CLUSTERS, NEBULAE & GALAXIES

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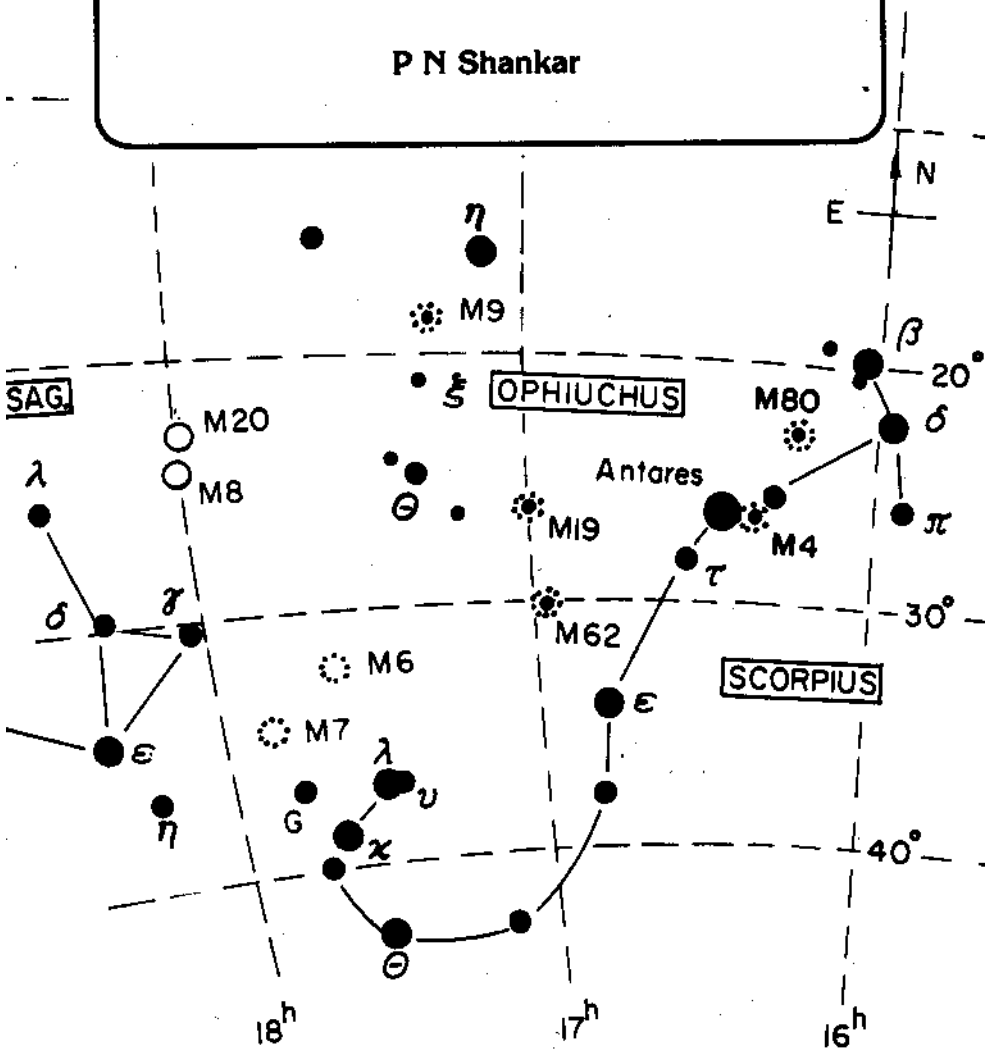

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CLUSTERS, NEBULAE & GALAXIES
A NOVICE OBSERVER'S HANDBOOK

By: Prof. P. N. Shankar

PREFACE

In the normal course of events, an amateur who builds or acquires a telescope will use it initially to observe the Moon and the planets. After the thrill of seeing the craters of the Moon, the Galilean moons of Jupiter and its bands, and the rings of Saturn he(*) is usually at a loss as to what to do next; Mars and Venus are usually disappointing as are the stars (they don't look any bigger!). If the telescope had good resolution one could observe binaries, but alas, this is often not the case. Moreover, at this stage, the amateur is unlikely to be willing to do serious work on variable stars or on planetary observations. What can he do with his telescope that will rekindle his interest and prepare him for serious work? I believe that there is little better for him to do than hunt for the Messier objects; this book is meant as a guide in this exciting adventure. While this book is primarily a guide to the Messier objects, a few other easy clusters and nebulae have also been included.

I have tried, while writing this handbook, to keep in mind the difficulties faced by a beginner. Even if one has good star maps, such as those in Norton's Star Atlas, a beginner often has difficulty in locating some of the Messier objects because he does not know what he is expected to see! A cluster like M29 is a little difficult because it is a sparse cluster in a rich field; M97 is nominally brighter than M76, another planetary, but is more difficult to see; M33 is an approximately 6th magnitude galaxy but is far more difficult than many 9th magnitude galaxies. Thus star maps indicating the positions of these objects are, alone, not sufficient; tables indicating magnitudes and sizes, and descriptions and hints for difficult objects are essential. Plates are a luxury but are most useful if available. In order to keep the size of the book to a minimum, complete star maps of the whole night sky are not given; the Guide Charts given here are self contained and should be sufficient for locating the relevant objects.

Locating and observing clusters, nebulae and galaxies is an exciting task. A beginner who undertakes to see all the objects discussed here is likely to be kept occupied for quite some time. 1 do hope that a significant fraction of such amateurs wilt develop a taste for serious work in observational astronomy,

P. N. Shankar, Bangalore, February, 1985

(*) In this book 'he' = 'he or she', 'him' = 'him or her' etc., except for obvious exceptions.

ACKNOWLEDGEMENTS

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As regards the plates, I would like to thank the OS Naval Observatory and the Anglo-Australian Telescope Board for so graciously giving permission to use their photographs for illustrative purposes. I regret that the plates do not do justice to the originals.

This small book is dedicated to my parents, Smt. and Shri P.S. Narasimhan, who continue to encourage me in my various activities, even when they have doubts about their efficacy.

I. INTRODUCTION

For whom this book is meant

The user of this book is assumed to have some knowledge of the night sky and to have at his disposal a small telescope, say a 10 cm refractor or a home-made 15 cm reflector. He is expected to be familiar with the brighter stars and constellations and to be capable of using star charts and maps. Presumably, he would have observed through his small telescope, the Moon and the planets such as Jupiter and Saturn; it is not, however, assumed that the user has done any serious work on planets or binaries or variable stars. The telescope is expected to have some sighting arrangement, say a simple gun sight, but no finder or guide scope is assumed. More about the telescope later.

The purpose of this book is to help one to locate and observe, through one's telescope, some of the most beautiful objects in the skies. These are the clusters, nebulae and galaxies that dot the heavens. It will be found that, apart from the aesthetic pleasure that one derives from seeing these objects with one's own eyes, there is a thrill even in locating some of them! One has to have had the experience of hunting patiently for many nights before finally seeing, say, a faint galaxy or nebula to fully appreciate this thrill. This is not all; this exercise should provide valuable training in honing observational skills and in preparing one for more serious observational work.

Stars, clusters and other astronomical objects

In order to keep this book self contained, definitions and brief descriptions of the astronomical objects of interest to us will now be given.

Star: A hot, luminous, gaseous body that generates and radiates heat and light through nuclear fusion reactions in its interior. Stars are born in clouds of gas and dust, steadily radiate heat and light during most of their lives and finally die, often explosively.

Planet, satellite, and comet: A planet is a relatively cold, non-radiating, non-gaseous object that orbits about a star. A satellite or moon is a similar object that orbits about a planet. A comet is similar to a planet but its orbit and composition are such that, when close to the star, a part of it vaporizes rendering it luminous and possibly visible.

Nova: A star whose brightness increases in a few days by 100 to 1,000,000 times its original brightness; the star's brightness then slowly diminishes in time.

Supernova: A gigantic stellar explosion in which a star loses a significant fraction of its mass, causing its brightness to increase by many orders. Supernovae are by-products of the death of massive stars, which lead to the formation of neutron stars and black holes.

Neutron star, pulsar, black hole: These are condensed objects, i.e. highly dense objects, that represent the end states of moderately massive and very massive stars. It is believed that stars more massive than about 1.5-2 solar masses evolve into red giant stars then shed *a* fraction of their mass in supernova explosions and end up as neutron stars, pulsars or black holes. In a neutron star, the nuclei and electrons are crushed to such an extent that the protons and electrons fuse to form neutrons, the primary constituent of a neutron star. Pulsars are believed to be rotating neutron stars. Black holes are even more condensed than neutron stars; their gravitational fields are so intense that even light cannot escape from their surfaces.

Cluster: Stars are often born together in huge clouds of gas and dust; these stars are then gravitationally bound and tend to move together. Such an aggregation of stars is called a cluster. There are basically two important types of star clusters. In an open or *galactic cluster,* the stars, say a few tens to a few hundreds of them, are loosely packed in an arrangement that has no special symmetry; open clusters, by and large, lie in the plane, i.e. the disc, of the galaxy. On the other hand, *globular clusters* are approximately spherically symmetric, densely packed aggregates that contain 10,000-1,000,000 stars; they do not lie in the plane of the galaxy but form a halo around its nucleus.

Nebula or diffuse nebula: A cloud of interstellar gas and dust. Nebulae can emit light (by fluorescence), reflect light and absorb light; hence the names *emission nebulae, reflection nebulae* and *absorption nebulae.*

Planetary nebula: An approximately spherically symmetric shell of gas moving away from a very hot star. A planetary nebula and a white dwarf star are the final remains of a solar mass star after its red giant stage.

Galaxy: A huge collection of stars (say, 1,000,000-1,000,000,000 of them), their planets etc., gas and dust held together by gravity. While there appear to be very many types of galaxies, in the simplest classification they generally fall into three groups: *the spirals, the ellipticals and the irregulars.* The galaxy to which our Sun belongs is called the Milky Way; it is believed to be a spiral galaxy. Our nearest neighbours are two irregulars, the *Large and Small Magellanic Clouds;* the *Andromeda Galaxy* is the spiral closest to the Milky Way.

For more information regarding these objects one can refer to books on astronomy, for example, the one by Zeilik (1979).

Position, size and magnitude in astronomy

The simplest, but least precise, way of specifying the position of an astronomical object, is to give its location with respect to the constellations; to say that the *Crab Nebula* lies in Taurus, does roughly specify its position, but not precisely enough to enable us to locate it easily. The most precise way of specifying the position is to give the celestial coordinates, say the right ascension and declination of the object. The right ascension (R.A.) corresponds to the longitudinal position of the object on the celestial sphere; the declination (Dec.) corresponds to the latitude of the object on the same sphere. The R.A. of an object is normally given in hours, minutes and seconds while the Dec. is given in degrees, minutes and seconds. Since we shall not be using celestial coordinates, these will not be discussed any further. An approximate but sufficiently accurate way for our purposes is to give the position with respect to known objects that are nearby; thus the knowledge that the *Crab Nebula* is about 1.5^0 NW of the star Zeta *Tauri* is sufficient to locate it; similarly the knowledge that the *Ring Nebula* is approximately half-way between Beta and Gamma *Lyrae* is sufficient to find it. We shall use this method of description, in conjunction with special Guide Charts, to help locate the objects of interest to us.

It is often of considerable help to know the rough size of the object that we are trying to locate. The apparent size of an object is given in terms of its apparent angular size, i.e. the solid angle that it subtends, in degrees, minutes and seconds of arc. Recall that 1 degree (°) — 60 minutes (‘) = 3600 seconds (“). For purposes of comparison it is useful to keep in mind that the apparent diameter of the Moon is about 0.5° (i.e., about 30' of arc).

In astronomy, the apparent brightness of an object is given by specifying its magnitude (Warning: magnitude refers to brightness not size!). The brightest stars are said to be of 1st magnitude; 2nd magnitude stars are fainter, 3rd magnitude fainter still etc. The faintest stars visible to the naked eye, under good conditions, are approximately of 6th magnitude. For stars and objects fainter than 6^{th} magnitude, optical aid is essential. *When considering brightness one should keep in mind that a diffuse object of given magnitude will appear fainter than a star of the same magnitude; this is because the same amount of tight is spread out over a diffuse object, making it appear fainter.*

II. TELESCOPES

Types and Characteristics

The principal types of telescopes available to most amateurs are simple refractors and reflectors. For any given aperture, a refractor is more expensive to make or buy than a reflector of the same aperture; this is because a refractor has to employ an achromatic objective lens, an optical element that is difficult to make and is consequently expensive. Thus, whereas an amateur can hope to make, reasonably inexpensively, a 15-20 cm diameter reflector, even a 10 cm refractor is very likely beyond his means and abilities. Consequently, it is more than likely that the instrument used by the amateur is a Newtonian reflector. On the other hand, it should be pointed out that for the same aperture, if cost is of no consequence, a good refractor is likely to be superior to a good reflector; this is primarily because of the increased useful field of view and the reduced convection currents in the telescope tube.

A telescope is characterised primarily by the aperture or diameter D and the focal ratio *(f-* ratio) **F/D** of the primary mirror or objective; here F is the focal length of the primary. The main functions of a telescope are to i) gather light in order to be able to see faint objects, (ii) resolve (i.e., get better definition of) objects and (iii) magnify objects. For the first two functions, namely for light gathering power and resolving power, the aperture D has to be as large as possible. As regards magnification, since angular magnification M — F/f_e, where f_e is the focal length of the eyepiece, for a given

objective the magnification increases when shorter focal length eyepieces are used. A related parameter is the *field of view* or the area of sky visible through the eyepiece of the scope; in general, the field of view is inversely proportional to the magnification i.e. the field of view will decrease with increased magnification.

For the objects described in this book a reflecting telescope of 15 cm aperture, i.e. D=15 cm, should be sufficient; a good refractor of 10cm aperture would probably also be sufficient. With smaller telescopes, say 10-12.5 cm reflectors or 7.5 cm refractors, most of the clusters and some of the brighter nebulae and galaxies will be visible on clear, dark nights. The focal ratio is not too important, but it is likely that a home-made reflector would have a focal ratio around 8, while a refractor would have a focal ratio around 15. Most amateurs will find it difficult to obtain anything better than a Ramsden eyepiece of focal length around 25 mm i.e., f_e = 25 mm; thus for an *f/8 (i.e.,* F/D =8) primary mirror of 15 cm aperture, the magnification with a 25mm eyepiece will be M = 8 X 15/2.5=48.

In principle, one should have a range of eyepieces, say 3 of them, for low, medium and maximum magnification depending on the type of object being observed; low magnification may be suitable for observing large open clusters and high magnification for resolving stars in a globular cluster, say. In practice, most amateurs will for reasons of availability and finance be limited, at least in the beginning, to using a single eyepiece; for most purposes an eyepiece of 25 mm focal length will be found to be adequate. As regards type of eyepiece, at present only the Ramsden eyepiece is manufactured in India; while this is adequate for our purposes, Kellner or orthoscopic eyepieces would certainly be preferred if and when available.

The telescope mount should be as rigid as possible. The mount could be either an equatorial mount or a simple altazimuth; no mechanical drive is assumed. The telescope must have a gun sight or a finder. A finder is a small telescope, of low magnification and wide field, attached to the main telescope, in order to help locate objects. Most amateurs, especially in India, will have difficulty in obtaining a decent finder scope. A simpler, and for our purposes, satisfactory, alternative is to use a gun sight i.e., two rings of diameter 20 mm and 8 mm, say, mounted about 50 cm apart and aligned so that a distant object centred, when viewed through these, will be sighted in the eyepiece of the main instrument. In any case it is essential that the telescope have a gunfight or finder.

Adjustments and tests

Before starting any serious observations it is a good idea to make any adjustments that might be necessary to get the best out of the scope. If the telescope is a home-made reflector, make sure that both the main mirror and the diagonal are floating, i.e. they should be loosely held in place, unstressed. Make sure that the telescope is properly collimated: when the diagonal is viewed through the eyepiece draw-tube with the eyepiece removed, it should appear centred and the image of the main mirror and the images of the diagonal and your eye, by double reflection, should all appear concentric. For more details on collimation consult, for example, Shankar (1985b). After the collimation, the gun sight or finder must be carefully aligned so that it is easy to locate objects in the telescope.

While it is not essential, one should however, try to estimate the actual performance of one's instrument. Here are a few simple tests that might be conducted:

a. Locate a 2nd or 3rd magnitude star in the eyepiece on a clear, dark night when the air is still. Defocus it slightly and examine the image (with maximum magnification, if two or three eyepieces are available); in a good telescope the star will appear as a bright round spot of light, surrounded by two or three concentric diffraction rings.

b. *It is most useful to know the actual diameter of the field of view of an eyepiece.* Since for our purposes a rough estimate is sufficient, it is suggested that this diameter be estimated by observing the Moon. Mote how big the field is compared to the image of the Moon seen through the eyepiece. The Moon's diameter subtends an angle of about *0.5"* (=30 minutes) of arc; if the Moon exactly covers the eyepiece field the diameter of the field of view is *0.5"* etc.

c. A knowledge of the resolving power of the instrument is sometimes quite useful. A telescope of the best quality should, in principle, be able to separate a binary or double, consisting of two 6th magnitude stars, whose angular separation in seconds of arc is equal to about 11.5 divided by the aperture of the primary expressed in centimetres. Thus a 5 cm instrument ought to be able to separate two stars 2.3 seconds apart, a 10cm instrument 1.15 seconds

apart etc. Note *that the eyepieces have to be sufficiently strong to utilize the full resolving power of the* primary *mirror or lens.* Table 1 lists a number of binaries that can be observed to determine the resolving power of the telescope. Start by observing easy pairs, i.e., ones of approximately equal magnitude and rather well separated, say, by 10 seconds or more. Unequal pairs are difficult, especially if one of them is very bright.

A word of warning may not be out of place in this context. When testing a telescope it should be kept in mind that the state of the atmosphere can severely affect its performance; thus prolonged testing on many nights is necessary before the instrument's true capability can be assessed. A poor instrument may also result from the use of a bad eyepiece. On the other hand, many amateur telescopes do suffer from a variety of defects, e.g. coma, astigmatism, poor figure etc. of the main mirror. Thus the diffraction spot may not be circular, stars may have small tails, the resolving power may be as bad as a tenth of the theoretical resolving power, etc. One should not be discouraged; one should carefully try recollimating the instrument or using a new eyepiece, diagonal etc. Moreover, even with a relatively poor instrument many of the objects discussed in this book can be observed and enjoyed. These observations will provide motivation to build a bigger and better telescope and, hopefully, to do more serious work

III. OBSERVING CLUSTERS, NEBULAE & GALAXIES

The objects to be seen

The Guide Charts given in this chapter are meant as a guide to a large number of clusters, nebulae and galaxies that can be seen with small telescopes- Primarily they deaf with the *Messier objects;* these are the objects listed in the catalogue of nebulae and clusters compiled by the famous French astronomer of the 18th century, *Charles Messier (1730- 1817).* !t is interesting and curious that Messier's own purpose for the compilation was to help comet hunters to avoid confusing these objects with the comets that they were searching for! So too the fact that till this century it was not known that many of the 'nebulae' listed are actually distant star systems (galaxies) like our own Milky Way. A brief biography of Messier is given near the end of this book.

Exactly which collection of objects should be considered as the collection of Messier objects is a matter of some controversy? Some of the objects in Messier's catalogue were actually discovered by other astronomers like Pierre Mechain, while some astronomers argue the" certain missing objects ought to have been in his catalogue. For our purposes, we shall, for the most part, follow Mailas and Kreimer's (1978) classification of 110 Messier objects with the understanding that MI02 duplicates M101, i.e. M102 = M101, and that M91 is a missing' object. The richness in variety among these is indicated by the fact that there are *27 open clusters. 29 globular clusters, 6 diffuse nebulae. 4 planetary nebulae. 38galaxies. I supernova remnant, I double star. I asterism (a group of stars) and a patch of Milky Way.* In addition, a few other easy objects like the *Perseus double cluster,* the globular *Omega Centauri* etc., are also included in the Charts; see Table 2 for a full list and brief description of all the objects included.

The distribution of Messier objects in the sky is shown in a Chart near the end of the book. Mote that the distribution is quite non-uniform: a large number of galaxies in the Coma-Virgo region and a cluttering of clusters and diffuse nebulae in the Sagittarius-Scorpius region. The constellation with the largest number of Messier objects is Sagittarius with 15 (no galaxies) followed by Virgo with 11 (all galaxies). This non-uniform distribution of objects prevents one from being able to see any particular type of object at a given time of the year. For normal viewing between 9pm and 2am in India, one is offered open clusters in winter, galaxies in spring and globular clusters in summer! For Indian observers the occurrence of the summer monsoons, at a time when Sagittarius is in a favourable position, makes observations of that most interesting region somewhat difficult.

The rarities in this collection are the planetary and diffuse nebulae; there are only 5 of the former (including 4 Messier objects) and 6 of the latter. Each planetary is distinct and striking in appearance; the *Ring* (M57), the *Dumb-bell* (M27) and WGC3242are not difficult but M76 and especially the *Owl* (M97) may pose problems. The most striking of the diffuse nebulae are the *Orion Nebula* (M42), the *Lagoon* (M8), and the *Omega* (Ml 7); the *Trifid* (M20), which looks so spectacular in coloured photographs, is not an easy object for small telescopes. The *Crab Nebula* (Ml) is unusual in that it is believed to be a supernova remnant.

By and large the open (or galactic) and globular clusters are not difficult objects. While many of the globular clusters look quite alike in a small telescope, the open clusters present quite a variety. Ml1 in Scutum is a small gem; M37 is larger but just as beautiful, while M7 and the *Beehive* (M44) are huge, brilliant clusters. Clusters likeM29 in Cygnus and M103 in Cassiopeia are a little difficult for the beginner because they are somewhat inconspicuous clusters lying in rich star fields. For an observer who has a number of eyepieces and wishes to resolve the stars in a globular cluster, the most promising candidates are to *Centauri,* M3 in Canes Venatici, M4 in Scorpius and M22 in Sagittarius. The great globular in Hercules, Ml 3, and the one in Centaurus are visible to the naked eye.

While the well known Andromeda *Galaxy (M31)* is bright enough to be visible without optical aid, the majority of galaxies are quite faint. Among the brighter and more unusual galaxies are M81 and M82 in Ursa Major, the northern most Messier objects; M81 is a spiral, while M82 is an irregular and both can be seen in the same field. Fairly nearby, M51 and M94 in Canes Venatici are also quite bright; the former is the famous *Whirlpool* Galaxy and is a pretty sight even in a small telescope. The *Sombrero Galaxy* (Ml 04), known as such because of its resemblance to the Mexican hat, is a lovely sight in a striking field. For those seeking a challenge, try M33 in Triangulum and M74 in Pisces.

In brief, the collection presents a wide variety in type, appearance and difficulty. It is unlikely that any one who sets out to observe all these objects will fail to be captivated by them. They are likely to be objects of lifelong observation and study.

Hints on observation

Most of the objects given in the Charts should be visible through a reasonably good, 10-12.5cm aperture, home-made reflector. The faint galaxies will naturally be a little difficult and will require clear, dark nights in order to be seen. The faintest objects like the Owl Nebula (M97), M76, M74, etc. may well require, in addition, a 15 cm aperture given the kind of sky conditions now prevailing. Apart from the telescope, success in observation does depend on the observer's technique. Here are a few general hints that may help the novice:

a. Time and atmospheric conditions: An object is best viewed when it is as far above the horizon as possible, preferably, close to the meridian (i.e. the N-S line overhead). The best nights for observation are clear, dark, moonless nights, preferably close to new moon; observations should be made a few hours after sunset, when true darkness has set in and when the day's dust has settled, say from 10 pm or 11 pm to 3am or 4am. It is true that the brighter clusters can been seen under less than optimal conditions but for the faintest objects optimal conditions are essential. The condition of the atmosphere plays a significant role during observations; dust, haze and especially turbulence can seriously degrade viewing conditions. If on a clear, dark night the stars twinkle a lot, then it is likely that the air is unsteady; such conditions are poor for viewing bright objects, which may best be seen on slightly hazy, still nights. For diffuse objects, though, clear nights are essential.

b. Locating an object: The Guide Charts that follow will help to locate the objects of interest by relating their positions to known, brighter stars. For the brighter objects this is sufficient. For the faintest, marginally visible objects it may be necessary to employ the following technique; get the required field in view and then gently tap the telescope tube and see whether the object is there or not. While a faint frozen object might pass unnoticed, it might just become visible when in relative motion.

c. Dark adaptation: The eye becomes much more sensitive to faint illumination after it has been in the dark for sometime; this ability to adapt to darkness increases the longer the eye is in darkness. For this reason it is important to start observations only after the eye has been in darkness for sometime; further, once the eye has adapted, adaptation should not be lost by moving into illumination; a torch, covered by a dark red filter or red transparent material should be used for looking at charts etc.

d. Averted vision: When looking for a faint object it is best to look with averted vision, i.e., the gaze should be directed not at the object but slightly to one side of it. This is because at low intensities the centre of the retina is less sensitive than regions slightly away from the centre.

During observations the faint object should be brought to the centre of the eyepiece field while the eye concentrates on it while looking at the edge of the field. It might also help to keep the other eye covered by a black patch; in this

manner it can be kept open, causing less strain, during observations.

e. Recording observations: It would be an excellent idea to keep a complete record of all observations. The observations could include the condition of the sky, the shape and brightness of the object, markings and other features, colour, if any, positions of nearby stars etc. An attempt at drawing the object in the field of view would train one in careful observation. In this connection remember that the image is inverted in an astronomical telescope.

Finally the importance of training and practice cannot be overemphasised; observing capability is a talent that can be developed.

The Guide Charts: How to use them

In the Guide Charts that follow, the following symbols are used for various objects:

INSERT PAGE 12 TWO LINES

For the convenience of the user, in all Charts except Chart 10B, north points to the top of the page. For easy recognition, the outlines of the well known constellations have been marked in. The lines of constant right ascension (R.A.), in hours, and declination (Dec.) in degrees have been dotted in; these will help to estimate the actual angular distances between objects, a help since *the field of view of the telescope is known. Remember that 1 hour in R.A. is equal to 15^0 of arc.*

The following steps are suggested in the use of the Charts:

a. For the time of the year and the time of the night at which observations are to be made (say 10pm-12am) note the constellations that are visible and preferably overhead. Turn to the Chart near the end of the book showing the distribution of Messier objects in the sky and note which objects will be suitable for observation. Choose a few of them for viewing.

b. For each of the objects chosen, turn to Table 2 and note down what type of object it is, its magnitude, its size and the expected difficulty in locating it. Remember that the magnitude and size are approximate and the notion of difficulty is really somewhat subjective; for diffuse objects the integrated magnitude can be misleading and the actual size seen may be much smaller depending on the quality of the telescope. Table 2 also indicates the Guide Charts to be used.

c. During the daytime itself, prior to observation, carefully examine the appropriate Guide Chart. For the object under consideration note its position with respect to nearby stars and estimate angular distances if they are small. Read the text and hints opposite the Guide Chart and make a plan of how to locate the object.

d. At night, prior to observations, it might help to take this book out opened to the appropriate Chart, hold it overhead with north and east aligned with their true directions, and note, using a dimmed torch, exactly where in the sky the object is to be found. Note the locating stars and nearby groupings.

e. Finally, after having let your eye adjust to the dark, use your gun sight to locate the object; look through the eyepiece and slowly make small sweeps of the area until the object is located. *Knowledge of the field of view of your eyepiece can help you greatly in estimating distances.* If you have difficulty in locating what should be an easy object it might help to start afresh with the gun sight.

Example 1: In the middle of February, between 10 pm and 11 pm the Puppis-Canis Major region of the sky is close to the meridian and, hence, is suitable for telescopic observation. Say that one wishes to see some objects in this region; looking at the Chart showing the distribution of the Messier objects in the sky, one notes that the open clusters M46 and M47 are in the region of interest. Turning now to Table 2, we find that these clusters in Puppis are of magnitudes 6 and 5 respectively and of diameter of about 25' - 30', i.e. they are fairly large and bright clusters; Table 2 also indicates

that Guide Chart 6 is to be used. The locating hints given in this Chart are to be studied prior to observation. Finally at night, using the Guide Chart, we locate the stars Xi *Puppis* and alpha *Monocerotis.* After proper dark adaptation, the telescope is pointed to a spot a little Wand 2/3rdoftheway up from Xi *Puppis* to *alpha Monocerotis.* Looking into the eyepiece we scan the field and make small sweeps with the telescope until M46 is located. The cluster is carefully studied, noting the brighter stars and patterns: a search, possibly unsuccessful, is made for the planetary *NGC2438.* A sketch might be made. The telescope is now rotated 1°NW, by making use of the fact that the eyepiece field is about 0.5^0 (30'), to find the brighter cluster M47. A similar study is made for M47 followed by a return to M46 as a check.

Example 2: During the early part of September we wish to see the *Omega Webitia* (Ml 7). Table 2 indicates that the object, a diffuse nebula and associated open cluster, is of about 7th mag., about 20' in diameter, of average difficulty and that Guide Chart 14 is the relevant one. In the evening, after suitable preparation, we follow the suggestions given in the Chart. First the brighter stars of Scutum and Serpens Cauda are identified as are Mu and Xi *Sagittarii* and Mu and Upsilon *Ophiuchi.* Using the gunsight, the scope is pointed at a location halfway between Xi *Sagittarii* and o *Serpentis;* after a few small sweeps of the area the open cluster Ml 8 is located and identified. We now move 1° N and a little E to find M17 which is easily identified.

Example 3: Say we wish to observe the two Virgo galaxies M49 and M61 in the month of March. Table 2 indicates that M49 is of average difficulty but that 10th mag. M61 is somewhat difficult. We study the hints given in Guide Chart 10 prior to observation. At around 2 am we search forM49onthe line joining delta *Virginisto Denebola;* after a little difficulty M49 is found a little less than half-way towards *Denebola* and a little N. We then search for M61 near the midpoint of the line *delta-nu Virginis.* After a futile search for 15 minutes we give up and go back to the book; a figure giving the field near M61 is found. This figure shows the pattern of stars to be seen near M61, which includes a triangular configuration containing the galaxy. After a careful study of this field, we go back to the scope, and after the eye has adapted to the darkness we again search for M61. A small search is now sufficient to locate the pattern of stars shown in the figure. Now, using averted vision the faint galaxy becomes visible at the expected location in the field; we tap the telescope to confirm the presence of M61. Repeated observations over a period of a few days leads to easy and immediate identification-of the galaxy.

GUIDE CHART 1

OBJECTS: M31, M32, M33. M74, M76. Ml 10

GENERAL COMMENTS: For evening viewing suitable months are October through December; however. M33, M74, M76 and M110 are best seen late at night (after 11 pm) in October.

LOCATING & OBSERVING HINTS:

M31 (E). *The Andromeda Galaxy:* Can be seen by the naked eye as a faint, hazy patch 1 ° W and a little N of Upsilon *Andromedae.* Best seen with low powers; very bright but no features, such as spiral arms, will be visible.

M32 (A): About 25' S of the centre of M31; seen as a small fuzzy ball about 2'-3' in diameter. Best to locate M31, centre it and move the field about 0.5^0S to see M32.

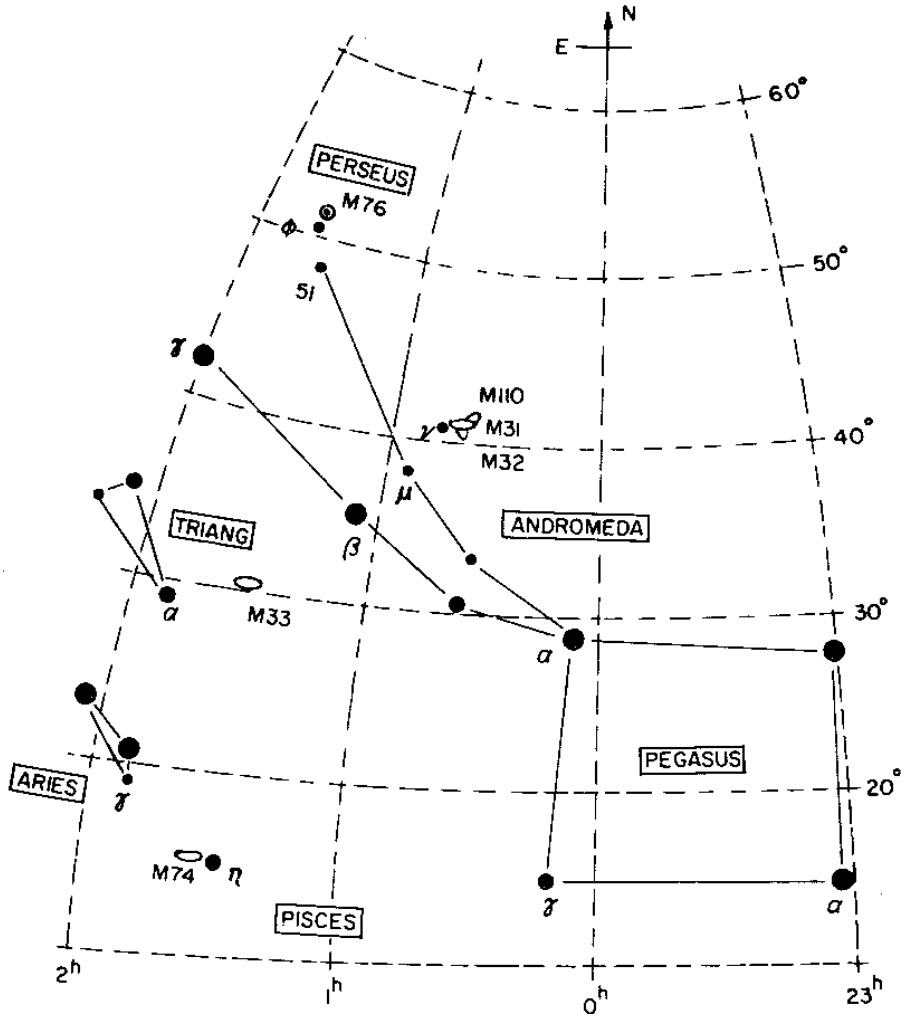
Ml10 (D): About 0.5^0 W and 0.5°N of M31; faint and elongated. Locate by centring M31 and moving NW 40'-45'.

M.33 (X): Still, clear, dark nights are essential for this giant, spiral galaxy. To find M33, locate Alpha *Trianguli and Beta Andromedae;* the galaxy is just south of the line joining them, a little more than 1/3rd of the way from *a Trianguli.* Low powers are best; in fact, it is said that this object is easier in a good pair of binoculars (say, a 7 x 50) than in a 20 cm telescope.

M74 (X): Another faint, elusive, difficult galaxy. Starting from the *Great Square of Pegasus,* find 17 *Piscium* which lies on the extended line joining Eta and *Gamma Pegasi,* M74 lies a quarter of the way up and just S of the line joining Eta Piscium to *Gamma Arietis.* In the same field, 6' to the east are a pair of 10th mag. stars lying N-S about 3' apart. Dark adaptation and averted vision may be essential.

M76 (D): Although this planetary nebula is one of the faintest objects in Messier's catalogue, it is not so difficult to find. Locate *51 Andromedae* on the northern limb of Andromeda; 4th mag. Phi Persei is just N of this star. M76 is less than 1°N and a little W of Phi Persei. This pretty object is a miniature M27.

GUIDE CHART 1



GUIDE CHART 2

OBJECTS: M52, Ml03, *h, Epsillon and Chi Persei*

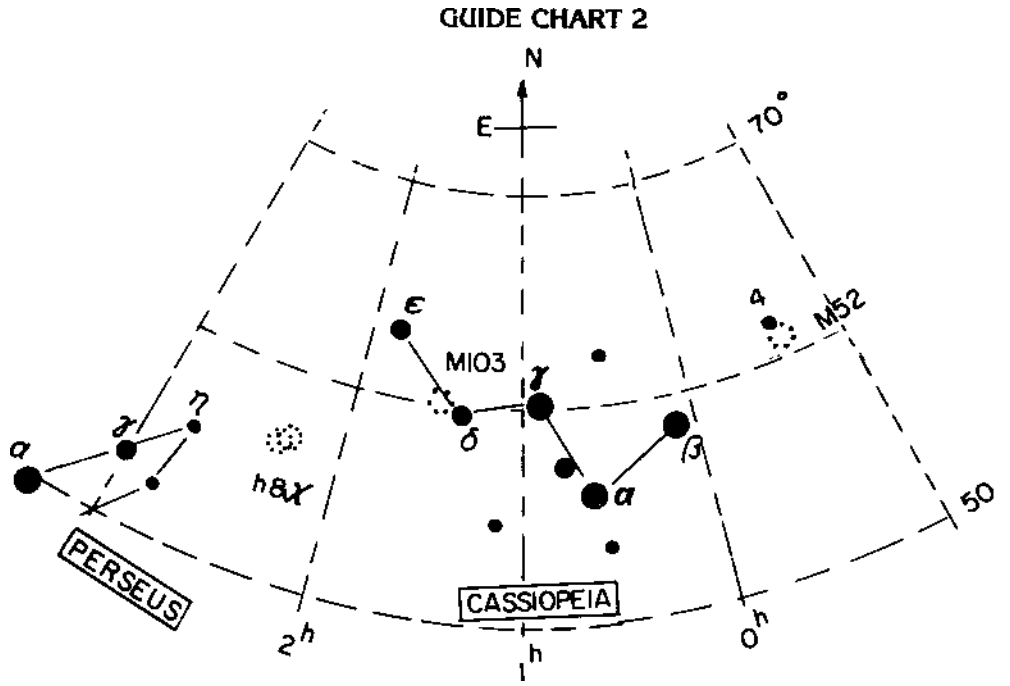
GENERAL COMMENTS: While these four northerly open clusters can be seen from October to January, the best months are October and November, when they will be close to the meridian around 11pm -12am.

LOCATING & OBSERVING HINTS:

M52(A): Lies 1° S and a little W of 5th mag. *4 Cassiopeiae,* which is a little N of the extended alpha - beta *Cassiopeiae* line. A small cluster, with an orange star of about 8th mag. and an arrowhead shape.

Ml 03(A): Locate by moving 1° E and 0.5° N of Delta *Cassiopeiae.* A loose, poor cluster which can be confused with a number of equally impressive objects in the vicinity. The outer stars form an isosceles triangle, one side of which contains a red star at its middle; the bright star Sigma 131 at the apex is a double star.

h, Epsillon and Chi Persei (E): This beautiful double cluster is also known as the *Sword-Handle in Perseus;* visible to the naked eye. It is possible to manoeuvre the centres of the clusters into the same field. Locate 4th mag. 17 *Persei* (see Chart 3 also); the double cluster lies 1 /3rd of the way up and a little S of the line joining Eta *Persei* to *Delta Cassiopeiae.*



GUIDE CHART 3

OBJECTS: M34, M45, M77

GENERAL COMMENTS: The *Pleiades* can be observed through February, but October to December would be best for M34 and especially M77. The three objects are somewhat widely spaced in the sky.

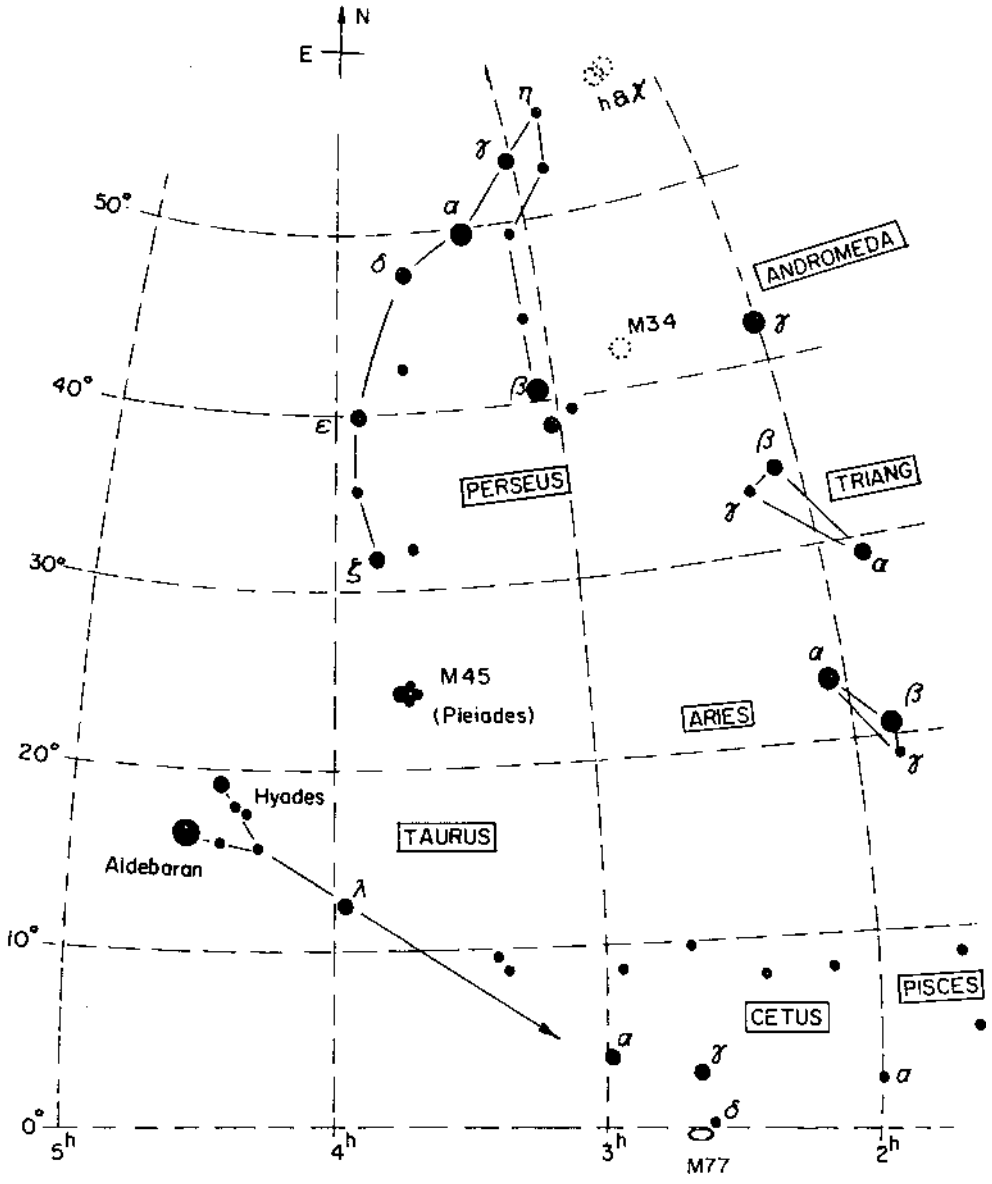
LOCATING & OBSERVING HINTS:

M34(E): This easy open cluster lies a little more than 1 /3rd of the way from *Algol (Beta Persei)* to *y Andromedae* and a little N of the line joining them. It is bright, more than 30' dia. with many stars distributed in pairs; just visible to the naked eye under good conditions.

M45 (E), The *Pleiades:* The most well known open cluster, also known as the *Seven Sisters, Seven Virgins* etc. Shining at 1.5 mag. it is easily visible to the naked eye. The whole cluster contains several hundred members and is surrounded by nebulosity, especially around the star *Merope.* M45 contains many beautiful strings of stars {like pearl necklaces); it is best seen with as wide a field (low power) as possible; while the nebulosity is easily photographed, it is not that easy to see and is apparently best seen at low powers.

M77 (A): This *Seyfert galaxy* appears almost star-like in a small telescope. The V of the *Hyades* cluster points to the triangle formed by alpha, gamma and Delta *Ceti;* M77 lies about 1 ° to the E and 0.5 ° *to* the S of Delta Ceti. Close to its east is a 10th mag. star which can be used to confirm the nebulous appearance of the galaxy.

GUIDE CHART 3



GUIDE CHART 4

OBJECTS: Ml, M35, M36, M37, M38

GENERAL COMMENTS: This Chart contains the unique Crab Nebula and 4 open clusters each distinct in its own way. Best months are late November through February.

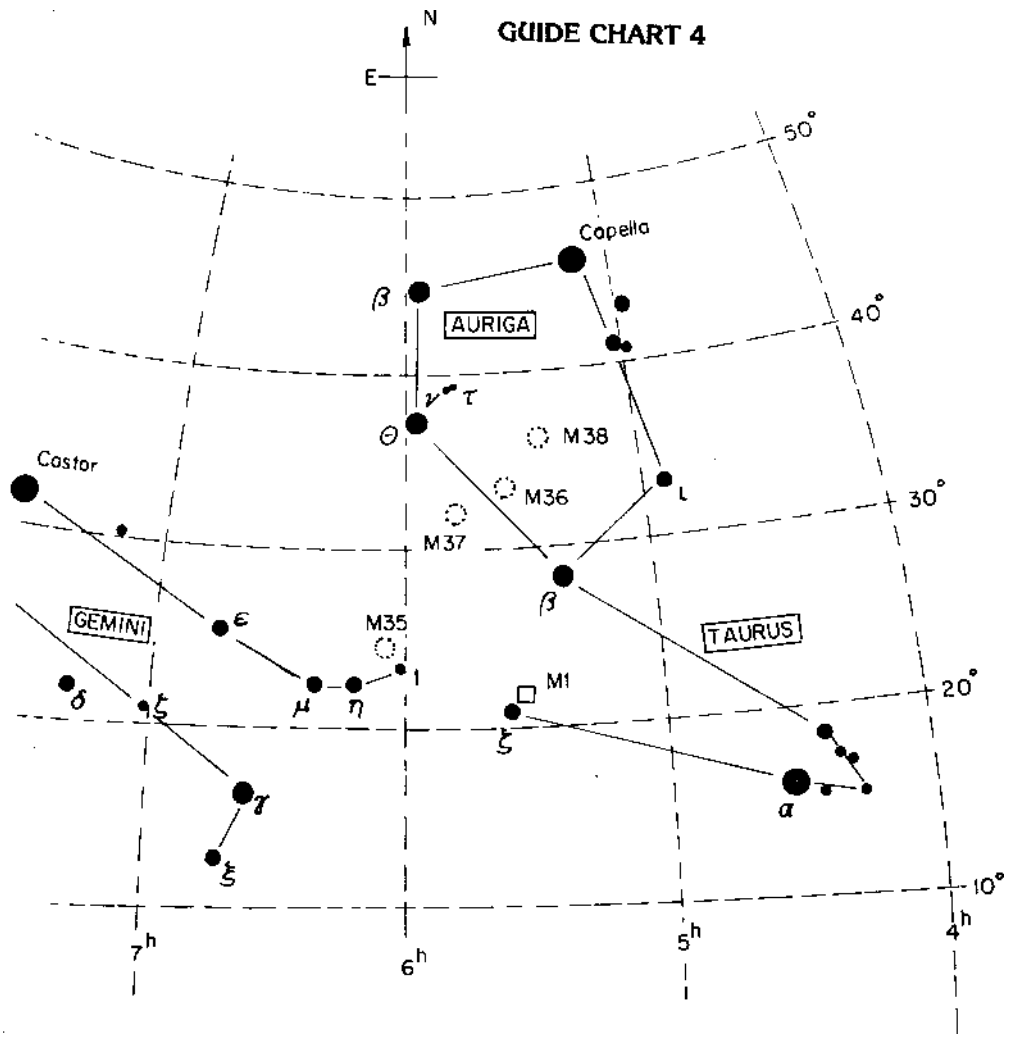
LOCATING & OBSERVING HINTS:

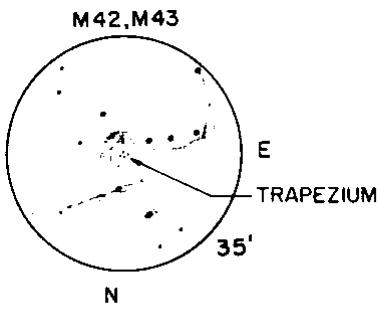
M1(A), *The Crab Nebula:* A dear, dark moonless night is essential. Starting from *Aldebaran (alpha Tauri)* and the *Hyades* cluster locate Zeta and *Beta Tauri,* the tips of the horns of the Bull. The Crab is close to the line joining them, about 1 °N and 1 °W of Zeta; to its east about 30' away is 6th mag. Signa 742. Under good conditions Ml will appear as a fairly bright, hazy patch.

M35(E): Starting from Castor trace the loop of stars Epsillon, Mu, Eta and *l Geminorum.* M35 forms a right triangle with the latter two stars and lies 1 °N and 1°E of *l Geminorum.* A beautiful cluster.

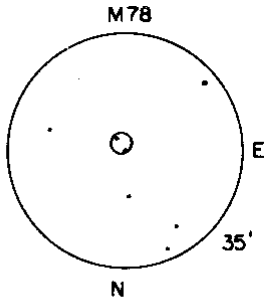
M36 (A) & M37 (A): Locate the pentagon formed by the brightest stars of Auriga together with Beta *Tauri.* These two clusters lie on either side of the Theta *Aurigae and Beta* Tauri line; M36 is almost exactly at the middle and a little inside the pentagon, while M37 is a little closer to *Theta* and somewhat outside the pentagon. M36 is a little smaller than M37 and contains a larger number of bright stars. M37, a real 'pepper shaker' cluster of faint stars, is one of the finest clusters to be seen; dark skies are essential to savour its richness.

M38 (A): Lies well within the pentagon, almost exactly half-way between *Theta* and *Aurigae.* A pretty cluster whose brightest stars appear to form an X.





Field Near M42&M43



Field Near M78

GUIDE CHART 5

OBJECTS: M42, M43, M78, M79

GENERAL COMMENTS: The 4 objects in this Chart, 3 diffuse nebulae and a globular cluster, are confined to the Orion-Lepus region of the sky. For evening viewing the best months are December through February.

LOCATING & OBSERVING HINTS:

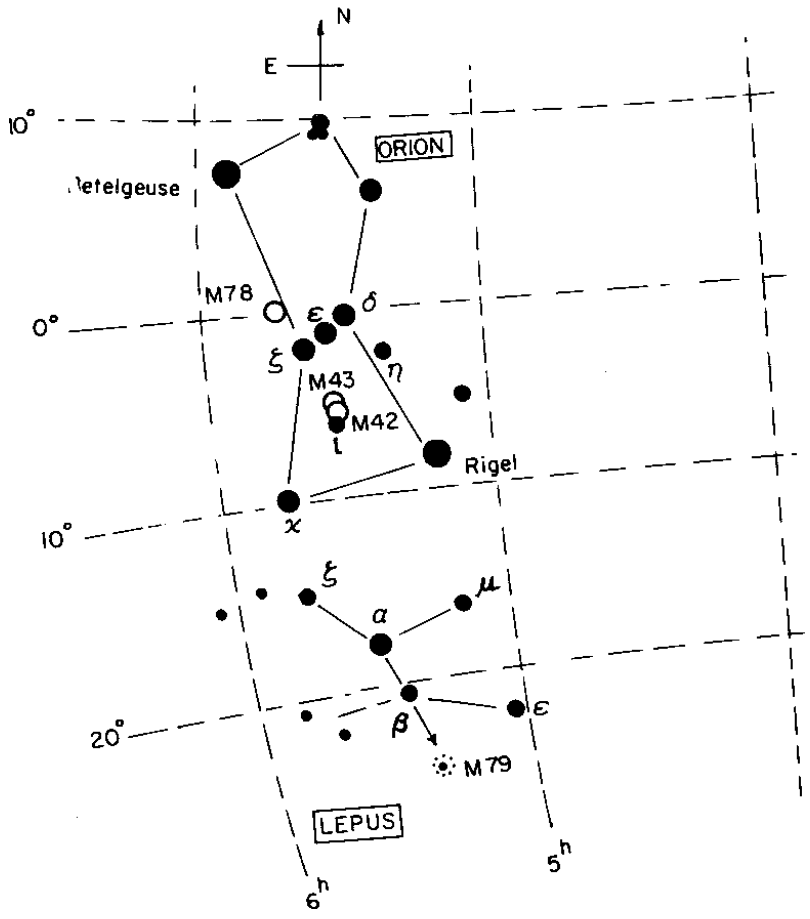
M42(E), *The Orion Nebula:* Perhaps the most famous nebulous object in the skies; can be seen with the naked eye as hazy *Theta Orionis* in the Sword *of* Orion. This spectacular object is one of those objects which appear far better in a small telescope than in photographs of them. The nebula is made up of bright regions and dark regions with stars embedded in them. Most prominent are (i) the bright central portion with wing like regions spreading to the SE and NW, (ii) the dark wedge of the 'Fish's mouth' that penetrates into the central bright portion, (iii) the 4 stars that make up the *Trapezium* at the end of the *Fish's mouth* and (iv)the line of 3 bright stars S and E of the *Trapezium.* M42 bears repeated viewing and study.

M43(E): Is an almost circular patch of nebulosity surrounding an 8th mag. star about 10' N of the Trapezium.

M78(A): The difficulty with this object is recognizing it when seen; it appears comet-like, a short, stubby nebulosity with glowing ends. To locate: draw a perpendicular to the *Belt of Orion* through Zeta *Orionis;* M78 lies on this line towards *Betelgeuse,* as far from Zeta as Delta is from Zeta.

M79(A): A rather small, unimpressive globular cluster that needs dark skies for reasonable viewing. Locate alpha and beta *Leporis* and extend the line joining them by a little more than the distance between them to find M79. The cluster lies almost equidistant between two 8th mag. stars, 20' apart and lying NS.

GUIDE CHART 5



GUIDE CHART 6

OBJECTS: M41, M44, M46, M47, M48, M50, M67, M93

GENERAL COMMENTS: All the 8 objects in this Chart are open (i.e., galactic) clusters. Although open clusters are often bright and easy to see, identification is sometimes troublesome if the duster is in a rich star field, say, in a part of the Milky Way. The best months for the objects in this Chart are January through March.

LOCATING & OBSERVING HINTS:

M41 (E): A beautiful, bright open cluster, a little to the W and 2/3rd of the way up from delta Caniss *Majoris* to *Sirius.*

M44(E), *Praesepe* or the *Beehive Cluster:* This brilliant, lovely cluster, which is visible to the naked eye is too large for the field of a normal telescope to be seen in its entirety; best at low powers. To find M44 locate the lamba formed by the principal stars of Cancer; *Praesepe* lies between gamma and delta and a little to the W.

M46(A): A gem of faint stars that needs a dark sky to be fully appreciated; contains a planetary nebula, *NGC2438,* about 10' NE of centre, but this requires high power, good aperture and excellent conditions to be seen. Locate 4th mag. a *Moriocerotis* which lies almost half-way between Xi *Puppis* and *Procyon;* M46 lies a little Wand 2/3rd of the way up from Xi *Puppis* to *a Monocerotis.*

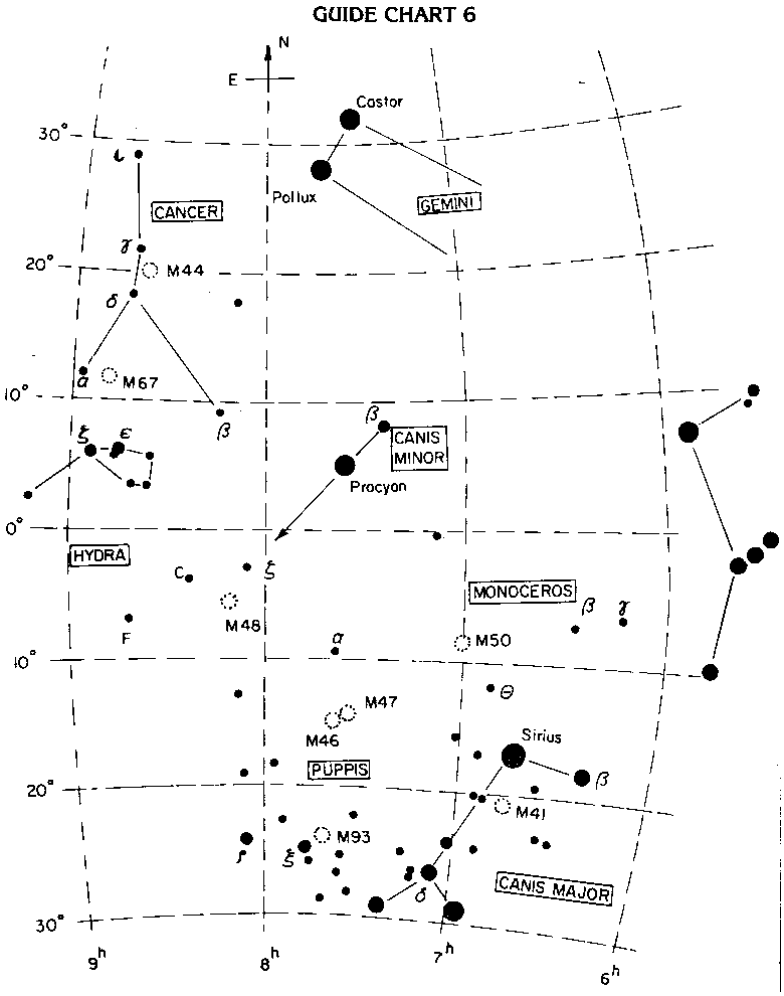
M47(A): Lies a little more than 1 °NW of M46; contains a number of very bright stars including a double, Sigma 1121 (separation 8"), near the centre.

M48(A): Use Beta Canis *Minoris* and *Procyon* to locate the 4th mag. stars Zeta *Monocerotis* and *C-Hydrae;* this fine cluster forms a right triangle with these two stars as shown.

M50(A): Although this cluster lies in the rich Monoceros portion of the Milky Way, it is distinguishable as it has a boundary of slightly darker sky around it; the brightest stars form a heart shaped figure. First locate the three 4th mag. stars alpha, beta and *gamma Monocerotis;* M50 lies almost half-way between *alpha* and beta *Monocerotis.*

M67(A): Once the A shape of the principal stars of Cancer has been located, M67 can be found 2°W of *alpha Cancri.*

M93(A): The central portion of this cluster is compact and triangular in shape with many coloured stars. A little difficult to locate as it is in a rich portion of the Puppis Milky Way. Locate Xi *Puppis;* M93 lies about 1.5'NWof Xi.



GUIDE CHART 7

OBJECTS: M40, MB1, M82, M97, MIDI, M108, M109

GENERAL COMMENTS: All the 7 objects in this Chart are in Ursa Major, M81 and M82 being the northern most Messier objects. As a consequence it is essential, especially for the last four objects in the list, that viewing be done when the objects are close to the meridian, late at night or very early in the morning, i.e., between 11pm and 3am. Best months are February-May.

LOCATING & OBSERVING HINTS:

M40(A): This pair of almost identical 9th mag.stars (Winneke4.9.0 and 9.3 mag., 49" separation) is less than 2°NE of *Delta Ursae Majoris*. First locate 5th mag. *70 Ursae Majoris* by moving 1 ° along the extended line joining gamma to delta, now move another 0.5° in the same direction; M40 should be close to the centre of the field.

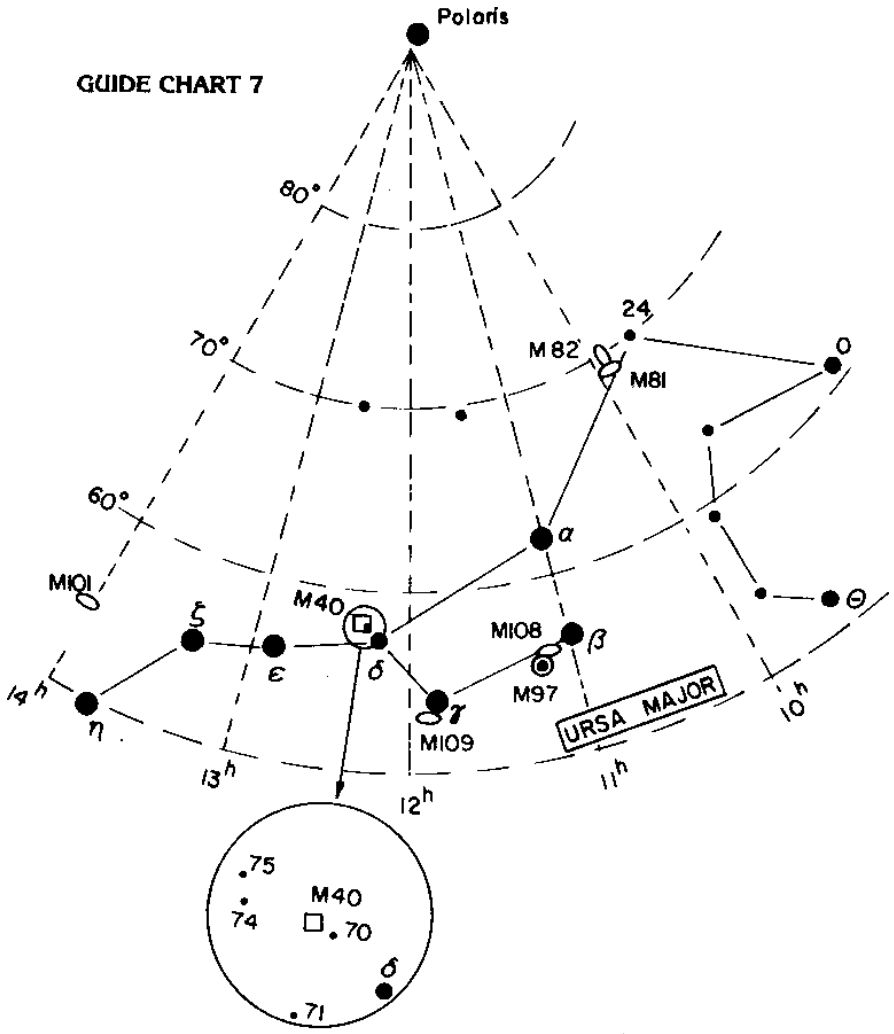
M81 (A) & M82(A): These two galaxies which can be manoeuvred into the same low power field are quite different in appearance; M81 is a large oval while M82, the irregular, is narrow and elongated. This pair of beautiful objects is among the brighter of the Messier galaxies. To locate: join gamma to delta and proceed an equal distance farther, then move ME about 2°.

M97(X), *The Owl Nebula:* The best sky conditions are necessary to locate this planetary. From Beta *Ursae Majoris* move a quarter of the way to gamma, then move 1° S and carefully scan the region using averted vision; if you see a 6th mag. star, M97 is about 0.5°ENE. The planetary appears as an almost circular, faint patch. Bears repeated hunting and viewing.

M101(X): The position of this galaxy is easily located; it forms an almost equilateral triangle with Zeta and Eta *Ursae Majoris*. It lies about 10'E of an 8th mag. star and 25'S of a curve of fainter stars. Best conditions, dark adaptation and averted vision are essential.

M108(X): Lies about 2° from Beta *Ursae* Majoris just S of the beta-gamma line. This difficult, elongated galaxy appears as a pretty sliver when seen.

Ml 09(X): Another spiral that requires good conditions, dark adaptation, averted vision etc. Just about 40'SE of *gamma Ursae Majoris*.



GUIDE CHART 8

OBJECTS: M3, M51, M53, M63. M64, M85, M94, Ml00, M106

GENERAL COMMENTS: The objects include two fine globulars and some of the more unusual and brighter Messier galaxies. In order to locate these objects, first locate the triangles made up of alpha, beta and *20* Canum Venaticorum and alpha, beta and *gamma Comae.* For late evening - early morning viewing March to May would be best.

LOCATING & OBSERVING HINTS:

M3(A):This bright globular cluster lies a little less than half-way from' *Arcturus* to 3rd mag. alpha Canum Venaticorum. Note that *gamma* and beta Comae also point to it.

M51(A), *The Whirlpool Galaxy:* Although M51 is quite bright compared to the fainter Messier galaxies it can be elusive; good sky conditions are essential for satisfactory observation. In a 15 cm scope the fainter companion galaxy to the N should be visible; together they make a superb sight justifying the name given to the object. To find M51 move *0.25* of the way from Eta *Ursae Majoris* to Beta *Canum Venaticorum* and then a little S.

M53(E): This small, pretty globular lies almost exactly 1°NE of alpha Comae.

M63(D): This faint spiral requires good conditions and averted vision.

It lies about 1.5° Nand a little W of *20 Canum Venaticorum.*

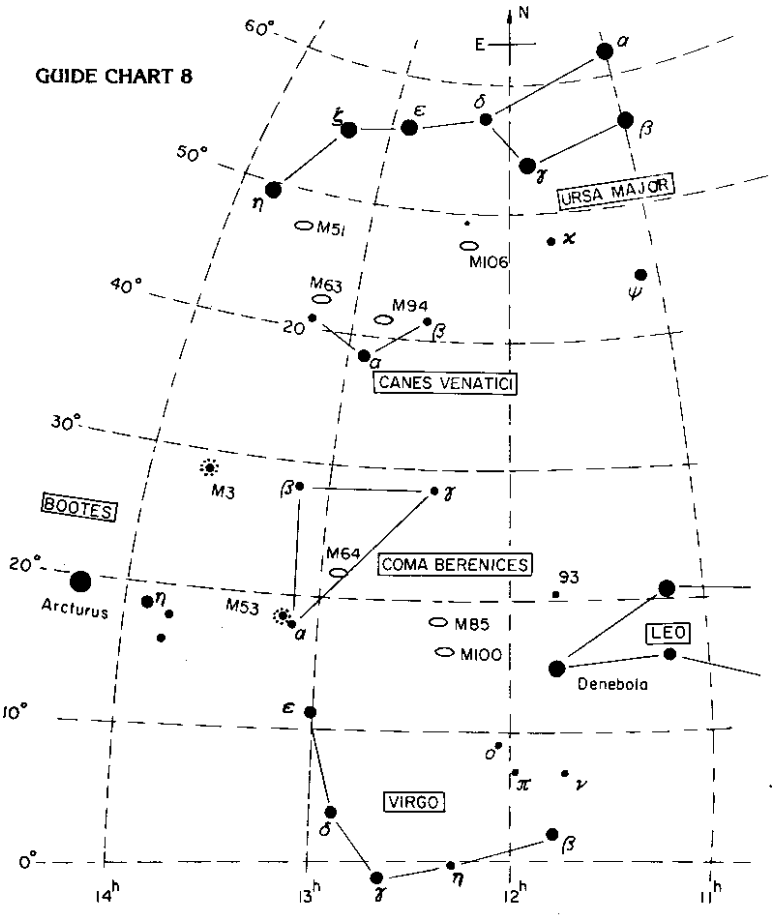
M64(A), *The Black-Eye Galaxy:* A comparatively bright and large spiral compared to the other galaxies in the Coma-Virgo region. Even though the 'black-eye' is not that easily visible in small telescopes, the use of averted vision does help to see some detail. M64 is about l/3rd of the way up from *alpha to gamma Comae* and a little to the E.

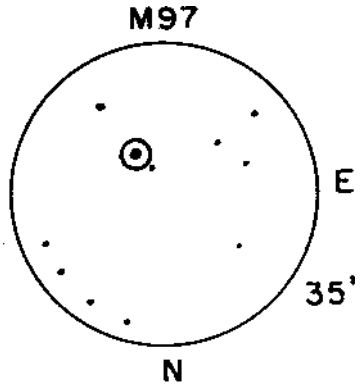
M85(A): Like M84 this is an SO spiral, i.e. in appearance almost an elliptical; appears as a bright oval in a small telescope. Nearby, 8' toils E, is a fainter galaxy *NGC4394,* which may also be seen. Locate 4th mag. *93 Leonis;* M85 is almost half-way between this star and alpha Comae and a little to the S.

M94(A): One of the brighter Messier galaxies, M94 forms an isosceles triangle with *alpha* and *beta Canum Venaticorum.* As the nucleus is bright, the galaxy is not difficult to pick up.

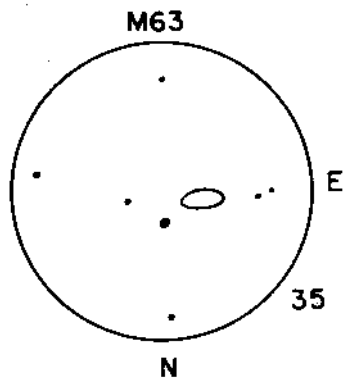
M100(D): This spiral appears as a circular patch, almost like a faint globular. Location: almost exactly half-way between Epsillon Virgins and 4th mag. *93 Leonis.*

Ml 06(A): Elongated spiral, half-way between beta *Canum Venaticorum* and gamma U*rsae* Majoris.

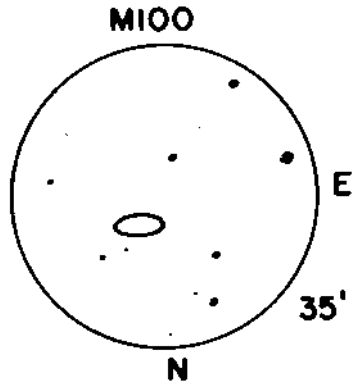




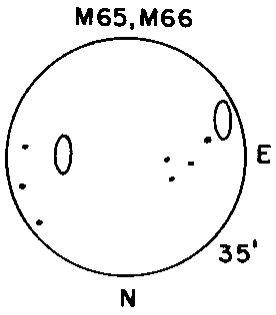
Field Near M97



Field Near M63



Field Near M100



Field Near M65 & M66

GUIDE CHART 9

OBJECTS: M65, M66, M95, M96, M105.

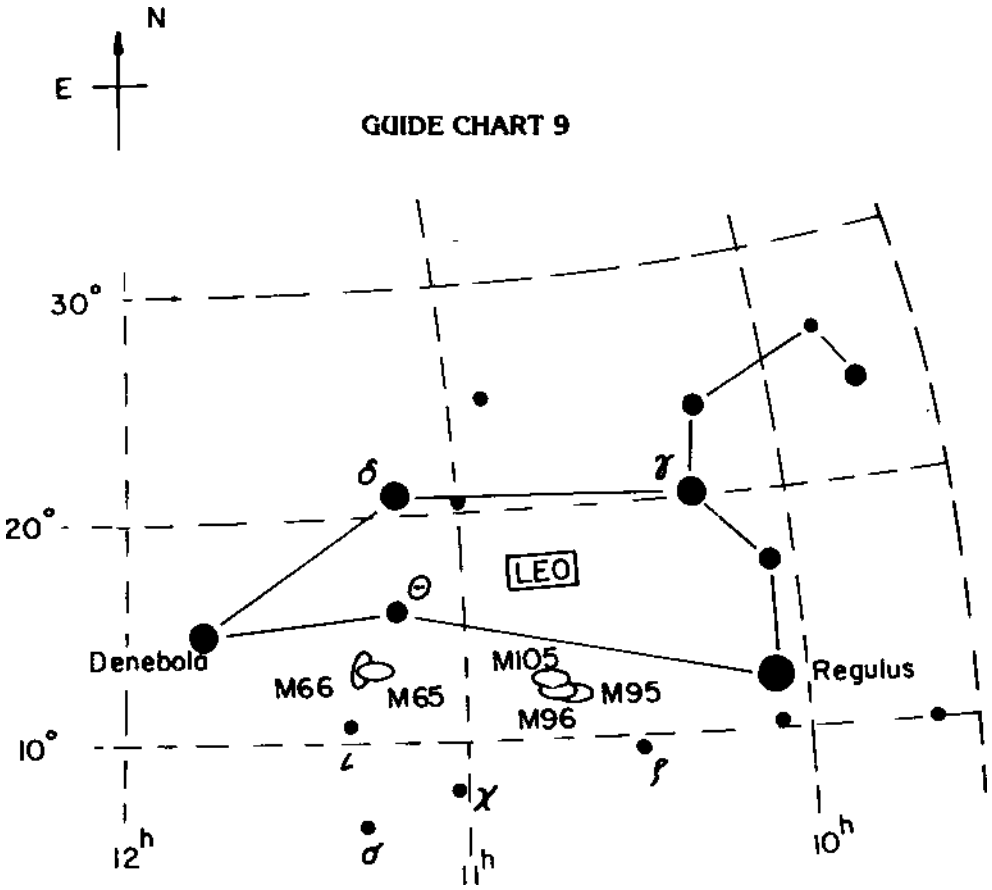
GENERAL COMMENTS: These are all spiral galaxies in Leo. All the usual care required for viewing faint objects should be exercised. For late evening viewing the best months are January through March.

LOCATING & OBSERVING HINTS:

M65(A) & M66(A): Both these spirals are faint and elongated, M65 being the fainter of the two; their major axes lie in an approximately MS direction. Locate t *Leonis;* this pair lies about half-way between t and *theta Leonis.* As the distance between them is only about 30' they can be manoeuvred into the same field.

M95(D) & M96(A): The two galaxies are about 50' apart, M95 being E and just a little S of M96. M95, much the fainter of the two, appears as a glowing patch with a faint, star-like nucleus; M96 is brighter and has a better defined centre. Locate 4th mag. Rho Leonis; M96 lies a little more than 1 /3rd of the way from Rho to Theta and M95 is a little to the E. It's best to find M96, then hunt for M95, return to M96 and confirm by locating Ml05 to the N.

M105(A): This small elliptical lies almost half-way between Rho to Theta *Leonis* and a little to the W; or can be found by moving a little more than 1/3rd of the way from *Regulus* to *Denebola* and then a little S. In the same field can be seen another elliptical, *MGC3364,* about 8' to the E; a third galaxy, *MGC3389,* also lies in this field to the S, making a right angle with the other two, but it is much fainter. Confirm by locating M96 which lies about 1 ° SSW.



GUIDE CHARTS 10A & 10B

OBJECTS: M49, M58, M59, M60, M61. M84, M86, M87, M88, M89, M90, M98, M99

GENERAL COMMENTS: These Charts deal primarily with the Messier galaxies in the Coma-Virgo region. Most of these galaxies are visually small and faint; they require full darkness adaptation, averted vision and clear dark skies for best results. One must also be warned that the whole region teems with faint galaxies and so care and checking are required to make sure that the object seen is indeed what is sought to be seen. The Virgo-Coma galaxies are an excellent exercise for training in observational skills. It is suggested that M49 and M61 be tackled individually. For the rest: (a) make a trip starting with M60, M59 and going carefully through M58, M87, M86 and M84, (b) go back to M58 and find M89, M90 and M88 in that order, and (c) finally tackle M98 and M99 separately. Repeat, to be certain that you know the region welt. For early morning and late evening viewing, the best months are February through April.

LOCATING & OBSERVING HINTS:

M49(A): A comparatively bright elliptical that looks a bit like a globular cluster. Just slightly N of the *delta Virginis - Deneboia* line and a little less than half-way from *delta.*

M6I(D): A diffuse, pale spiral for which averted vision is essential. Locate the triangle formed by 4th mag. *omicron, pi* and nu *Virginis.* M61 is almost exactly half-way between delta and nu *Virginis.*

M60(A) & M59(A): These two elliptical are *a* little less than 30' apart. M60. the brighter of the two has a round outline and a bright nucleus. In the same field, if the instrument is adequate, can be seen two fainter galaxies: *MGC4647,* a 11.5 mag. spiral very close toM60, and a 12th mag. elliptical *HGC4638.* which lies equidistant from M59 and M60 and 20' S of the line joining them. To locate: using averted vision, if necessary, locate 5th mag. rho *Virginis* and move 1.5°N and a little E to find M60.

M58(A): This spiral is the brightest of the Messier galaxies in the Virgo group; looks somewhat like nearby M60. Located by moving 1 ° W of M59 and a little N.

M87(A); One of the most famous galaxies; a giant elliptical with an optical jet issuing from it, it is an intense radio source. One of the brightest in this group, it lies a little more than 1.5°WNW of M58.

M86(A) & M84(A): Like M85, M84 is an SO spiral and hence appears almost like its nearby neighbour M86, an elliptical. This pair, which are about 20' apart, can be found by moving about 1.5°WNW of M87;they appear almost round and brighten towards the centre. About 25'ENE of M86 can be seen a pair *of* 10th mag. galaxies, *NGC4438* and *HGC4435;* more difficult is *NGC4388* which lies about 30' SE of M84. Thus under good conditions, one can see 5 galaxies is this1.0°field with *a* 15cm telescope!

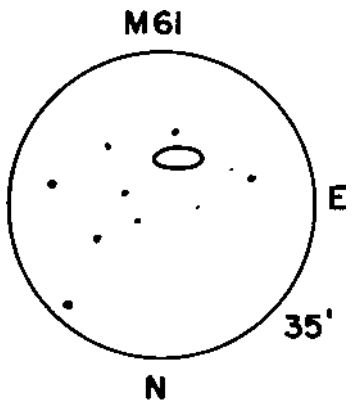
M89(A); Move about 50' MW from M58 to locate this elliptical; small and round in appearance.

M90(A): Can be located by moving about 40' N of M89 and a little E. The spiral's major axis clearly lies approximately N-S.

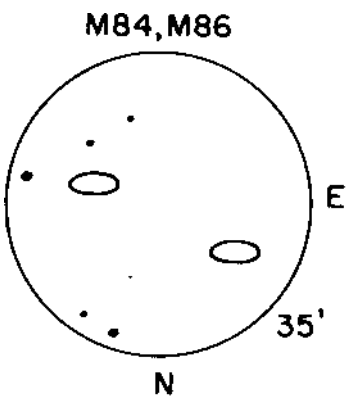
M88(A): The flattened, disc shape can be made out clearly. The principal axis of the galaxy lies along the N W-SE direction and a single star and a pair of stars lie at the two ends of this axis. Locate by moving a little more than 1.5°NW of M90.

M98(D): This faint, almost edge-on spiral lies 30' to the W of 5th mag. *6 Comae;* appears pale and elongated.

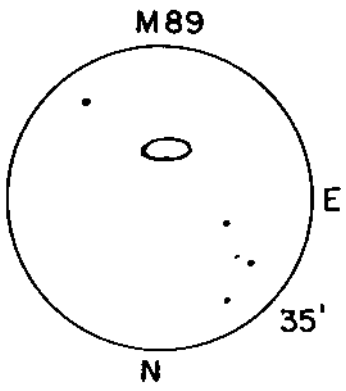
M99(D): Lies about 45' SE of 6 Comae; this spiral is face-on and easier than M98.



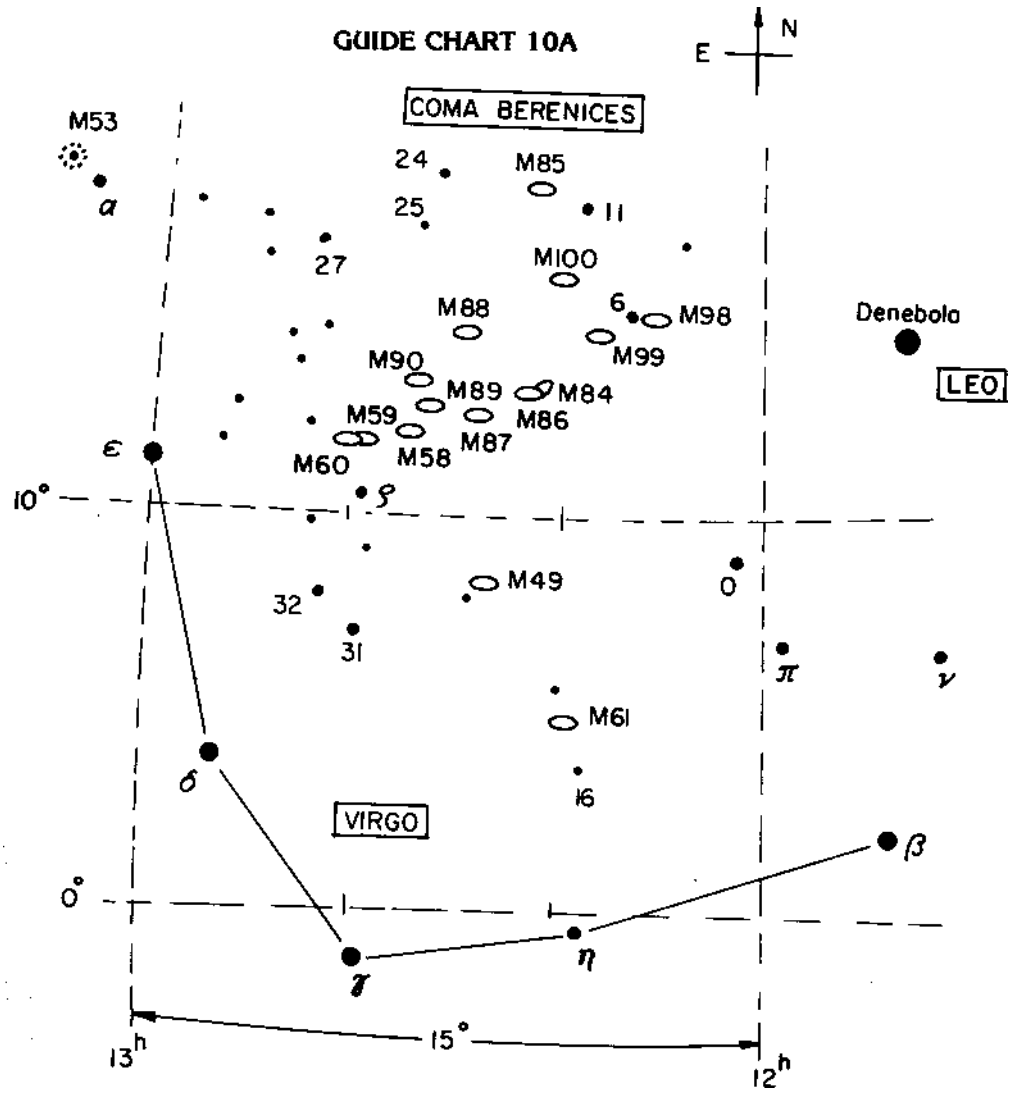
Field Near M61



Field Near M84 & M86



Field Near M89


GUIDE CHART 10A
N
E
COMA BERENICES
M53
α
24
M85
25
11
27
M100
M88
6
M98
Denebola
M99
M90
M89
M84
LEO
M59
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M87
ε
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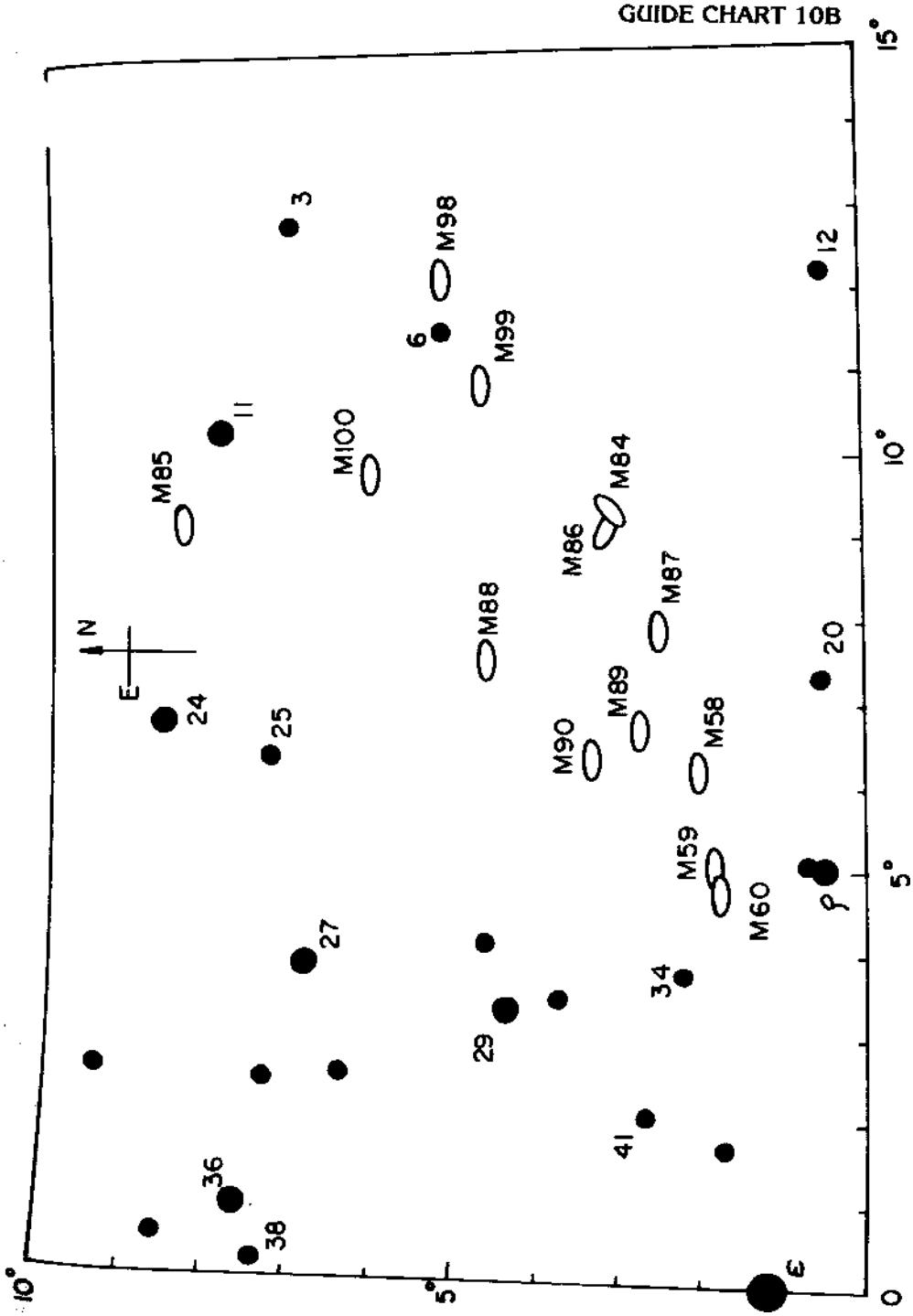
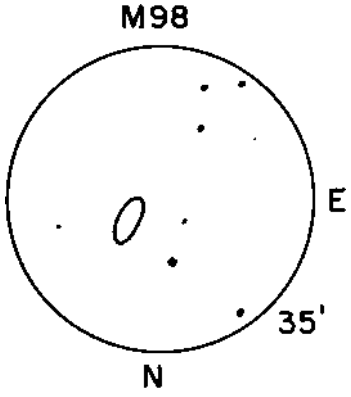
η
γ
15°
13h
12h





Field Near M98

GUIDE CHART 11

OBJECTS: M68, M83, M 104, *NGC3242, omega Centauri, kappa Crucis*

GENERAL COMMENTS:

This Chart contains a variety of interesting objects in the southern sky none of which are faint February through April should be good months for viewing.

LOCATING & OBSERVING HINTS:

M68(A): Easy globular in Hydra. Move southward along the delta to beta *Corvi* line for a distance equal to half the distance between them; move a little E to find M68.

M83(A): A bright face-on spiral whose nucleus appears elongated in a small scope; the galaxy is in Hydra. From gamma *Hydrae,* move a little less than half-way towards *theta Centauri* and then a little W.

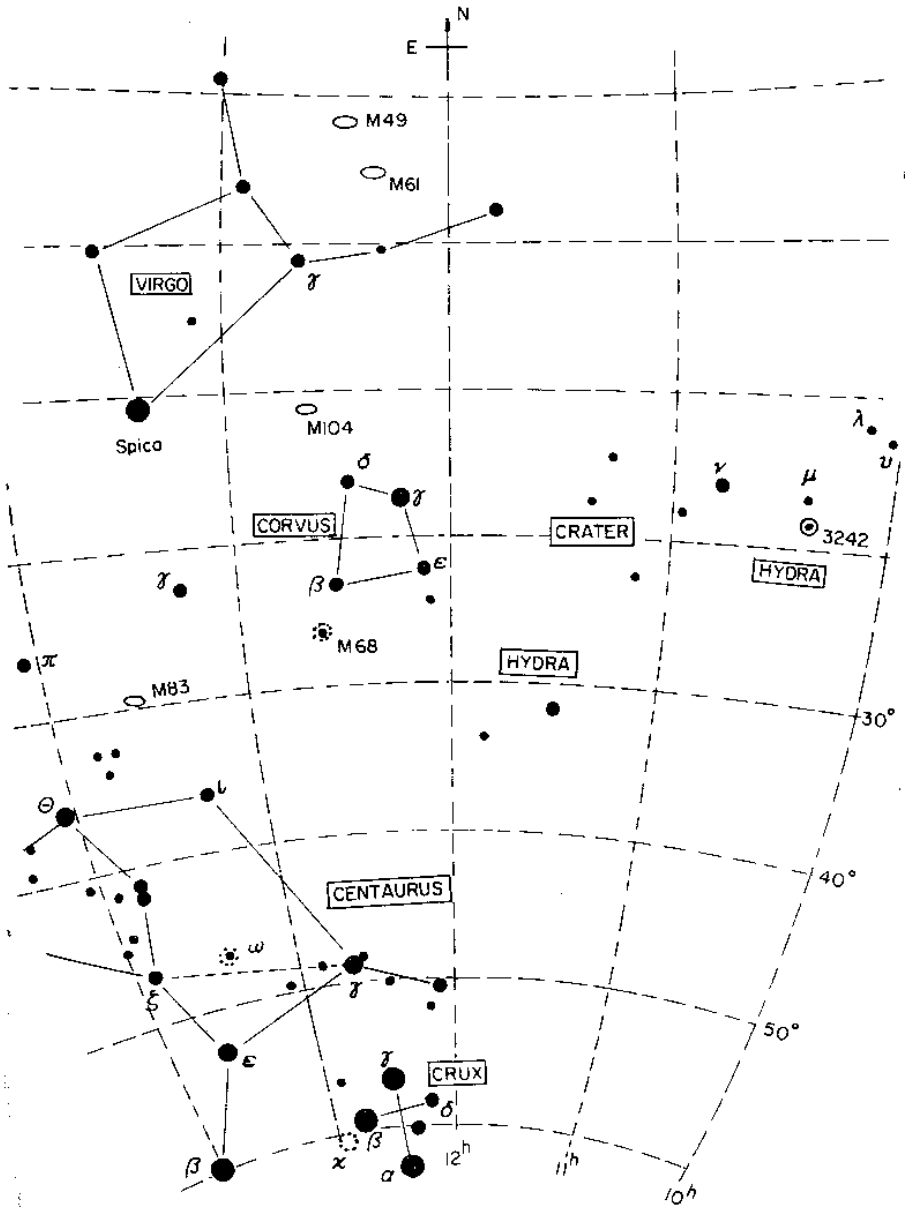
M104(A), *The Sombrero Galaxy:* This edge-on spiral in Virgo is a real beauty, surrounded by pretty groups of stars. With practice and the use of averted vision one can, indeed, make out its hat-like shape. To locate: move 1 /3rd of the way from delta *Corvi* to gamma *Virginis,* then move about 2^0 E.

NGC3242(A): This is a small, bright planetary whose central star is as bright as 11.5 mag. Locate the triangle formed by lambda, mu and nu *Hydrae;* move 2^0 S of Mu to find this planetary nebula.

Omega Centauri(E): A marvelous naked eye globular cluster that is quite spectacular in a small telescope. About 1^0N of the intersection of the lines beta-epsillon and Zeta - Gamma *Centauri.*

Kappa Crucis(E), *The Jewel Box:* A beautiful cluster containing many stars of various colors. About 2^0 SE of beta *Crucis.*

GUIDE CHART 11



GUIDE CHART 12

OBJECTS: M5, M9, M10, M12, M13, M14, M92, M107

GENERAL COMMENTS: This Chart contains 8 globular clusters in the Serpens-Ophiuchus- Hercules part of the sky. Some of these can be resolved with a 15 cm or 20 cm telescope but high magnification will be required. April and May are likely to be the best months for viewing.

LOCATING & OBSERVING HINTS:

M5(E): Bright, pretty globular; easy to resolve. Locate 4th mag. *109* and /*10 Virginis* which lie between *Arcturus* and beta *Librae;* M5 lies to the E of *110* in line with *109* and almost equidistant.

M9(A): Small globular. Locate 4th mag. Xi *Ophiuchi;* this globular lies a little to the E of the midpoint of the Xi – Eta line.

M10(A): Bright; outer portions can be resolved in a 15cm. Move l/3rd of the way from Zeta to Alpha *Ophiuchi* and a little E to find M10.

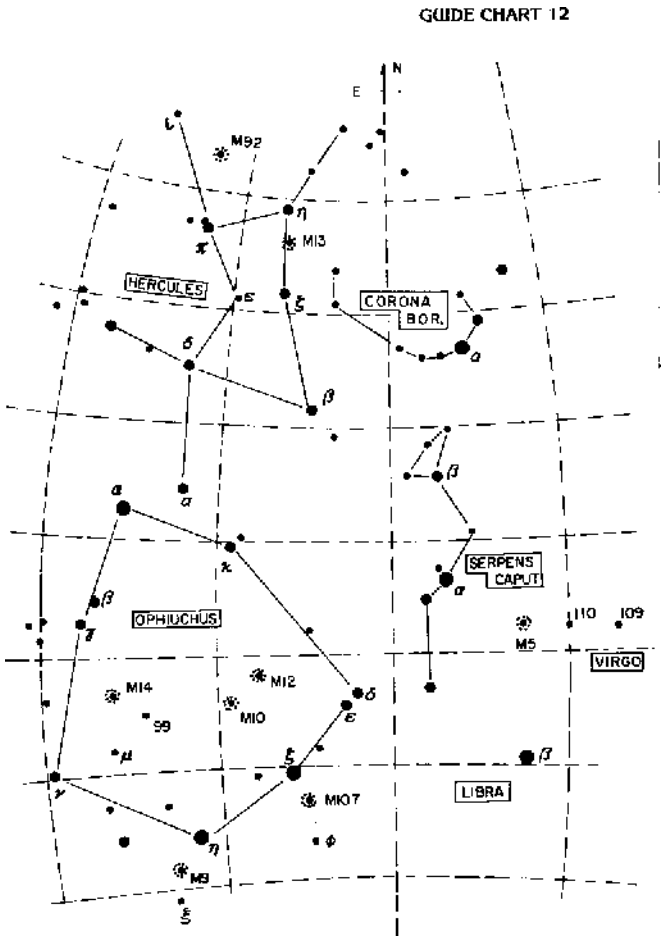
Ml 2(A): Bright; easy to resolve. Can be found by moving 1 /3rd of the way from *Delta* to *Alpha Ophiuchi* and a little S.

M13(E): A very famous globular, it can be made out with the naked eye on clear, dark nights. Can be partially resolved even with a 10 cm scope. A little less than half-way from Eta to Zeta *Herculis*.

M14{A):Move l/3rd of the way from Gamma to Eta *Ophiuchi and* slightly SE to locate this object. Round and faint it appears like an elliptical galaxy.

M92(E): Almost as bright as its near neighbour M13 in Hercules; outer portions can be resolved. A little further than half-way from *Eta to t Hercuiis*.

Ml 07(A): A small faint globular, found by moving a little more than a third of the way from Zeta to Phi *Ophiuchi* and then a little W.



GUIDE CHARTS 13A & 13B

OBJECTS: M4, M6, M7, MS, Ml9, M20. M2I, M22, M28, M54, M55, M62, M69, M70, M80

GEMERAL COMMENTS: Apart from the globulars Ml 9 and M62, all the other objects belong to the Scorpius - Sagittarius region; the Milky Way passes through this area and as a consequence it is rich in star fields and clusters. These Charts contain two outstanding examples of diffuse nebulae, the *Lagoon* and the *Trifid.* Best months are middle March to May for early morning viewing; August and September for early evening viewing but these months will not be very satisfactory as the objects will be setting at this time.

LOCATING & OBSERVING HINTS:

M4(E): Bright, large, easily resolvable globular almost exactly 1.5° W of *Antares.*

M6(E) & M7(E): A pair of beautiful open clusters near the tail of Scorpius. M6 appears like a butterfly with outspread wings; brilliant M7 is visible to the naked eye. M7 is almost exactly half-way between Kappa *Scorpii* and *Gamma Sagittarii;* M6 is 3° NW of M7.

M19(A): Compact but pretty globular; forms an equilateral triangle with *Antares* and epsillon *Scorpii.*

M62(A): A somewhat unsymmetrical, compact comet-like globular. Locate 4th mag. Xi Ophiuci; M62 lies l/3rd of the way from Epsillon *Scorpii* to Xi *Ophiuchi.*

M80(A): Small but bright globular, half-way between Antares and Beta *Scorpii.*

M8(E), *Lagoon nebula:* Beautiful, bright, diffuse nebula that is just visible to the naked eye; however, a clear, dark sky is required to see its full beauty. Associated with M8 is the brilliant open cluster NGC6530. To locate: M8 is on the Rho- Lambda *Sagittarii* line with M8 and Rho equidistant from Lambda.

M20{A), *Trifid nebula:* This famous emission-reflection nebula is best located by moving about 1.25°N of M8 and a little W, Not an easy object in a small telescope, the dark lanes require a large aperture for resolution; dark skies and averted vision are a must to make anything out

M21(A): This somewhat small, sparse cluster is just about 1° NE of M20.

M22(E): Is a smaller version of to *Centauri;* big, bright, easily resolvable globular. Locate by moving along the Tau-Rho *Sagittarii* line beyond *Rho;* the distance from M22 to *Rho* is a little less than twice the distance from Tau to Rho.

M28(E): Globular, 1° NW of Lambda *Sagittarii.*

M54(E): Small, bright globular about l/5th of the way from Zeta to *Epsillon Sagittarii* and a little N.

M55(A): Open, somewhat irregular globular. Move from Zeta along the *Delta-Zeta, Sagittarii* line, about the distance between them; then a little S to find M55.

M69{A) & M70(A): Two small, comparatively faint globulars; the centre of M70 appears more condensed and a 'tail' of small stars appears attached to it. M70 lies about half-way between Zeta and Epsillon *Sagittarii;* M69 is about 0.25th of the way from Epsillon to Phi *Sagittarii.*

GUIDE CHART 14

OBJECTS: Mil, Ml6, Ml7, Ml8, M23, M24, M25. M26

GENERAL COMMENTS: These objects are in Serpens, Scutum and Sagittarius. For the objects in this Chart one must be familiar with the 3rd mag. stars Xi *Sagittarii and Xi Serpentis* and the 4th mag. stars *alpha, beta, gamma* and delta Scuti, *Mu Sagittarii* and *omicron Serpentis* and the 5th mag. Star Eta *Scuti.* For early morning viewing the best months would be April-May and for early evening viewing, September.

LOCATING & OBSERVING HINTS:

M11(A), *Wild Duck:* A superb, fan shaped cluster, with a compact dense centre and an outer periphery of stars in the shape of a flight of wild ducks. There is a bright star at the apex of the fan and two more to the SE. First locate the Scutum area by following the line *Altair- delta- lamba Aquilae* to *12Aquilae* (see Chart 15); to its W is 5th rnag. *Eta Scuti.* M11 is about *2°* W and a little S of eta or find the midpoint between lambda *Aquilae* and *alpha* Scuti and move a little NW.

M16(A): A galactic cluster and associated diffuse nebula in Serpens; the cluster is easy to locate but the nebulosity is not that easy to see. Clear, dark skies and averted vision are essential for seeing the nebulosity. To locate: move l/ 3rd of the way from *gamma Scuti* to *Nu Ophiuchi* and then a little S.

M17(A), *Omega* or *Horse-Shoe Nebula;* Best approached from M16 by moving about 2.5° S and a little E; or, move 1.0° N and a little E of Ml 8, which lies half-way between Xi *Sagittarii* and Omicron Serpents. This is a real beauty, the brightest portion of which looks like the number 2; quite unmistakable and worthy of careful study.

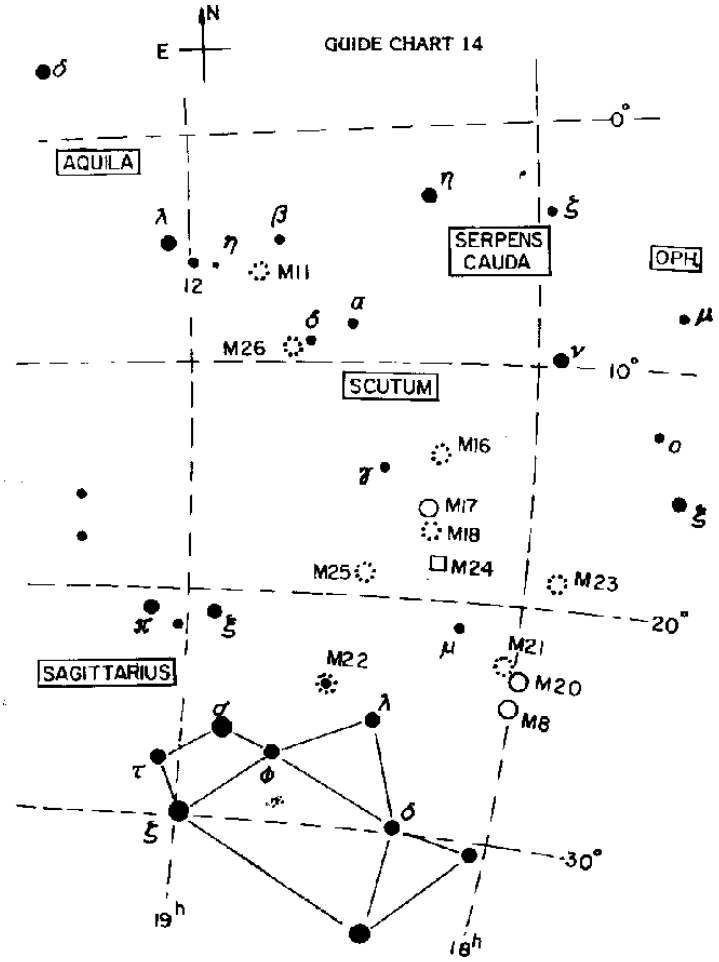
M18(A): A rather poor, undistinguished open cluster with one or two bright stars; the fainter ones form an S. Located half-way between Xi *Sagittarii* and *Omicron Serpentis.*

M23{A): This pretty open cluster lies a little less than midway from Mu *Sagittarii* to Xi *Serpentis.*

M24(A): Is a detached patch of Milky Way, about 1.0° x 1.5° in size halfway between *Xi Sagittarii and Xi Serpentis.* Near the NE boundary of M24 is a genuine cluster NGC6603 (about 4' in diameter); it lies N of a reddish star.

M25(A): A very fine cluster with many bright, coloured stars. A little more than half-way from lambda *Sagittarii* to gamma *Scuti* and slightly to the E.

M26(A): A small, comparatively faint open cluster; near the centre, 4 bright stars form a kite shape and immediately to the N and S are patches of faint stars. M26 is about 1.0° ESE of delta *Scuti* (4.5 mag.)



GUIDE CHART 15

OBJECTS: M27, M29, M39, M56, M57, M71

GENERAL COMMENTS: Except for M39 all the objects lie within the Summer *Triangle.* Included among these are two celebrated planetary nebulae: the *Dumb-bell* and the *Ring.* Best months would be August and September for early evening viewing; clear nights in July would be even better for late night viewing if the weather permits.

LOCATING & OBSERVING HINTS:

M27(A), *The Dumb-Bell nebula:* This is a grand object whose appearance fully justifies the name given to it. The planetary is quite bright and easy to locate. M27 is on the *gamma Lyrae - beta Cygni* line, as far from beta as *gamma* is from *beta* it is also 3° N of *gamma Sagittae.*

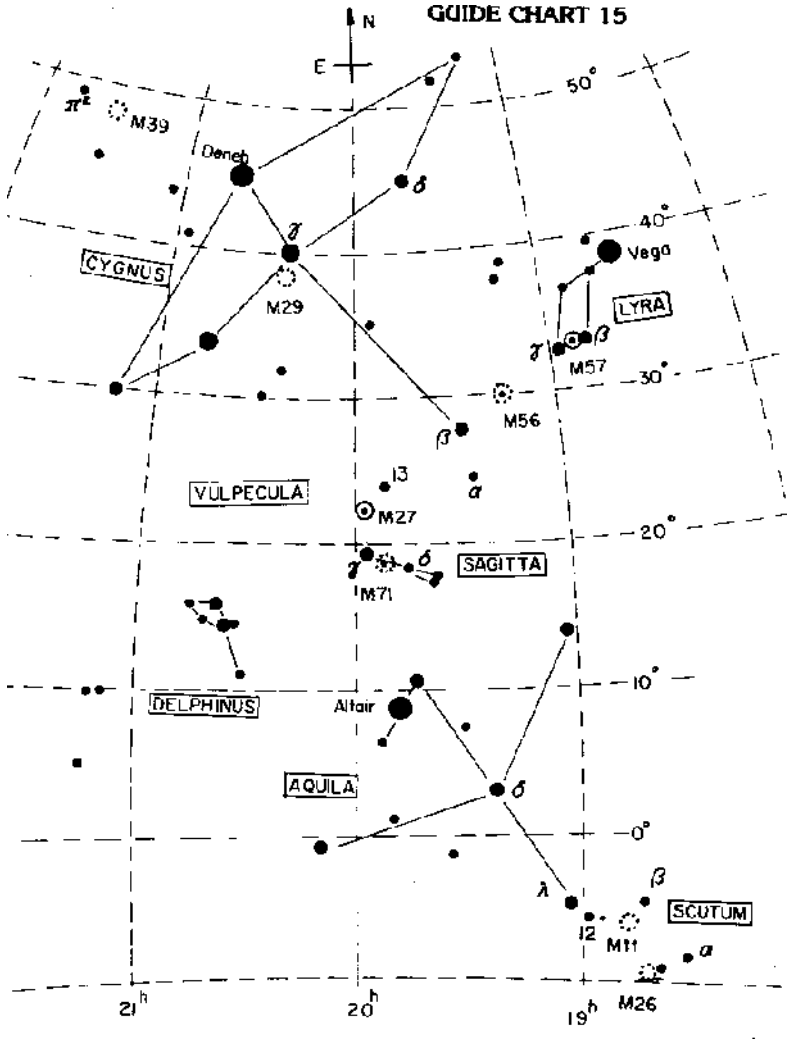
M29(A): A poor open cluster consisting of very few stars. The four brightest stars form a rectangle and three others form a triangle just N of the rectangle. The surrounding star field is far more impressive! M29 is almost 2° S of gamma *Cygni* and a little E.

M39(A): Bright open cluster with three stars at the corners of an equilateral triangle and most of the rest falling inside the triangle. Locate 4th mag. *pi*^{2} *Cygni;* M39 is 0.25th of the way from this star to Deneb.

M56(A): Small globular, a little less than half-way from beta *Cygni* to gamma *Lyrae.*

M57(A), *Ring nebula:* Though of 9th mag. this small, pretty planetary is clear and distinct; the ring can be made out as the centre is quite dark. Easily located a little more than half-way from gamma to beta Lyrae.

M71(A): Somewhat faint, irregular shaped globular cluster. Locate Sagitta in the *Summer Triangle;* M71 lies between gamma and *beta Sagittae.*



GUIDE CHART 16

OBJECTS: M2. Ml 5. M30, M72. M73, M75

GENERAL COMMENTS: For early evening viewing, the best months are August and September; clear nights in July would be best for late evening viewing.

LOCATING & OBSERVING HINTS:

M2(A): Bright globular cluster about 1/3rd of the way from *beta Aquarii* to *epsillon Pegasi* and a little to the W.

M15(A): Very fine globular cluster. Continue the line *Theta* to Epsillon *Pegasi* beyond Epsillon by an amount equal to one half the distance between Theta and Epsillon to find Ml 5.

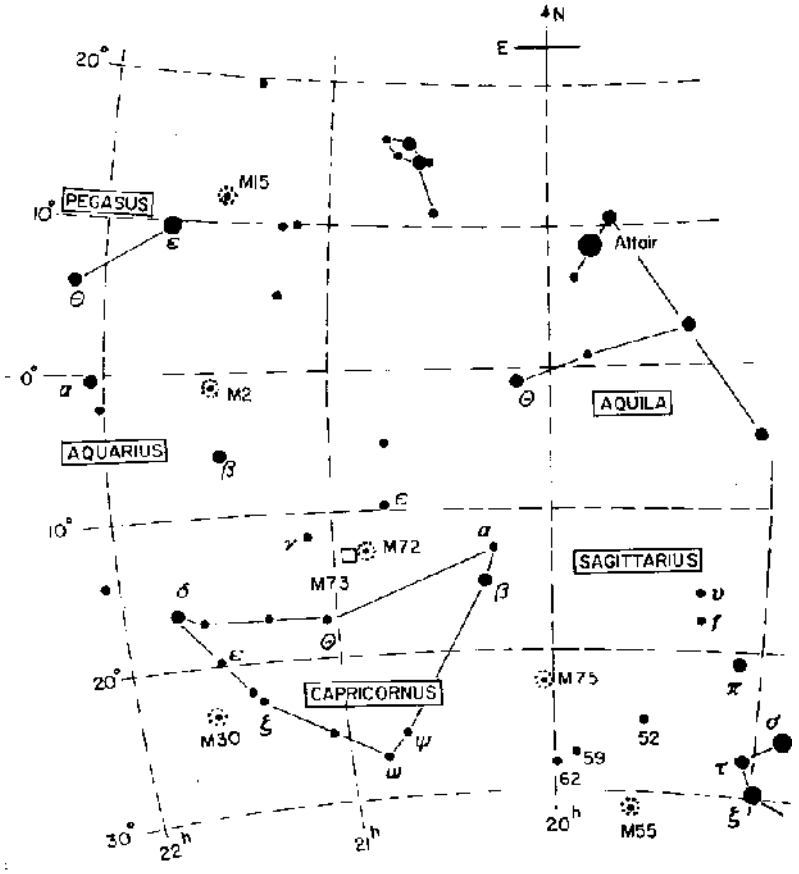
M30(A): A smaller globular. M30 almost forms an equilateral triangle with Epsillon and Theta Capricorni 5.5 mag 41Capricorni lies about 0.5° E of the globular.

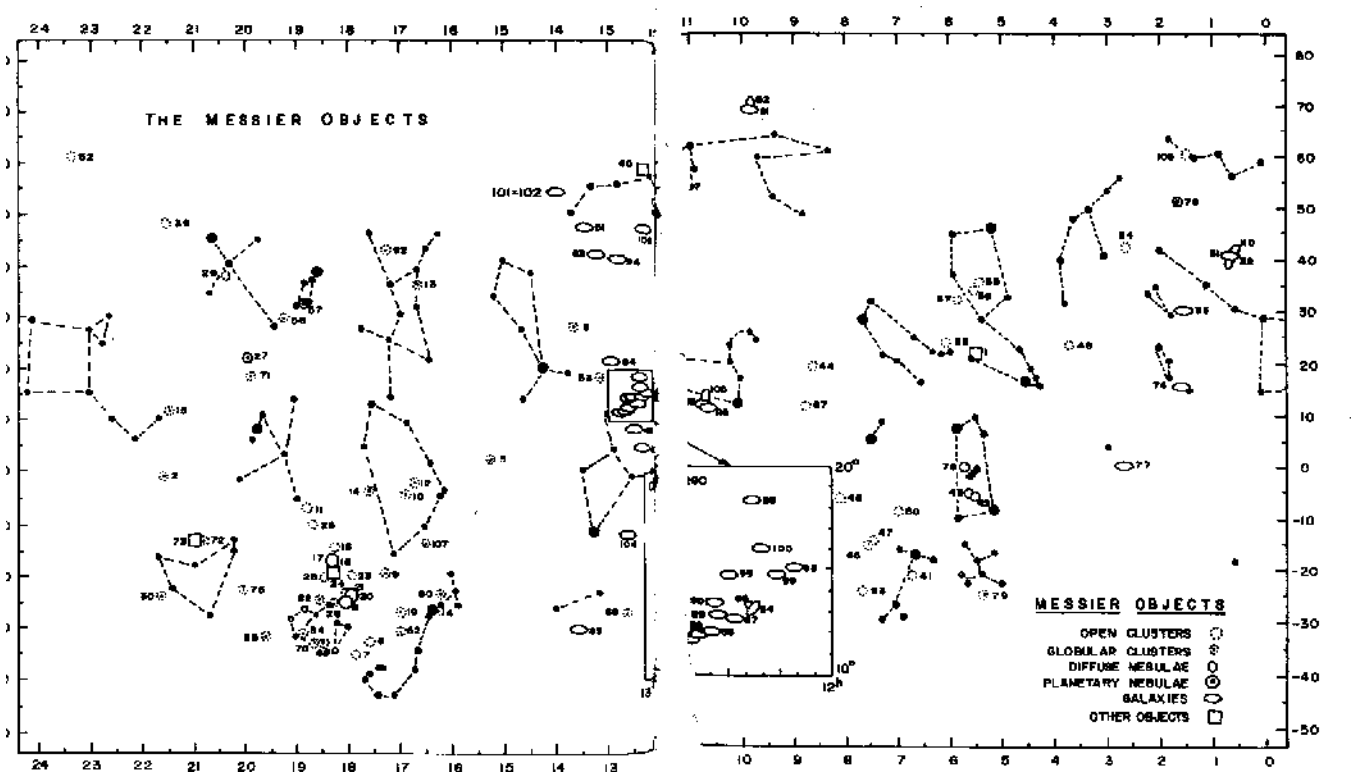
M72(A): The faintest of the Messier globulars. First find Epsillon *Aquarii; M72* is a little beyond half-way from *Theta* Capricorni to *Epsillon Aquarii*

M73(A): Is just an asterism, i.e. a group of stars. Best located by moving 1.5° E and a little S of M72; three faint but distinct stars form a triangle with a much fainter star to their W (see the relevant figure).

M75(A): A small globular with a bright centre. In order to locate this object, first note 4th mag. Rho and Upsillon *Sagittarii;* M75 lies half-way between Upsillon *Sagittarii* and Omega Capricorni.

GUIDE CHART 16





CHARLES MESSIER - A Brief Biography

Charles Messier was born on June 26, 1730, in a small town in the province of Lorraine in France. He was the 10th of 12 children in a family that was not well to do. Orphaned at the age of 11, he finished his schooling and decided at the age of 21 to seek his fortune in Paris the French capital. To his great luck, he was hired, apparently on account of his neat and legible handwriting, by the astronomer J. M. Delisle, as a draftsman and as a recorder of observations. Thus began the career of a remarkable astronomer.

Fortunately for Messier, in addition to his drafting work, he was given instruction in the use of astronomical instruments by Delisle and his secretary, Lisbour. By 1754 the young man's position as a clerk was regularised and in the meanwhile he had become a skilful observer. His favourite task was observing comets, a glamorous task in those days when the discovery of a new comet could bring fame and status to its discoverer. At the time, around 1758-1759, astronomers were eagerly anticipating the first predicted return of a comet, that of Halley. For many months Messier searched for the returning comet and was indeed the first person in France to make a sighting on January 21, 1759. Unfortunately for him the priority for the first sighting went to a German gentleman-farmer named Palitzsch, who had sighted the comet on December 25, 1758. Stoically, Messier put behind this and other disappointments and diligently continued his work. He discovered the comet of 1764 that of 1766 and for the next 15 years most comet discoveries made were his.

Rewards now began to come his way. He was accepted as a member of the Russian Academy of Sciences, as a foreign member of the Royal Society of London in 1764 and, finally, as a member of the Academie Royale des Sciences in Paris in 1770. The following year he was given the official position of Astronomer of the Navy; the young provincial with only a neat hand and some drawing skill had through his hard work, dedication and skill become the leading astronomer of France.

It was at this time, in 1771, that Messier published the first instalment of the work that was to ensure his fame - his catalogue of clusters and nebulae. As early as 1758, Messier had discovered the Crab Nebula in Taurus while observing the passage of a comet; the second object in the list, a globular duster in Aquarius, was observed in 1760 and by 1764 he had 40 objects in his proposed catalogue. While the first instalment of his catalogue had 45 objects, this was periodically revised until the final list in 1781 contained 103 objects, many of the later ones having been discovered by his friend and professional colleague, Pierre Mechain. A curious feature of Messier's catalogue is that his original motivation was to list these objects that might confuse comet hunters in their search for comets! In our times the objects in the catalogue are of interest, not so much the comets.

Apart from his work on comets and the related observations of clusters and nebulae. Messier observed transits, the movement of sunspots, occupations etc. In 1781, following William Herschel's momentous discovery of the planet Uranus, Messier, by careful observations, helped to establish that Uranus was indeed a planet of the Sun. Soon after he suffered a serious accident, a fall into an ice cellar, that left him incapacitated for more than a year. He later continued his work on comets, survived the French Revolution and managed to work assiduously inspite of great hardships. He died in his 87th year on April 12, 1817. The man who was known in his own times as 'the ferret of comets' is best remembered in our times as the author of his *Catalogue of Nebulae &* Star *Clusters.*

TABLE 1. Binaries (Double Stars)

Binary		Magnitudes of the components	Separation (seconds of arc)	Comments
ζ	*Aquarii*	4.4, 4.6	2.0	Test for 5 cm
δ	*Cephei*	Var., 7.5	41.0	Yellow and bluish
σ	*Cassiopeiae*	5.1, 7.2	3.1	
λ	*Cassiopeiae*	5.5, 5.8	0.5	
η	*Cassiopeiae*	3.6, 7.5	10.1	
γ	*Arietis*	4.8, 4.8	8.2	
α	*Piscium*	4.3, 5.2	2.1	Test for 5 cm
γ	*Andromedae*	2.3, 5.1	10.0	Orange, bluish
γ	*Ceti*	3.7, 6.4	3.0	
η	*Persei*	3.9, 8.6	28.4	Yellowish, bluish
ϵ	*Arietis*	5.2, 5.5	1.5	Test for 7.5 cm
ω	*Aurigae*	5.0, 8.0	5.8	
ρ	*Orionis*	4.7, 8.6	7.0	
η	*Orionis*	3.7, 5.1	1.5	Test for 10 cm
θ	*Aurigae*	2.7, 7.5	3.0	
μ	*Geminorum*	3.0, 9.8	122.5	
μ	*Canis Majoris*	5.2, 8.5	3.0	Yellowish, bluish
λ	*Geminorum*	3.7, 10.0	10.0	Easy test for 7.5 cm
δ	*Geminorum*	3.5, 8.1	6.8	Test for 5 cm
ι	*Cancri*	4.2, 6.6	30.7	Yellowish, bluish
κ	*Leonis*	4.6, 9.7	2.6	
γ	*Leonis*	2.6, 3.8	4.3	
δ	*Corvi*	3.1, 8.4	24.2	
γ	*Crucis*	1.6, 6.7	110.6	Wide pair
24	*Comae*	5.2, 6.7	20.3	Yellow, bluish
α	*Canum Venaticorum*	2.9, 5.4	19.7	
θ	*Virginis*	4.4, 8.6	7.2	Test for 7.5 cm
ζ	*Ursae Majoris*	2.4, 3.9	14.5	
τ	*Bootis*	4.5, 10.6	5.7	
k	*Centauri*	4.7, 6.2	7.6	
h	*Centauri*	4.8, 8.5	15.1	
τ	*Virginis*	4.3, 9.5	80.1	
κ	*Bootis*	4.6, 6.6	13.2	
ι	*Bootis*	4.8, 8.3	38.4	
ϕ	*Virginis*	5.0, 9.2	4.7	Test for 7.5 cm
ζ	*Bootis*	4.6, 4.6	1.2	

Binary		Magnitudes of the components	Separation (seconds of arc)	Comments
ε	*Bootis*	2.7, 5.1	2.9	Yellowish, bluish
5	*Serpentis*	5.2, 10	11.0	Near M5
δ	*Serpentis*	4.2, 5.2	3.9	
η	*Lupi*	3.6, 7.7	15.2	
β	*Scorpii*	2.9, 5.1	13.7	
ν	*Scorpii*	4.3, 6.5	41.4	Both are close doubles
	Antares	1:2, 6.5	2.9	Red, green
δ	*Herculis*	3.2, 8.8	10.0	
ρ	*Herculis*	4.5, 5.5	4.0	
ν	*Draconis*	4.9, 5.0	62.0	Wide pair
τ	*Ophiuchi*	5.3, 6.0	2.0	
ε	*Lyrae*	4.7, 4.5	207.8	Both doubles about 2".5 apart.
ζ	*Lyrae*	4.3, 5.9	43.7	
θ	*Serpentis*	4.5, 4.5	22.6	
γ	*Coronae Australis*	5.0, 5.1	2.7	
η	*Lyrae*	4.5, 8.7	28.2	
β	*Cygni*	3.2, 5.4	34.6	Yellow, greenish
δ	*Cygni*	3.0, 6.5	2.1	Test for 10 cm
γ	*Cygni*	2.3, 9.6	141.7	
γ	*Delphini*	4.5, 5.5	10.4	Yellow, greenish
μ	*Cygni*	4.7, 6.1	1.6	

TABLE 2. Summary Data On All Objects

1. The data collected here, for the convenience of the user, have been obtained from various sources including those listed in the Bibliography.

2. In specifying the types of objects, the following abbreviations have been used: A = *asterism,* DN — *diffuse nebula,* EG — *elliptical galaxy,* GC - *globular cluster,* IG - *irregular galaxy, MWP = Milky Way patch,* OC - open *cluster,* PN = *planetary nebula,* SG = *spiral galaxy,* SR — *supernova remnant.*

3. As regards magnitude, one is warned that there are serious discrepancies between data published in different sources. For example, for M76 Mallas and Kreimer (1978) give a value of 10-11 while Jones (1968) gives a value of 12.2; for M95 the same sources give 9 and 10.4 respectively, etc. For this reason the values given in Table 2 are to be understood to be *nominal values;* they are useful in comparing the relative brightness's of objects, even if the absolute values are not quite reliable.

4. For faint, nebulous, extended objects the apparent size depends on whether the observation is visual or photographic; if photographic, longer exposures often yield larger values for the size. Again the values given here are *nominal visual values;* the sizes actually seen may well be smaller, especially if the telescope is poor. Note r = 60' ~ 3600" (i.e. 1 degree = 60 minutes = 3600 seconds).

5. As a guide for the novice, an indication is given, for each object, of how difficult it is to locate and observe; difficulty is, admittedly, a subjective notion yet it may be of help. Note that E — easy, A — average, D = a little difficult X = quite difficult

OBJECT	GUIDE CHART	CONSTELLATION	TYPE	MAGNITUDE	SIZE	DIFFICULTY
M1 (*Crab*)	4	Taurus	SR	8.5	6′×4′	A
M2	16	Aquarius	GC	7	8′ dia.	A
M3	8	Canes Venatici	GC	6.5	6′ dia.	A
M4	13	Scorpius	GC	6.5	14′ dia.	E
M5	12	Serpens	GC	6	12′ dia.	E
M6	13	Scorpius	OC	5	25′ dia.	E
M7	13	Scorpius	OC	4	50′ dia.	E
M8 (*Lagoon*)	13	Sagittarius	DN	6	60×35′	E
M9	12	Ophiuchus	GC	8	3′ dia.	A
M10	12	Ophiuchus	GC	7	8′ dia.	A
M11 (*Wild Duck*)	14	Scutum	OC	6.5	15′ dia.	A
M12	12	Ophiuchus	GC	6.5	8′ dia.	A
M13	12	Hercules	GC	6	12′ dia.	E
M14	12	Ophiuchus	GC	8	3′ dia.	A
M15	16	Pegasus	GC	6.5	8′ dia.	A
M16	14	Serpens	OC & DN	6.5	10′ dia.	A
M17 (*Omega*)	14	Sagittarius	DN & OC	7	20′ dia.	A
M18	14	Sagittarius	OC	7.5	10′ dia.	A
M19	13	Ophiuchus	GC	7	5′ dia.	A
M20 (*Trifid*)	13	Sagittarius	DN	9	29′×27′	A
M21	13	Sagittarius	OC	6.5	12′ dia.	A
M22	13	Sagittarius	GC	6	18′ dia.	E
M23	14	Sagittarius	OC	7	25′ dia.	A

OBJECT	GUIDE CHART	CONSTELLATION	TYPE	MAGNITUDE	SIZE	DIFFICULTY
M24	14	Sagittarius	MWP	4.5	1°×1.5°	A
M25	14	Sagittarius	OC	5.5	35′ dia.	A
M26	14	Scutum	OC	9	10′ dia.	A
M27 (*Dumb-bell*)	15	Vulpecula	PN	8	8′×4′	A
M28	13	Sagittarius	GC	7	15′ dia.	E
M29	15	Cygnus	OC	7	6′ dia.	A
M30	16	Capricornus	GC	8	6′ dia.	A
M31 (*Andromeda Galaxy*)	1	Andromeda	SG	4.5	30′×8′ (nucleus)	E
M32	1	Andromeda	EG	8.5	3′ dia.	A
M33	1	Triangulum	SG	6.5	1° dia (centre: 6′ dia.)	X
M34	3	Perseus	OC	5.5	30′ dia.	E
M35	4	Gemini	OC	5.5	30′ dia.	A
M36	4	Auriga	OC	6.5	15′ dia.	A
M37	4	Auriga	OC	6.5	20′ dia.	A
M38	4	Auriga	OC	7	20′ dia.	A
M39	15	Cygnus	OC	5.5	30′ dia.	A
M40	7	Ursa Major	DS	9,9.3	49″ sep.	A
M41	6	Canis Major	OC	5	30′ dia.	E
M42 (*Orion Nebula*)	5	Orion	DN	4	60′ dia. (30′×10′ central)	E
M43	5	Orion	DN	9	4′ dia.	E

OBJECT	GUIDE CHART	CONSTELLATION	TYPE	MAGNITUDE	SIZE	DIFFICULTY
M44 (*Beehive*)	6	Cancer	OC	4	1° dia.	E
M45 (*Pleiades*)	3	Taurus	OC	1.5	2° dia.	E
M46	6	Puppis	OC	6	30′ dia.	A
M47	6	Puppis	OC	5	25′ dia.	A
M48	6	Hydra	OC	5.5	30′ dia.	A
M49	10	Virgo	EG	8.5	3′ × 2′	A
M50	6	Monoceros	OC	6.5	16′ dia.	A
M51 (*Whirlpool*)	8	Canes Venatici	SG	8	11′ × 7′	A
M52	2	Cassiopeia	OC	7	20′ × 12′	A
M53	8	Coma Berenices	GC	7.6	3.5′ dia.	E
M54	13	Sagittarius	GC	7.5	4′ dia.	E
M55	13	Sagittarius	GC	7	15′ dia.	A
M56	15	Lyra	GC	8	5′ dia.	A
M57 (*Ring*)	15	Lyra	PN	9	75″ × 50″	A
M58	10	Virgo	SG	8.5	4′ × 3′	A
M59	10	Virgo	EG	9.5	2′ × 1.5′	A
M60	10	Virgo	EG	9	2′ dia.	A
M61	10	Virgo	SG	10	5′ dia.	D
M62	13	Ophiuchus	GC	7	6′ dia.	A
M63	8	Canes Venatici	SG	10	10′ × 6′	D
M64 (*Black-eye*)	8	Coma Berenices	SG	7	6′ × 3′	A
M65	9	Leo	SG	9.5	8′ × 1½′	A
M66	9	Leo	SG	9.0	8′ × 2½′	A
M67	6	Cancer	OC	6	25′ dia.	A
M68	11	Hydra	GC	8	4′ dia.	A
M69	13	Sagittarius	GC	9	3′ dia.	A
M70	13	Sagittarius	GC	9	3′ dia.	A
M71	15	Sagitta	GC	8.5	6′ dia.	A
M72	16	Aquarius	GC	10	2′ dia.	A
M73	16	Aquarius	A	10	2′ dia.	A
M74	1	Pisces	SG	10	6′ dia.	X
M75	16	Sagittarius	GC	8.5	5′ dia.	A
M76	1	Perseus	PN	12	1.5′ × 1′	D
M77	3	Cetus	SG	9	3′ dia.	A
M78	5	Orion	DN	8.5	8′ × 6′	A
M79	5	Lepus	GC	8	3′ dia.	A
M80	13	Scorpius	GC	8	3′ dia.	A
M81	7	Ursa Major	SG	8	10′ × 7′	A
M82	7	Ursa Major	IG	9	8′ × 2′	A
M83	11	Hydra	SG	8	8′ × 5′	A
M84	10	Virgo	SG	9.5	2′ dia.	A
M85	8	Coma Berenices	SG	9	4′ × 2′	A
M86	10	Virgo	EG	9.5	2′ × 1′	A
M87	10	Virgo	EG	8.5	2′ dia.	A
M88	10	Coma Berenices	SG	9	5′ × 2′	A
M89	10	Virgo	EG	9.5	2′ dia.	A

OBJECT	GUIDE CHART	CONSTELLATION	TYPE	MAGNITUDE	SIZE	DIFFICULTY
M90	10	Virgo	SG	9.5	5′×2′	A
M91						
M92	12	Hercules	GC	6	8′	A
M93	6	Puppis	OC	6	18′ dia.	A
M94	8	Canes Venatici	SG	8	5′×2′	A
M95	9	Leo	SG	10	3′ dia.	D
M96	9	Leo	SG	9	6′×4′	A
M97 (*Owl*)	7	Ursa Major	PN	12	3′ dia.	X
M98	10	Coma Berenices	SG	10.5	8′×2′	D
M99	10	Coma Berenices	SG	10	4′ dia.	D
M100	8	Coma Berenices	SG	10	5′ dia.	D
M101 = M102	7	Ursa Major	SG	9.5	10′ × 8′	X
M103	2	Cassiopeia	OC	6	12′ × 5′	A
M104 (*Sombrero*)	11	Virgo	SG	8.5	6′ × 2′	A
M105	9	Leo	EG	9	2′ dia.	A
M106	8	Canes Venatici	SG	8.5	10′ × 5′	A
M107	12	Ophiuchus	GC	9	3′ dia.	A
M108	7	Ursa Major	SG	10.5	8′ × 1′	X
M109	7	Ursa Major	SG	10.5	7′ × 4′	X
M110	1	Andromeda	EG	9.5	10′ × 5′	D
h & χ Persei	2	Perseus	OC	4	45′ dia. each	E
ω Centauri	11	Centaurus	GC	3.5	30′ dia.	E
κ Crucis (Jewel Box)	11	Crux	OC	6-7	10′ dia.	E
NGC3242	11	Hydra	PN	9	40″ × 35″	A

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