaptation, although some people argue that any light is suitable provided it is very dim. Once you are fully dark-adapted you will be surprised just how little light you need for illumination, and it is best to obtain or make a variable intensity light that can be adjusted depending on how faint an object you are observing and how well dark-adapted you are. A red LED connected through a variable resistor makes an ideal adjustable light source that can be built into a small container and fitted to a drawing clipboard.

When searching for a difficult object, try varying the magnification, as often an object that is invisible at one power will be visible at another. It is generally accepted that increasing magnification makes very diffuse objects easier to see, but there is no hard and fast rule and much depends on local sky conditions, the type of object you are looking at and the telescope/eyepiece combination being used.

For stars, which are point sources, it is the magnitude that is important in determining how easy they are to see. For diffuse objects it is the surface brightness that is relevant. A small 13th magnitude galaxy will generally be much easier to see than a large 10th magnitude one whose light is spread over a bigger surface area. M33, the large 7th magnitude galaxy in Triangulum, can be very difficult to see in a telescope unless the sky is very transparent: yet it can often be seen easily in small binoculars and is a naked eye object from a very dark site.

Filters are an important tool in the visual deep-sky observer's armoury. There are two main types, light pollution filters and nebular filters. Light pollution filters, as the name suggests, are blocking devices that counteract some of the effect of street lights. They work by blocking the transmission of light at wavelengths from around 550 to 600nm, the common light pollution wavelengths. They can work well if you are observing from a heavily light polluted area with a large telescope, but if you have a small telescope – say under 100mm – there may be little or no benefit.

Nebular filters are quite different, and are very sophisticated devices. Although they look similar to light pollution filters, they operate in quite a different way. Whereas light pollution filters let most light through but block out a portion of the waveband associated with street lights, nebular filters block everything except a few narrow emission bands.

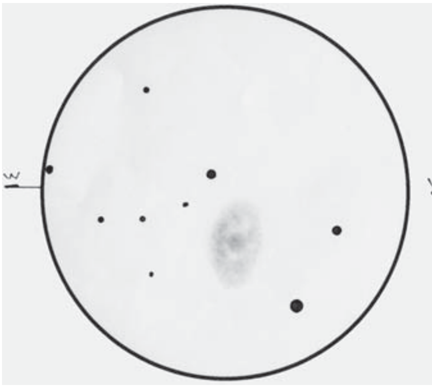
These filters are of no use on continuous spectrum objects, such as galaxies or star clusters, or on reflection nebulae, but they can give superb views on emission nebulae, where they increase the contrast with the background sky and, in many cases, totally transform the view. The O-III filter is designed specifically for planetary nebulae and is an essential tool for observing these objects. The faint outer wings of M27, the Dumbbell Nebula, become an easy target with one of these filters. The UHC filter has a slightly wider band-pass than the O-III and is a good filter for all emission nebulae. The H-Beta filter, sometimes known as the Horsehead filter, has a much more limited use but, as its name suggests, it can make the difference between seeing or not seeing the elusive Horsehead nebula in Orion. It is also excellent on the California nebula in Perseus.

All of these filters are designed to screw in the eyepiece barrel, but they can also be used in a 'blink' mode by passing them between the eye and the eyepiece. This is particularly useful when hunting for stellar planetary nebulae, as the planetary will brighten when in the field, while the stars will dim. Passing the filter rapidly back and forth will cause the planetary to blink on and off. Using the filter in this way also avoids the need for the telescope to be refocused, which will be necessary if the filter is screwed into the eyepiece barrel.

Before you start

Before starting to observe it is important to know both the magnification and the field of view of the eyepiece/telescope combination you are using. Determining the magnification is straightforward; it is simply the focal length of the telescope divided by the focal length of the eyepiece. If the telescope mirror is 300mm diameter and it has a focal ratio of f5 then the focal length is 300×5=1500mm. Used with a 25mm eyepiece this will give a magnification of 1500/25=60.

Determining the field of view is only slightly more complicated, although there is one term, apparent field, which sometimes causes confusion. This is a function of the eyepiece design and has nothing to do with the telescope you use it with. Modern (and often expensive) wide field eyepieces can have apparent fields of view of 80° or more, while older designs may have values as low as 30°. If you were to look through these two eyepieces with the same telescope the size of the object you were looking at (say the Moon) would



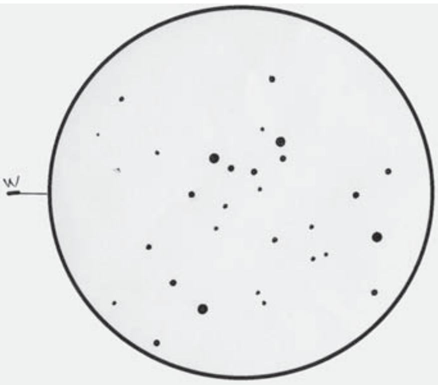


Figure 2a *(left)*. A drawing of M110 (NGC 205) made with a 14-inch (355mm) f5 Newtonian ×142 and an LPR filter. The faint dust lane S of the core makes this elliptical galaxy look like a spiral.

Figure 2b *(right)*. NGC 225, an open cluster in Cassiopeia, with the same equipment (no filter). As is often the case with open clusters, the appearance through the eyepiece does not translate well onto paper.

appear the same, but the wide field eyepiece would show much more surrounding sky. Wide field eyepieces come into their own when looking at objects such as large open star clusters.

If you know the apparent field of view (AFV) of the eyepiece, you can calculate the real field of view (RFV) by dividing this number by the magnification. If you don't know the AFV then you will need to time the transit of a star across the eyepiece. Point the telescope south and select a star close to the celestial equator. With the drive (if you have one) turned off, time the star as it travels across the centre of the eyepiece from edge to edge. The RFV (in arcmin) is the time it takes the star to transit in minutes ×15. For example, if it took the star 2.4 minutes to cross the eyepiece the real field of view is 2.4×15=36 arcmin.

It is also necessary to know the orientation of the eyepiece view, so that you can compare your drawing with photographs or star maps (or even find the object in the first place if you are star-hopping). The first step is to find west. The easiest way to do this is to centre a star in the eyepiece, turn off the drive and watch the star exit the field. The point of exit will be west.

With a conventional Newtonian telescope, or a refractor without a star diagonal, south is then 90° clockwise from this position. With an equatorially mounted telescope these positions will remain constant as the telescope is moved across the sky. If you are using an altazimuth telescope – such as a Dobsonian or an alt-az mounted SCT – field rotation will cause these positions to change as the telescope is moved.

Regardless of how the image is oriented in the eyepiece, this type of view is called 'correct', and can always be compared with a star map by rotating the drawing until the cardinal points coincide. If you are using a refractor fitted with a star diagonal, or a Schmidt–Cassegrain telescope, then you will have what is called an 'incorrect' image and north, rather than south, will be 90° clockwise from west. Comparison of an 'incorrect' image with a star map is very difficult as you need to look through the back of the map, but many software packages allow you to plot charts with this orientation.

The orientation of an object relative to north is known as its position angle. This is measured from north through east. For example, a lenticular galaxy lying northeast/southwest would have a position angle of 45°. Because objects exit the field of view on the west and enter on the east, these two directions are sometimes referred to as preceding and following. These terms can also be incorporated into the definition of position angle so, in the above galaxy example, its position angle could be stated as north following/south preceding or, as more usually written, nf/sp.

Drawing techniques – paper & pencils

It is useful to have standard forms on which to draw and report your observations. Some people use commercial art paper for the drawing and record notes either alongside or in a separate notebook, while others (including the writer) generate their own sheets on standard A4 printer paper. Normal printer paper has a plain surface, but if art paper is used as a backing sheet while sketching this gives the effect of texture, allowing a more realistic result to be obtained.

Other backing sheets can be used and it is always worth experimenting with different materials. Fine sandpaper can give interesting results if used with care. Two forms should be made, one for recording the full view as seen through the eyepiece, and the other for showing detail. An example of two suitable forms is shown as Figure 1. Suitable sizes for the drawing area are 90mm diameter for the eyepiece view and 90×90mm for the detailed sheet, but some people may prefer to make both larger.

The full eyepiece view sheet is ideal for drawing large objects at low power, or small objects at high power. It can also be used when more than one object is visible in the field, such as a cluster of galaxies. For many observations the two forms can be used together: one giving a wide field view with the surrounding star field – both attractive and useful for identification purposes – and the other giving a detailed view of part of the field or an object in the field.

Just because a galaxy looks tiny through the eyepiece is no reason to draw it that size. Often considerable detail will be visible in an object only 10 or 20 arcseconds in diameter. Mars often appears the same size as many planetary nebulae and yet it is drawn on BAA report forms as a 50mm disk, not as a 5mm disk.

Two examples of how to use the full eyepiece view sheet are given in Figure 2. In Figure 2a the galaxy NGC 205 (M110) is plotted with some of the surrounding star field. The field of view is 22 arcminutes, which in this case gives a scale sufficient for showing detail in the galaxy along with sufficient stars to make an attractive view, while Figure 2b, at the same scale, shows

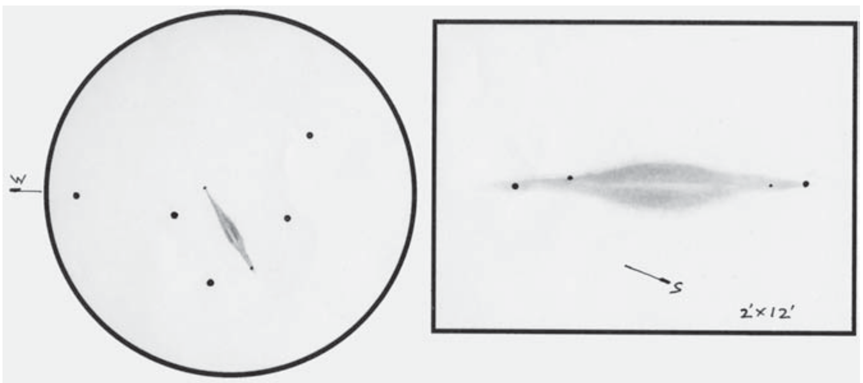


Figure 3. Two drawings of the galaxy NGC 891 in Andromeda made from COAA with a 12" (305mm) f5 Newtonian ×58, illustrating the use of the field and detail templates. Note the dark dust lane in the centre, clearly seen with two small brighter patches of condensation on either side.

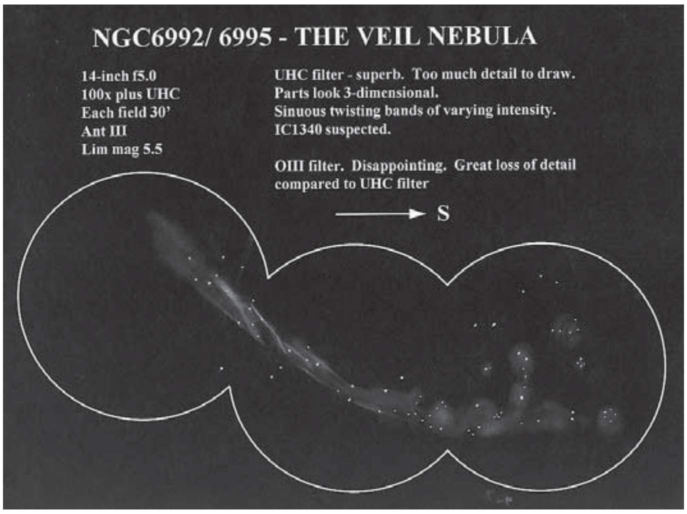


Figure 4. A multi-field sketch of the Veil Nebula, scanned from the original negative drawing and reversed by computer software to give a realistic eyepiece view.

the open cluster NGC 225 which completely fills the field of view.

Figure 3 shows an example, using the galaxy NGC 891 in Andromeda, where the two sketching sheets can be used together. The full eyepiece view shows the galaxy and surrounding stars while the detailed view shows the galaxy alone at an enlarged scale.

Some deep-sky objects are so large that even with a low power eyepiece they still extend beyond the field of view. In this case more than one eyepiece view can be joined together to form a multi-field sketch. When doing this it is important to find field stars that allow the separate views to be stitched together. An example of a multi-field sketch on part of the Veil Nebula is shown in Figure 4. This sketch was originally drawn as a negative image and has been scanned and reversed to give a positive view.

Many nebulous objects have a 'woolly' look to them. Sometimes this is caused by atmospheric turbulence but, more often, it is real and due to the structure of the object itself. There are several ways that this appearance can be transferred to paper. First, it is necessary to choose the correct grade of pencil. While HB tends to be the standard hardness for everyday use, it is too hard for astronomical sketching. A better choice would be 4B, although grades from 2B and 6B should be obtained as each have their use.

Even with a very soft pencil such as 4B, it is still possible to obtain light shading by using it gently, and the soft lead allows erasing without spoiling the paper. A darker outline can easily be obtained by pressing harder. To create a smooth pencilled area, such as that representing a galaxy, using a pencil alone is not easy, even with the pencil held at a shallow angle to the paper, and some method of smoothing is really necessary.

Rubbing the image with a finger will help, and also add some texture to the sketch, but a better option is to use a cotton-bud or an artist's stub. Artist stubs are dense close-rolled tubes of paper in the shape of a pencil. They can be obtained in various sizes and are available from most art shops. Unlike a finger, they will not impart any texture to the image, and so if a 'woolly' feel to the drawing is needed a backing sheet of art paper or some other suitable material should be used (unless you are drawing on textured paper). Cotton buds can work well for smoothing but, as they are smaller and more flexible, less control is achieved than with a stub.

Many galaxies or areas of nebulosity fade gently into the background sky instead of having hard or well defined edges. A finger rubbed over the sketch is a particularly good way of achieving this. Bright areas, such as the core of a galaxy, can be added using a soft pencil, while dark areas can be removed from the drawing with a small eraser. Use a high quality eraser that is firm and which can be cut to shape with a sharp knife to give a fine edge.

If you are using an artist's stub or a cotton bud the best results will be achieved by shaving the pencil lead into a small pile with a sharp knife and then dipping the stub or bud into it and using it like a paint brush. The same technique can be used with a finger if you don't mind ending up with rather grubby hands. An alternative is to rub pencil lead onto the end of the stub until it is thoroughly impregnated.

At the telescope

With any observation there are certain facts that should be noted which will make it more useful for future reference. These should include the following:

Date/Time. Use a double date format to avoid confusion and always use universal time e.g. 2003 July 13/14, 23.40UT.

Telescope/eyepiece combination. Give the telescope type with mirror or lens diameter, focal ratio and the type of eyepiece used.

Magnification and field of view. Magnification is often an important factor in the visibility of diffuse objects.

Observing site. If possible note latitude, longitude and altitude of the site.

Condition of sky. This is most important, as it allows different observations to be compared. Condition of the sky includes such things as seeing and transparency. Humidity levels can also be important, as dew forming on eyepieces can cause everything to appear nebulous.

Many newcomers are confused by the terms 'seeing' and 'transparency' and often use the terms interchangeably. 'Seeing' is a measure of the steadiness of the atmosphere, and is usually rated on the Antoniadi scale from I (perfect seeing with a totally steady atmosphere allowing very close double stars to be cleanly split – very rare) to V (dreadful seeing where the atmosphere is boiling continuously, no detail can be made out and stars' images are fuzzy and dance around the eyepiece). In practice most seeing will range between II and IV. However, even under poor conditions, there will often be short periods of better seeing when more detail can momentarily be made out.

Always allow time for a telescope to stabilise thermally if it has been carried outside from a warm room. Often what seems to be poor seeing will be due to air currents in the tube which will disappear once the telescope has reached the temperature of its surroundings. Depending upon the size of the telescope and the thickness of the mirror, this can take up to an hour.

Generally, the best seeing occurs when the sky is slightly misty and the air appears very still and calm. This is fine for planetary and lunar observing, but not ideal for hunting deep-sky objects. Observing over the roofs of nearby buildings is a sure way to experience poor seeing, as during the night the roof tiles and brickwork start to release all the heat they have absorbed during the day, causing local turbulence.

'Transparency' is a measure of how clear the sky is, and is determined by noting the magnitude of the faintest naked eye star visible. There is a convenient range of stars around the north celestial pole which is ideal for this purpose and which is given in many observing handbooks (e.g. *Norton's Star Atlas and Reference Handbook* – see list of suggested books at end of this article). Most star charting software also gives star magnitudes but beware, many of these magnitudes are slightly wrong, and a better guide would be the special charts used by variable star observers.

Of course, although the faintest star visible overhead is a convenient comparative guide to night-by-night conditions, if you are observing close to the horizon the conditions will be markedly different.

Observing near the zenith means you are looking through approximately 16km of atmosphere, while observing at an elevation of 5° from the horizon increases this to 185km. This results in a magnitude loss of around 4 through atmospheric absorption alone. Any light pollution will increase this loss still further.

Making notes

When observing any object and making notes it helps to have a mental list of points to look for. This is particularly important if only rough sketches are made at the telescope with the drawing worked-up later. These notes will vary with the type of object being observed and the list below, although not exhaustive, shows the sort of things to consider. Some points are obviously relevant to all objects.

Galaxies

Is the shape regular or irregular?
What size is it?
Are there any extensions or indentations?
Is it of uniform brightness?
Is there any concentration to the centre?
Are there any stars superimposed or touching?
How bright or faint is it?
Does it have a woolly or mottled texture?
Are there distinct edges or does it fade gently?
What is the effect of magnification?
How does the appearance differ with direct or averted vision?

Globular clusters

What size is it?
Is there any concentration towards the centre?
Is it open or compressed?
Are any stars resolved?
What is the magnitude range of the stars?
What shape is it?
Is it similar to any other clusters?
What is the effect of magnification?

Open clusters

What does it look like?
What size is it?
What is the magnitude range of the stars?
Are there any holes or star-poor areas?
Are there any chains of stars or particular patterns?
Are there any double stars?
How open is it?
Roughly how many stars are visible?
What is the faintest star seen?
Is there any associated nebulosity?

Making the drawing

One of the biggest problems in transferring the image from eyepiece to paper is getting the scale correct. The best way is to start at the outside of the field and work inwards. If you have a galaxy surrounded by stars, then plot the stars first and draw the galaxy last. In the galaxy sketch shown in Figure 3 it is easy to see how the position of the field stars once plotted will allow the scale of the galaxy to be determined.

Always start with the brightest stars as these can form a framework onto which the fainter stars can be added. If you imagine the eyepiece view and the drawing paper as a clock face this can help in getting the positions correct. It also helps if there are some bright stars near the edge of the field as these can be used to reposition an undriven telescope as the field drifts. In the open cluster sketch shown in Figure 2b the four brightest stars form an easy framework on which the fainter stars can be added, so care should be taken to get the initial plotting correct.

If you are drawing a very rich open cluster, or a globular cluster in which many of the outer stars are resolved, it may not be feasible to draw all the faint stars. In this case, plot the brightest stars and position as many other stars as accurately as possible and then draw an impression of the very faint stars with an added note to explain what you have done.

One interesting area of work for visual observers is to see how areas of nebulosity shown on star maps or star charting programs compare with what can be seen through the eyepiece. An example might be to map the extent of the Orion nebula, the Omega nebula or similar emission objects as seen through different filter systems.

If drawing the nebulosity is the primary aim, then it is quite legitimate not to try to position the field stars by hand but, instead, to plot the stars from a charting program for the field of view of your eyepiece and use this as a template. This technique was used by some of the great visual observers of the past who were interested in discovering if some nebulae were expanding. Of course, they didn't have access to star charting software and had to make do with the limited atlases that were then available. Most charting programs allow you to plot the stars without the deep-sky object added, and you can then sketch the observed nebulosity onto this.

Although some visual deep-sky observers do undertake serious astronomy by carrying out systematic searches for supernovae and the like, the majority of visual observing is recreational. To be out under a dark sky, observing at first hand faint galaxies whose light has travelled for millions of years before impinging on the retina, can give a sense of awe and wonder that just cannot be achieved by seeing the same galaxy in brilliant detail on a computer screen. If this is how you feel about astronomy, then I hope these notes will help you to enjoy it even more.

Useful reading

Norton's Star Atlas and Reference Handbook. Various editions, edited by Ian Ridpath. First published in 1910 and updated at regular intervals, *Norton's* is a mine of useful practical information for the amateur astronomer.

The night sky observer's guide. George Robert Kepple & Glen W. Sanner, Willmann–Bell, Inc. Published in 1998, the NSOG is a 2 volume work aimed at the mid-northern observer. Compiled by amateurs for amateurs, it is predominately a 'visual' book with many drawings of deep-sky objects and descriptions of what might be seen through different aperture telescopes. There is also a useful section on recording and drawing deep-sky objects. This is an excellent book for the visual observer.

Webb Society deep-sky observer's handbooks. Published by the Webb Society. Although out of print these books are still available on the secondhand market. They are an excellent resource for the visual observer. Different handbooks cover different classes of objects. There are many sketches and visual descriptions made through different aperture telescopes. The Webb Society also publishes other material related to deep-sky observing.

Observing handbook and catalogue of deep-sky objects. Christian B. Luginbuhl & Brian Skiff, Cambridge University Press. First published 1990. Excellent descriptions of deep-sky objects observed visually through different apertures, but it only contains a few sketches.

Visual astronomy of the deep sky. Roger N. Clark, Cambridge University Press. First published in 1990, this book is now out of print. In addition to comparisons between photographs and drawings (mainly the Messier objects, but some other objects as well), there are useful sections on the human eye and the whole process of observing and recording what you see.

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Address: Conifers, New Town Road, Thorpe-le-Soken, Essex CO16 0ER. [slm@sigarro.demon.co.uk]