Chapter 7

Naked-Eye Objects

All the objects discussed so far in the book have needed some sort of telescopic equipment, be it binoculars or varying sizes of telescope, in order to be seen. However, it may come as a surprise to you to know that there are a number of interesting celestial objects that can be glimpsed with the naked eye!

Be aware though that they will NOT appear anything like the views seen through an eyepiece. In fact, more often than not, all that will be seen is a very faint star-like object. Nevertheless, it is possible to see unique stars, star clusters, nebulae and galaxies all with the naked eye.

Remember that exceptionally clear and transparent skies will be needed, as well as a minimum of light pollution. From discussions with very experienced amateur astronomers, in order to see these elusive objects, a good knowledge of the night sky also helps, as is good eyesight.

Please note that those objects listed are ones that I know from personal experience and correspondence with other astronomers. Many more can possibly be seen that have yet to be reported or even attempted. To that end I have set up a dedicated website that seeks to list all those deep sky objects that can be seen; http://web.me.com/mdiastro/faintestobject.

The usual information that is provided in previous object descriptions is used here.

The following descriptions also contain detail that can be seen with telescopes.

M.D. Inglis, *A Field Guide to Deep-Sky Objects*, Patrick Moore's Practical Astronomy Series, DOI 10.1007/978-1-4614-1266-3_7,

Double and Red Stars

ζ^2 Sco	HD 152334	$16^h\ 54.6^m$	–42° 22′	June 5
3.62 m	0.3 M	K4 III	Scorpius	Easy

The brighter of the two stars in this naked-eye optical double star system, the orange supergiant star contrasts nicely with its slightly fainter blue supergiant companion.

θ Orionis C	θ Ori	$05^h\ 35.3^m$	–05° 23′	December 14
5.13 m	–3.2 M	O6 pe V	Orion	Easy

A member of the famous Trapezium multiple-star system in the Orion Nebula. Splitting the group is always a test for small telescopes. A fairly new star, maybe only several thousand years old, and as a consequence most of the star's light is emitted at ultraviolet wavelengths. It has the honor of having highest surface temperature of any star that is visible to the naked eye.

La Superba	Y Canum Venaticorum	$12^h\ 45.1^m$	+45° 26′	April 2
4.8_vm	B-V:2.9	C7		Easy

One of the reddest stars in the sky, the color of this star is best seen through binoculars or a small telescope. With a period of 159 days and varying in magnitude between 4.9 and 6.0 m, this red giant has a diameter of 400 million km. La Superba (Y CVn) also has two other surprises: it is the brightest J-star in the sky, a very rare category of carbon stars that contain large amounts of carbon-13 (carbon atoms with seven neutrons instead of the usual six) and is one of the coolest of naked-eye stars, with a temperature[1] around 2,200 K.

ζ Ursae Majoris	ADS 8891	$13^h\ 23.9^m$	+54° 56′	April 12
2.3, 4.0 m	P.A. 152°| Sep. 14.4"			Very easy ©

The famous double Mizar and Alcor (80 UMa). Visible to the naked eye and very nice in binoculars. A small telescope will resolve Mizar's fourth magnitude companion. Alcor and both members of Mizar are themselves spectroscopic binaries. Thus there are six stars in the system. Mizar also has several other distinctions: the first double to be discovered by telescope, by Riccioli in 1650; the first to be photographed, by Bond in 1857; and the first spectroscopic binary detected, by Pickering in 1889.

[1]Research indicates the figure could be 2,800 K.

α Capricorni	ADS 13632	$20^h\ 18.1^m$	−12° 33′	July 26
3.6, 4.2 m	P.A. 29°| Sep. 378”			Very easy

A widely spaced, naked-eye optical double. Both stars are a yellow-orange color, but when they are viewed through small telescopes it will be seen that both stars are themselves binaries.

ε Lyrae[1,2]	ADS 11635	$18^h\ 44.3^m$	+39° 40′	July 2
4.7, 6.2 m	P.A. 357°| Sep. 2.6″			Easy/moderate
5.1, 5.5 m	P.A. 94° | Sep. 2.3″			Easy/moderate

The famous Double-Double, easily split, but to resolve the components of each star, ε^1 (magnitude 4.7) and ε^3 (magnitude 4.6), requires a high power. The stars themselves are at a P.A. 173°, separated by 208″, which is near the naked-eye limit, and some keen-eyed observers report being able to resolve them under perfect seeing. However, there is fierce debate among amateurs – some saying the double is difficult to resolve, others the opposite. All stars are white- or cream-white colored. This system is definitely a highlight of the summer sky.

Garnet Star	μ Cephei	$21^h\ 43.5^m$	+58° 47′	August 17
4.04_v m	B-V:2.26	M2Ia		Easy

Located on the northeastern edge of the nebulosity IC1396, the Garnet Star, named by William Herschel, is one of the reddest stars in the entire sky. It has a deep orange or red color seen against a backdrop of faint white stars. It is a pulsating red supergiant star, with a period of about 730 days, varying from 3.4 to 5.1 m. It is in the last stages of its life and could go supernova anytime now, relatively speaking of course.

Star Clusters

Open Clusters

Messier 41	NGC 2287	$06^h\ 47.0^m$	−20° 44′	January 2
4.5 m	⊕ 38′	70	II 3 m	Easy

Easily visible to the naked eye on very clear nights as a cloudy spot slightly larger in size than the full Moon. Nicely resolved in binoculars, it becomes very impressive with medium aperture, with many double- and multiple-star combinations. Contains blue B-type giant stars as well as several K-type giants. Current

research indicates that the cluster is about 100 million years old and occupies a volume of space 80 light-years in diameter.

Messier 50	NGC 2323	$07^h\ 03.2^m$	–80° 20′	January 6
5.9 m	⊕ 16′	80	II 3 m	Easy

The only Messier object in Monoceros and one that is often overlooked by amateurs. Discovered by Cassini, this is a fine, heart-shaped cluster easily seen in binoculars and visible to the naked eye on clear nights. Within the large, bright and irregular cluster of blue stars is a striking red star. What makes the cluster particularly challenging is that the area of the sky where it resides is full of small stellar groupings and asterisms. The question often arises, where does the cluster end and the background star field begin?

Messier 44	NGC 2632	$08^h\ 40.1^m$	+19° 59′	January 30
3.1 m	⊕ 95′	60	II 2 m	Easy

A famous cluster, called Praesepe (the Manger) or the Beehive. One of the largest and brightest open clusters from the viewpoint of an observer. An old cluster, about 700 million years old, distance 500 light-years, with the same space motion and velocity as the Hyades, which suggests a common origin for the two clusters. A nice triple star, Burnham 584 is located within M44, just south of the cluster's center. A unique Messier object in that it is brighter than the stars of the constellation within which it resides. Owing to its large angular size in the sky, it is best seen through binoculars or a low-power eyepiece.

Melotte 111	–	$12^h\ 25.0^m$	+26°	March 28
1.8 m	⊕ 275′	75	II 3 p	Easy

Also known as the Coma Star Cluster, this is a large and impressive cluster of fifth- and sixth-magnitude stars, spanning about 5°. Owing to its large size, it is only worth observing with binoculars because telescope observation will lose the clustering effect. Believed to be 400 million years old and 260 light-years distant, it is the third nearest cluster. Because of its extremely weak gravitational field the cluster may be on the verge of complete disruption. Paradoxically, although this cluster is visible to the naked eye, it has neither a Messier nor an NGC designation.

Messier 6	NGC 6405	$17^h\ 40.1^m$	–32° 13′	June 16
4.2 m	⊕ 33′	100	II 3 r	Easy

Also known as the Butterfly Cluster. Easily seen with the naked eye as a dim patch of light. It is perhaps one of the few stellar objects that actually looks like the entity after which it is named. A fine sight in binoculars, it contains the lovely orange-tinted star BM Scorpii east of its center. This star is a semi-regular variable, period 850 days, which changes from magnitude 5.5 to 7. Surrounding it are many nice steely blue-white stars. Believed to be at a distance of 1,590 light-years.

–	IC 4665	17^h 46.3^m	+05° 43′	June 18
4.2 m	⊕ 40′	30	III 2 m	Easy

A naked-eye object under perfect seeing conditions, this large cluster appears as a hazy spot measuring over two full Moon diameters. With binoculars, nearly 30 blue-white sixth magnitude stars can be seen. Its position in a sparse area of the sky emphasizes the cluster, even though it is not a particularly dense collection of stars.

Messier 7	NGC 6475	17^h 53.9^m	−34° 49′	June 20
3.3 m	⊕ 80′	80	I 3 r	Easy

An enormous and spectacular cluster. It presents a fine spectacle in binoculars and telescopes, containing over 80 blue-white and pale yellow stars. It is only just over 800 light-years away but is over 200 million years old. Many of the stars are around sixth and seventh magnitude and thus should be resolvable with the naked eye. Try it and see.

Messier 24[2]	–	18^h 16.5^m	−18° 50′	June 25
2.5 m	⊕ 95′× 35′		–	Easy

Another superb object for binoculars. This is the Small Sagittarius Star Cloud, visible to the naked eye on clear nights and nearly four times the angular size of the Moon. The cluster is in fact part of the Norma Spiral Arm of our galaxy, located about 15,000 light-years from us. The faint background glow from innumerable unresolved stars is a backdrop to a breathtaking display of sixth- to tenth-magnitude stars. It also includes several dark nebulae, which adds to the three-dimensional impression. Many regard the cluster as truly a showpiece of the sky. Spend a long time observing this jewel!

Messier 25	IC 4725	18^h 31.6^m	−19° 15′	June 29
4.6 m	⊕ 32′	40	I 3 m	Easy

Visible to the naked eye, this is a pleasing cluster suitable for binocular observation. It contains several star chains and is also noteworthy for small areas of dark nebulosity that seem to blanket out areas within the cluster, but you will need perfect conditions to appreciate these. Unique for two reasons: it is the only Messier object referenced in the *Index Catalogue* (IC) and is one of the few clusters to contain a Cepheid-type variable star – U Sagittarii. The star displays a magnitude change from 6.3 to 7.1 over a period of 6 days and 18 h.

[2]Located within Sagittarius are numerous open clusters. Only the brightest are listed here.

Collinder 399	–	$19^h\ 25.4^m$	+20° 11′	July 13
3.6 m	⊕ 60′	35	III 3 m	Easy

Also known as the Coathanger or Brocchi's Cluster. Often overlooked by observers, this is a large, dissipated cluster easily seen with binoculars; indeed, several of the brightest members should be visible with the naked eye. It contains a nice orange-tinted star and several blue tinted stars. Its three dozen members are set against a background filled with fainter stars. Well worth observing during warm summer evenings.

Herschel 30	NGC 7789	$23^h\ 57.0^m$	+56° 44′	September 20
6.9 m	⊕ 15′	300	II 1 r	Medium©

Visible as a hazy spot to the naked eye and even with small binoculars is never fully resolvable; it is believed to be one of the major omissions from the Messier catalog. Through a telescope it is seen as a very rich and compressed cluster. With large aperture, the cluster is superb and has been likened to a field of scattered diamond dust. Contains hundreds of stars of tenth magnitude and fainter.

Caldwell 14	NGC 869	$02^h\ 19.0^m$	+57° 09′	October 26
5.3 m	⊕ 29′	200	I 3 r	Easy©
	NGC 884	$02^h\ 22.4^m$	+57° 07′	
6.1 m	⊕ 29′	115	II 2 p	

Glorious! The famous Double Cluster in Perseus should be on every amateur's observing schedule and is a highlight of the northern hemisphere's winter sky. Strangely, never cataloged by Messier even though it is visible to the naked eye, but it is best seen using a low-power, wide-field optical system. Whatever system is used, the views are marvelous. NGC 869 has around 200 members, while NGC 884 has about 150. Both are composed of A- and B-type supergiant stars with many nice red giant stars. However, the systems are dissimilar. NGC 869 is 5.6 million years old (at a distance of 7,200 light-years), whereas NGC 884 is younger, at 3.2 million (at a distance of 7,500 light-years). But be advised that in astrophysics, especially as concerns distance and age determination, there are very large errors!

Also, it was found that nearly half the stars are variables of the type Be, indicating that they are young stars with possible circumstellar discs of dust. Both are part of the Perseus OB1 Association from which the Perseus spiral arm of the galaxy has been named. Don't rush these clusters; spend a long time observing both of them and the background star fields.

Messier 34	NGC 1039	$02^h\ 42.0^m$	+42° 47′	November 1
5.2 m	⊕ 35′	60	II 3 m	Easy

A nice cluster easily found, about the same size as the full Moon. It can be glimpsed with the naked eye and is best seen with medium-sized binoculars, as a telescope will spread out the cluster and so lessen its impact. At the center of the cluster is the double star H1123, both members being eighth-magnitude and of type A0. The pure-white stars are very concentrated toward the cluster's center, while the fainter members disperse toward its periphery. Thought to be about 200 million years old, lying at a distance of 1,500 light-years from us.

Messier 45	Melotte 22	$03^h\ 47.0^m$	+24° 07′	November 17
1.2 m	⊕ 110′	100	I 3 r	Easy

Outstanding! Without a doubt the sky's premier star cluster. The Seven Sisters, or Pleiades, is beautiful however you observe it – naked-eye, through binoculars or with a telescope. To see all the members at one go will require binoculars or a rich-field telescope. Consisting of over 100 stars, spanning an area four times that of the full Moon, it will never cease to amaze. It is often stated that from an urban location six to seven stars may be glimpsed with the naked eye. However, it may come as a surprise to many of you that it has ten stars brighter than sixth magnitude, and that seasoned amateurs with perfect conditions have reported 18 being visible with the naked eye. It lies at a distance of 410 light-years, is about 20 million years old (although some report it as 70 million) and is the fourth-nearest cluster. It contains many stunning blue and white B-type giants.

The cluster contains many double and multiple stars. Under perfect conditions with exceptionally clean optics, the faint nebula NGC 1435, the Merope Nebula surrounding the star of the same name (Merope – 23 Tauri), can be glimpsed and was described by W. Tempel in 1859 as "a breath on a mirror." However, this and the nebulosity associated with the other Pleiades are not, as they were once thought to be, the remnants of the original progenitor dust and gas cloud. The cluster is just passing through an edge of the Taurus Dark Cloud Complex. It is moving through space at a velocity of about 40 km a second, so by A.D. 32,000 it will have moved an angular distance equal to that of the full Moon. The cluster contains the stars Pleione, Atlas, Alcyone, Merope, Maia, Electra, Celaeno, Taygeta and Asterope. A true celestial showpiece.

Caldwell 41	Melotte 25	$04^h\ 27.0^m$	+16° 00′	November 27
0.5 m	⊕ 330′	40	II 3 m	Easy

Also known as the Hyades. The nearest cluster after the Ursa Major Moving Stream, lying at a distance of 151 light-years, with an age of about 625 million years. Even though the cluster is widely dispersed both in space and over the sky, it nevertheless is gravitationally bound, with the more massive stars lying at the center of the cluster.

Best seen with binoculars owing to the large extent of the cluster – over 5½°. Hundreds of stars are visible, including the fine orange giant stars γ, δ, ε and θ^{-1} Tauri. Aldebaran, the lovely orange K-type giant star is not a true member of the cluster but is a foreground star only 70 light-years away. Visible even from light-polluted urban areas – a rarity!

Herschel 47	NGC 1502	$04^h\ 07.7^m$	+62° 20′	November 22
5.7 m	⊕ 8′	45	II 3 p	Medium©

This cluster is easy to see, but can prove difficult to locate, even though it is in a relatively sparse area of the sky. Visible to the naked eye on clear nights. It is a rich and bright cluster but small and may resemble a fan shape, although this does depend on what the observer sees. What do you see? Also contained in the cluster are two multiple stars: Struve 484 and 485. The former is a nice triple system, but the latter is a true spectacle with nine components! Seven of these are visible in a telescope of 10 cm aperture, ranging between 7th and 13th magnitude. The remaining two components, 13.6 and 14.1 magnitude, should be visible in a 20 cm telescope. In addition, the system's brightest component, SZ Camelopardalis, is an eclipsing variable star, which changes magnitude by 0.3 over 2.7 days. What makes this cluster so special is its proximity to the asterism called Kemble's Cascade. This is a long string (2.5°) of eighth-magnitude stars to the northwest of H47. The cascade is best seen in low-power binoculars.

Melotte 28	NGC 1746	$05^h\ 03.6^m$	+23° 49′	December 6
6.1 m	⊕ 42′	20	III 2 p	Easy

Another large and scattered cluster, visible on clear nights with the naked eye. Within the cluster are two other smaller ones, each with its own classification – NGC 1750 and 1758. This phenomenon makes it difficult to determine accurately the true diameter of the cluster.

Messier 38	NGC 1912	$05^h\ 28.7^m$	+35° 50′	December 13
6.4 m	⊕ 21′	75	III 2 m	Easy

One of the three Messier clusters in Auriga visible to the naked eye. It contains many A-type main sequence and G-type giant stars, with a G0 giant being the brightest, magnitude 7.9. Is elongated in shape with several double stars and voids within it. Seen as a small glow in binoculars, it is truly lovely in small telescopes. It is an old galactic cluster with a star density calculated to be about eight stars per cubic parsec.

Messier 36	NGC 1960	$05^h\ 36.1^m$	+34° 08′	December 15
6.0 m	⊕ 12′	70	II 3 m	Easy

About half the size of M38, seen as a glow in binoculars. It is a large, bright cluster. Measurements indicate that it is ten times farther away than the Pleiades. It contains a nice double star at its center. Owing to the faintness of its outlying members it is difficult to ascertain where the cluster ends. Visible to naked eye.

Messier 37	NGC 2099	$05^h\ 52.4^m$	+32° 33′	December 19
5.6 m	⊕ 20′	150	II 1 r	Easy

In a word – superb! The finest cluster in Auriga. It really can be likened to a sprinkling of stardust, and some observers liken it to a scattering of gold dust. Contains many A-type stars and several red giants. Visible at all apertures, from a soft glow with a few stars in binoculars to a fine, star-studded field in medium-aperture telescopes. In small telescopes using a low magnification it can appear as a globular cluster. The central star is colored a lovely deep red, although several observers report it as a much paler red, which may indicate that it is a variable star. Visible to the naked eye.

Messier 35	NGC 2168	$06^h\ 08.9^m$	+24° 20′	December 23
5.1 m	⊕ 28′	200	III 2 m	Easy

One of the most magnificent clusters in the sky. Visible to the naked eye on clear winter nights with a diameter as big as that of the full Moon, and it seems as if the cluster is just beyond being resolved. Many more stars are visible in binoculars set against the hazy glow of unresolved members of the cluster. With telescopes, the magnificence of the cluster becomes apparent, with many curving chains of stars.

Globular Clusters

Messier 3	NGC 5272	$13^h\ 42.2^m$	+28° 23′	April 17
6.2 m	⊕ 18′		VI	Easy

A splendid object, easily seen in binoculars and a good test for the naked eye. If using giant binoculars with perfect seeing, some stars may be resolved. A beautiful and stunning cluster in telescopes, it easily rivals M13 in Hercules. It definitely shows pale colored tints, and reported colors include, yellow, blue and even green; in fact, it is often quoted as the most colorful globular in the northern sky. Full of structure and detail including several dark and mysterious tiny dark patches. Many of the stars in the cluster are also variable. One of the three brightest clusters in the northern hemisphere. Located at a distance of about 34,000 light-years.

Messier 5	NGC 5904	$15^h\ 18.6^m$	+02° 05′	May 11
6.65 m	⊕ 23.0′		V	Easy

A wonderful cluster and visible to the naked eye on clear nights. Easily seen as a disc with binoculars, and with large telescopes the view is breathtaking – presenting an almost three-dimensional vista. One of the few colored globular clusters, with a faint, pale yellow outer region surrounding a blue-tinted interior. It gets even better with higher magnification, as more detail and stars become apparent. Possibly containing over half a million stars, this is one of the finest clusters in the northern hemisphere; many say it is *the* finest.

Messier 13	NGC 6205	$16^h\ 41.7^m$	+36° 28′	June 1
5.8 m	⊕ 20′		V	Easy

Also known as the Great Hercules Cluster. A splendid object and the premier cluster of the northern hemisphere. Visible to the naked eye, it has a hazy appearance in binoculars; with telescopes, however, it is magnificent, with a dense core surrounded by a sphere of a diamond dust-like array of stars. In larger telescopes, several dark bands can be seen bisecting the cluster. It appears bright because it is close to us at only 25,000 light-years and also because it is inherently bright, shining at a luminosity equivalent to over 250,000 Suns. At only around 160 light-years in diameter, the stars must be very crowded, with several stars per cubic light-year, a density some 500 times that of our vicinity. All in all a magnificent cluster.

Messier 10	NGC 6254	$16^h\ 57.1^m$	–04° 06′	June 5
6.4 m	⊕ 20′		VII	Easy

Similar to M12, it is however slightly brighter and more concentrated. Can be seen with the naked eye on dark nights. It lies close to the orange star 30 Ophiuchi (spectral type K4, magnitude 5), and so if you locate this star then by using averted vision M10 should be easily seen. With apertures of 20 cm and more, the stars are easily resolved right to the cluster's center. Under medium aperture and magnification, several colored components have been reported: a pale blue tinted outer region surrounding a very faint pink area, with a yellow star at the cluster's center.

Messier 92	NGC 6341	$17^h\ 17.1^m$	–43° 08′	June 10
6.4 m	⊕ 11′		IV	Medium

A beautiful cluster often overshadowed by its more illustrious neighbor, M13. It is a somewhat difficult object to locate, but once found is truly spectacular. It can be glimpsed with the naked eye. In binoculars it will appear as a hazy small patch, but in 20 cm telescopes its true beauty becomes apparent with a bright, strongly concentrated core. It also has several very distinct dark lanes running across the face of the cluster. A very old cluster, 25,000 light-years distant.

Messier 22	NGC 6656	$18^h\ 36.4^m$	–23° 54′	June 30
5.1 m	⊕ 32′		VII	Easy

Wonderful, a truly spectacular globular cluster visible under perfect conditions to the naked eye. Low-power eyepieces will show a hazy spot of light, while high power will resolve a few stars. A 15 cm telescope will give an amazing view of minute bright stars evenly spaced over a huge area. Often passed over by northern hemisphere observers owing to its low declination. Only 10,000 light-years away, nearly twice as close as M13.

Messier 55	NGC 6809	$19^h\ 40.0^m$	–30° 58′	July 17
6.3 m	⊕ 19′		XI	Easy

A lovely cluster, easily seen in binoculars and just visible with the naked eye. Small-aperture telescopes (15 cm) show a bright, easily resolved cluster with a nice concentrated halo. Because it is very open, a lot of detail can be seen such as star arcs and dark lanes, even with quite small telescopes. With a larger aperture, hundreds of stars are seen.

Messier 15	NGC 7078	$21^h\ 30.0^m$	+12° 10′	August 13
6.2 m	⊕ 18′		IV	Easy

An impressive cluster in telescopes, this can be glimpsed with the naked eye. In binoculars it appears as a hazy object with no stars visible. Averted vision will be necessary in order to see the central stars. It does, however, under medium magnification and aperture, show considerable detail such as dark lanes, arcs of stars and a noticeable asymmetry. It is one of only four globular clusters that have a planetary nebula located within it – Pease-1, which is seen only in apertures of 30 cm and greater. The cluster is also an X-ray source.

Messier 2	NGC 7089	$21^h\ 33.5^m$	–00° 49′	August 14
6.5 m	⊕ 16′		II	Easy

This is a very impressive non-stellar object. It can be seen with the naked eye, although averted vision will be necessary. However, as it is located in a barren area of the sky it can prove difficult to locate. But when found it is a rewarding object, and even in large binoculars its oval shape is apparent. Telescopes will show its bright core, and larger instruments will show several star chains snaking out from the core. Believed to be about 37,000 light-years away and to contain over 100,000 stars.

Stellar Associations and Streams

So far we have discussed groups of stars that can easily be recognized as either an open cluster or a globular cluster, but there exists another type of grouping of stars that is much more ephemeral and spread over a very large region of the sky. In fact, after reading this section you may think that stellar associations are not a further classification of cluster at all but something very different!

A *stellar association* is a loosely bound group of very young stars. They may be swathed in the dust and gas cloud formed within, and continuing star formation is a distinct possibility. But where they differ from open clusters is in their size – they are enormous, covering both a sizable angular area of the night sky and at the same time encompass a comparably large volume in space. As an illustration of this huge

size, the Scorpius-Centaurus Association is around 700 by 760 light-years in extent and covers about 80° in the sky.

There are three types of stellar associations:

1. *OB associations*, containing very luminous O- and B- type main sequence, giant and supergiant stars.
2. *B associations*, containing only B-type main sequence and giant stars but with an absence of O-type stars. These associations are just older versions of the OB association, and thus the faster evolving O-type stars have been lost to the group as supernovae.
3. *T Associations*, which are groupings of T Tauri type stars. These are irregular variable stars that are still contracting and evolving toward being A-, F- and G-type main sequence stars. As they are still in their infancy, more often than not they will be shrouded in dark dust clouds, and those that are visible will be embedded in small reflection and emission nebulae (see Chap. 4).

The OB associations are truly enormous objects, often covering many hundreds of light-years. This is a consequence of the fact that massive O- and B-type stars can only be formed within the huge giant molecular clouds that are themselves hundreds of light-years across. On the other hand, the T associations are much smaller affairs, perhaps only a few light-years in diameter. In some cases, the T association is itself located within, or near, an OB association.

The lifetime of an association is comparatively short. As mentioned earlier, the very luminous O-type stars evolve rapidly to become supernovae, and, as usual, the ever-pervasive gravitational effects of the galaxy soon disrupt the association. The coherence and identity of the group can only exist for as long as the brighter components stay in the same general area of a spiral arm, as well as having a similar space motion through the galaxy. As time passes, the B-type stars will disappear through stellar evolution, and the remaining A-type and later stars will now be spread over an enormous volume of space. The only common factor among them will be their motion through space. The association is now called a *stellar stream*. An example of such a stream and one that often surprises the amateur is the Ursa Major Stream.[3] This is an enormous group of stars, with the five central stars of Ursa Major (the Plough) being its most concentrated and brightest members. Furthermore, the stream is also known as the Sirius Supercluster after its brightest member. The Sun actually lies within this stream (more information about this fascinating stream can be found below).

Although there are over 70 stellar associations and streams known to exist, only a handful are visible using the naked eye or amateur telescopes. Nevertheless, they are wonderful objects due to the fact that they cover an appreciable area in the sky and are composed of dozens of stars of naked-eye visibility. In fact they may be among the few deep-sky objects that can be observed without any optical aid. Even if the observing conditions for deep sky work are less than favorable, it should be possible to see these amazing objects.

[3]There is some debate as to whether these five stars are in fact the central stars of an open cluster. If so, it is the nearest to the Solar System at a distance of 75 light-years.

As stellar associations cover such a large area of the sky, it is difficult, and even pointless, to specify a specific set of coordinates for a particular association. Thus, any details listed below will refer to the association as a whole and not just to any one specific star, unless otherwise stated.

The Orion Association 1,600 l.y

This association includes most of the stars in the constellation down to 3.5 magnitude, except for γ Orionis and π^3 Orionis. Also included are several fourth, fifth and sixth magnitude stars. The wonderful nebula M42 is also part of this spectacular association. Several other nebulae[4] (including dark, reflection and emission nebulae), are all located within a vast Giant Molecular Cloud, which is the birthplace of all the O- and B-type supergiant, giant and main sequence stars in Orion. The association is believed to be 800 light-years across and 1,000 light-years. deep. By looking at this association, you are in fact looking deep into our own spiral arm that, incidentally, is called the Cygnus-Carina Arm.

The Scorpius-Centaurus Association 550 l.y

A much older but closer association than the Orion association. It includes most of the stars of first, second and third magnitude in Scorpius down through Lupus and Centaurus to Crux. Classed as a B-type association because it lacks O-type stars, its angular size on the sky is around 80°. It is estimated to be 750 × 300 light-years in size and 400 light-years deep, with the center of the association midway between α Lupi and ξ Centauri. Its elongated shape is thought to be the result of rotational stresses induced by its rotation about the galactic center. Bright stars in this association include θ Ophiuchi, β, ν, δ, and σ Scorpii, α, γ Lupi, ε, δ, and ε Centauri, and β Crucis.

The Zeta Persei Association 1300 l.y

Also known as Per OB2, this association includes ζ and ξ Persei, as well as 40, 42 and o Persei. The California Nebula, NGC 1499, is also within this association.

The Ursa Major Stream 75 l.y

Mentioned earlier in this section, this stream includes the five central stars of the Plough. It is spread over a vast area of the sky, approximately 24°, and is around 20 × 30 light-years in extent. It includes as members *Sirius* [α Canis Majoris],

[4] These nebulae are be described in Chap. 4.

α Coronae Borealis, δ Leonis, β Eridani, δ Aquarii, and β Serpentis. Due to the predominance of A1 and A0 stars within the association, its age has been estimated at 300 million years.

The Hyades Stream

There is some evidence (although it is not fully agreed upon), that the Ursa Major stream is itself located within a much older and larger stream. This older component includes M44, Praesepe in Cancer and the Hyades in Taurus, with these two open clusters being the core of a very large but loose grouping of stars. Included within this are Capella [α Aurigae], α Canum Venaticorum,[5] δ Cassiopeiae and λ Ursae Majoris. The stream extends to over 200 light-years beyond the Hyades star cluster and 300 light-years behind the Sun, and thus the Sun is believed to lie within this stream.[6]

The Alpha Persei Stream 540 l.y

Also known as Melotte 20, this is a group of about 100 stars, including α Persei, ψ Persei, 29, and 34 Persei. The stars δ and ε Persei are believed to be among its most outlying members, as they also share the same space motion as the main groups of stars. The inner region of the stream is measured to be over 33 light-years in length; the distance between 29 and ψ Persei.

Emission Nebulae

Messier 8	NGC 6523	$18^h\ 03.8^m$	–24° 23′	June 22
5.8 m (4.6 m)	• 1–5	⊕ 46|32′		Easy

The Lagoon Nebula is one of the finest emission nebulae in the entire sky, thought by many to be the premier emission nebula of the summer sky and visible to the naked eye on summer evenings. Binoculars will show a vast expanse of glowing green-blue gas split by a very prominent dark lane. Using light filters and telescopes of aperture 30 cm will show much intricate and delicate detail, including many dark bands. The Lagoon Nebula is located in the Sagittarius-Carina Spiral Arm of our galaxy, at a distance of around 5,400 light-years. A favorite for those equipped with CCD cameras.

[5] Capella and a Canum Venaticorum are also thought to be members of the even larger Taurus Stream, which has a motion through space similar to the Hyades and thus may be related.

[6] The bright stars that extend from Perseus, Taurus and Orion , and down to Centaurus and Scorpius, including the Orion and Scorpius-Centaurus associations, lie at an angle of about 1° 5 (?) to the Milky Way, and thus to the equatorial plane of the galaxy. This group or band of stars is often called Gould's Belt.

Messier 17	NGC 6618	$18^h\ 20.8^m$	−16° 11′	June 27
6.0 m	• 1–5	⊕ 40|30′		Easy

Also known as the Swan or Omega Nebula. This is a magnificent object in binoculars and is perhaps a rival to the Orion Nebula, M42, for the summer sky. Not often observed by amateurs, which is a pity, as it offers much. With telescopes the detail of the nebula becomes apparent, and with the addition of a light filter it can in some instances surpass M42. Certainly, it has many more dark and light patches than its winter cousin, although it definitely needs an OIII filter for the regions to be fully appreciated. Unlike the Trifid nebula, the stars responsible for nebulae are obscured within the cloud itself. Another celestial object that warrants slow, and careful, study.

Caldwell 20	NGC 7000	$20^h\ 58.8^m$	+44° 20′	August 6
4.0 m	• 1–5	⊕ 120|100′		Easy

Also known as the North America Nebula. A famous emission nebula, located just west of Deneb, it is magnificent in binoculars, melding as it does into the stunning star fields of Cygnus. Providing you know where to look and what to look for, the nebula is visible to the naked eye. With small- and large-aperture telescopes details within the nebula become visible, though several amateurs have reported that increasing aperture decreases the nebula's impact. The dark nebula lying between it and the Pelican Nebula is responsible for their characteristic shape. Until recently, Deneb was thought to be the star responsible for providing the energy to make the nebula glow, but recent research points to several unseen stars being the power sources.

–	IC 1396	$21^h\ 39.1^m$	+57° 30′	August 16
3.5 m	• 3–5	⊕ 170|40′		Easy©

One of the few emission nebulae visible to the naked eye (under perfect seeing of course!), and easily spotted in binoculars. It is an enormous patch of nebulosity, over 3°, spreading south of the orange star Mu (μ) Cephei. Any telescope will lessen the impact of the nebula, but the use of filters will help to locate knots and patches of brighter nebulosity and dark dust lanes. Dark adaption and averted vision will all enhance the observation of this giant emission nebula.

–	NGC 1499	$04^h\ 00.7^m$	+36° 37′	November 21
6 m	• 1–5	⊕ 160|50′		Easy/moderate

Also known as the California Nebula. This emission nebula presents a paradox. Some observers state that it can be glimpsed with the naked eye, others that binoculars are needed. The combined light from the emission nebula results in a magnitude of 6, but the surface brightness falls to around the 14th magnitude when observed through a telescope. Most observers agree, however, that the use of filters is necessary, especially from an urban location and when the seeing is not ideal. Clean optics is also a must to locate this nebula. Glimpsed as a faint

patch in binoculars, with telescopes of aperture 20 cm, the emission nebula is seen to be nearly 3° long. Whatever optical instrument is used, it will remain faint and elusive.

Messier 42	NGC 1976	$05^h\ 35.4^m$	–05° 23.5′	December 15
4.0 m	• 1–5	⊕ 85|60′		Easy

Now for the sky's most famous nebula. Visible to the naked eye as a barely resolved patch of light, the Orion Nebula shows detail from the smallest aperture upwards. It is really one of those objects where words cannot describe the view seen. In binoculars its pearly glow will show structure and detail, and in telescopes of aperture 10 cm the whole field will be filled. The entire nebulosity is glowing owing to the light (and thus energy) provided by the famous Trapezium group of four stars located within it. What is also readily seen along with the glowing nebula are the dark, apparently empty and starless regions. These are still part of the huge complex of dust and gas, but are not glowing by the process of fluorescence – instead they are vast clouds of obscuring dust. The emission nebula is one of the few that shows definite color and many observers report seeing a greenish glow, along with pale gray and blue. The British amateur astronomer Don Tinkler has this to say about M42: "The size of M42 always amazes me. Under dark skies it seems endless, with no edge or boundary. A wonderful nebula and a celestial showpiece." It has been reported that with very large apertures of 35 cm a pinkish glow can be seen. Located within the nebula are the famous Kleinmann-Low Sources and the Becklin–Neugebauer Object, which are believed to be dust-enshrouded young stars. The whole nebula complex is a vast stellar nursery, and in fact the stars AE Aurigae, 53 Arietis, and m (Mu) Columbae, believed to have been formed in the nebula, are currently moving away from it at velocities greater than 100 km/s. Such objects are termed runaway stars. Messier 42 is at a distance of 1,344 light-years and is about 40 light-years in diameter. Try to spend a long time observing this object – you will benefit from it, and many observers just let the nebula drift into the field of view. Truly wonderful!

Dark Nebulae

Barnard 59, 65–7	LDN 1773	$17^h\ 21.0^m$	–27° 23′	June 11
❒ 6	⊕ 300|60′			Easy

Also known as the Pipe Nebula (Stem) and Lynds Dark Nebula 1773. This is a large dark nebula visible to the naked eye. It is conspicuous because it stands against a star-studded field. Best viewed with lower-power binoculars. With the unaided eye, it appears as a straight line, but under magnification its many variations can be glimpsed.

Lynds 906		$20^h\ 40.0^m$	+42° 00′	August 1
❒ 5	⊕ –			Easy

Also known as the Northern Coalsack. This is probably the largest dark nebulosity of the northern sky. It is an immense region, easily visible on clear moonless nights just south of Deneb. It lies just at the northern boundary of the Great Rift, a collection of several dark nebulae that bisects the Milky Way. The Rift is of course part of a spiral arm of the galaxy. To get an idea of what it would look like from a view outside the Milky Way, check out photographs of other galaxies such as NGC 891 in Andromeda.

Supernova Remnant

Sharpless 2-276		$05^h\ 31^m$	–04° 54′	December 20
6.5 m?	⊕ 600′			Difficult

Also known as Barnard's Loop. Often mentioned in books, but very rarely observed, this is a huge arcing loop of gas located to the east of the constellation Orion. It encloses both the sword and belt of Orion, and if it were a complete circle it would be about 10° in diameter. Barnard's Loop is currently believed to have originated from a supernova that occurred 2–3 million years ago. In addition, it may also have given rise to several runaway stars that include AE Aurigae, μ (Mu) Columbae and 53 Arietis. It continues to glow due to a group of hot young stars in the Orion OB1 Association.

Observationally, the eastern part of the loop is well defined, but the western part is exceedingly difficult to locate and possibly has never been seen visually, only being observed by the use of photography or using a CCD. Impossible to see through a telescope, recent rumors have emerged that it has been glimpsed by a select few, by using either an OIII filter or an ultra-high-contrast filter. Needless to say, perfect conditions and very dark skies will greatly heighten the chances of it being seen. This is possibly the greatest observing challenge to the naked-eye observer.

Galaxies

Messier 81	NGC 3031	$09^h\ 55.6^m$	+69° 04′	February 18
7.3 m [*13.6 m*]	26′| 14′		SA(s)ab	Easy©

Also known as Bode's Galaxy, this is a spectacular object! In binoculars it will show a distinct oval form, and using high-power binoculars the nuclear region

will easily stand out from the spiral arms. Using a telescope will show considerable detail, and it is one of the grandest spiral galaxies on view. With an aperture of about 15 cm, traces of several of the spiral arms will be glimpsed. A real challenge, however, is to see if you can locate this galaxy with the naked eye. Several observers have reported seeing it from dark locations. If you do glimpse it without any optical aid, then you are probably looking at one of the furthest objects[7] that can be seen with the naked eye, lying at a distance of some 12 million light-years. M81 is partner galaxy to M82 (see the information in this book on irregular galaxies), and both these spectacular objects can be glimpsed in the same field of view.

Messier 31	NGC 224	00*h* 42.7*m*	+41° 16′	October 1
3.6 m [*13.6 m*]	3°| 1°		SA(s)b	Easy

Also known as the Andromeda Galaxy and the most famous galaxy in the sky is probably also the most often visited one. Always a first observing object for the beginner it is visible to the naked eye, even on those nights when the conditions are far from perfect. Many naked-eye observers, this author included, claim to have seen the galaxy spread over at least 2½° of sky, but this depends on the transparency. In binoculars it presents a splendid view, with the galactic halo easily seen along with the bright nucleus. Large binoculars may even show one or two dust lanes. Using averted vision and with a very dark sky, several amateurs report that the galaxy can be traced to about 3° of sky in telescopes of aperture 10 cm. In larger telescopes a wealth of detail becomes visible. With an aperture of about 20 cm, a star-like nucleus is apparent, cocooned within several elliptical haloes. Another striking feature are the dust lanes, especially the one running along its northwestern edge. Many observers are often disappointed with what they see when observing M31, as the photographs seen in books actually belie what is seen at the eyepiece. M31 is so big that any telescope cannot really encompass all there is to show. Patience when observing this wonderful galaxy will reward you with a lot of surprises. Spend several nights observing, and try to choose a dark night in a country location. This really is a spectacular galaxy. It contains nearly a trillion stars with a diameter of 130,000 light-years and is among the largest galaxies known. It is the largest member of the Local Group. In older texts it is often referred to as the Great Nebula in Andromeda.

Messier 33	NGC 598	01*h* 33.9*m*	+30° 39′	October 14
5.8 m [*14.4 m*]	70.8′| 41.7′		SA(s)cd	Easy

Also known as the Pinwheel Galaxy, this is famous for several reasons. It is without doubt one of the most impressive examples of a face-on spiral. But at the same time it has a reputation as one of the most difficult galaxies to find. Many

[7] The galaxy M83 lies at the same distance and has reportedly been seen with the naked eye.

amateurs have never seen it, while others have no trouble locating it. The problem arises from its having such a large surface area. Although it has an integrated magnitude of 5.8, it spreads out the light to such an extent that it is very faint. As a result, the galaxy may be all but invisible in telescopes, whereas it will be easily found with binoculars. It will look like a large, very faint cloud, with a slight brightening at its center. In addition, there are several reports of it being visible to the naked eye, and this author can testify to that, as it was strikingly visible from a totally dark sight under perfect conditions, when it was impossible not to see it! In a telescope of aperture 10 cm, several spiral arms can be glimpsed arcing from the very small nucleus. With large telescopes a plethora of detail becomes visible, such as star clusters, stellar associations and nebulae, all located within the galaxy.[8] This truly is a spectacular galaxy.

Caldwell 77	NGC 5128	$13^h\ 25.5^m$	–43° 01′	April 13
6.8 m [*12.9 m*]	18.2′| 14.5′		SOpec	Easy

This famous galaxy is also known as Centaurus A. Although this galaxy is too far south for some northern observers, it nevertheless warrants inclusion because it is so spectacular. Photographs show it as a nearly circular object bisected by a very prominent dark dust lane. Visible in binoculars as a hazy star, with larger binoculars the famous dark lane can just be glimpsed. In small telescopes, aperture 15 cm, the dark lane is easily seen. Larger aperture will of course give a more detailed view, with the dark lane showing some structure. The well-known writer and astronomer Iain Nicolson says about the galaxy, “Centaurus A (NGC 5128) is a magical object, one of those rare extragalactic objects that, when it swims into the field of view, looks just like the photographs that grace the pages of astronomy books. The first time I saw it, it seemed almost to fill the field of view. It’s a beautiful object in its own right: a near-spherical elliptical galaxy with a pronounced dark lane right through the middle. It is especially intriguing because of its status as the nearest active galaxy. To know that this object has a compact core that probably houses a supermassive black hole makes Centaurus, for me, one of the most exciting objects in the sky.” Its peculiar morphology is believed to be the result of a merger between two smaller galaxies.

Extra-Solar Planets

It is sobering to think that in a period of about 15 years our view of the universe has changed so much that we no longer believe that our Solar System is the only one but in fact is just one of many that exist in the Milky Way.

As these words are being written yet another star has been discovered that has planets orbiting it. It is as if there are new solar systems being discovered every

[8] A large HII region, NGC 604, is visible. See the entry under emission nebulae in Chap. 4.

month! Soon, with the advent of larger telescopes and improved image-processing techniques it will only be a matter of time before the first clear and detailed image of a non-solar-system planet is obtained. That will be a very special day. However, until then any indication as to what these new planets will look like will have to come from the minds of artists and scientists (not forgetting amateur astronomers).

Surprisingly many of the stars that have been reported as having planets are quite bright, and so easily within reach of small telescopes. Even though any signs of planets will be absent if these stars are observed, it is still a sobering and also wonderful thing to be able to view them and to think that circling these bright stellar objects are new worlds. And what else besides, one wonders…

One of the techniques used for detecting these planets makes use of the Doppler effect, which is the change in the wavelength of light from an object that is moving away from or towards an observer. The gravitational pull of a large planet orbiting a star causes the star to wobble slightly. When a star wobbles towards Earth, the star's light appears from Earth to be shifted towards the blue part of the visible light. When the star wobbles away from Earth, the opposite effect occurs.

The Doppler shift is proportional to the speed with which the star approaches or recedes from an observer on Earth. Unfortunately the Doppler shift caused by the wobbling of stars with companion planets is very small; the wavelength of the star's light changes by only about 1 part in ten million under the influence of a large, Jupiter-sized planet. For example, the Sun's "wobble speed" is only about 12.5 m/s.

The wobble motion of a star with a planetary companion can provide a great deal of information about the star's companion planet, including an estimate of its mass and the size and frequency of its orbit. The orbital period of a planet (the time it takes the planet to complete one full revolution around its star) is equal to the time it takes the star to finish one wobble cycle. The size of the star's wobble is also proportional to the size of the planet's orbit, and by using Kepler's third law of planetary motion, which states that the cube of the average distance between two orbiting bodies equals the orbital period squared (p^2), the distance between the star and its companion can be determined. Knowing that the orbital period is the same as the period of the star's wobble, one can calculate the average distance between a star and its companion.

Since the first extra-solar planet was discovered in 1989 hundreds more have been discovered,[9] and so to list them all would be impossible. So here are the brightest candidates for observation. A website is given in the appendix of this book that lists up-to-date information on all the planetary systems discovered.

The usual nomenclature is given in the details below, with the addition of the number of suspected planets in the system.

55 Cancri	HD 75732	$08^h\ 52.6^m$	+28° 20′	February 2
5.96 m	5.47 M	G8V	5 planets	41 l.y.

[9] As of autumn 2011, 474 planetary systems had been discovered.

Also known as ρ^1 Cancri. This is one of the so-called "51 Peg" planets (see 51 Pegasi). The star is surrounded by a dust disc extending at least a 40 AU, with an inclination $\approx 25°$. Furthermore, there may by a hole with a radius of ~10 AU in the disc. The star has a companion ρ^2 Cancri, about 1,150 AU away.

See also:

Star	Planets	Month
47 Ursae Majoris	3	March

March

47 Ursae Majoris	HD 95128	10^h 59.4^m	+40° 25′	March 7
5.03 m	4.29 M	G0V	3 planets	46 l.y.

These planets are among the few that appear to fit all the current models and theories about planetary formation.

See also:

Star	Planets	Month
70 Virginis	1	April
τ Boötis	1	April

April

70 Virginis	HD 117179	13^h 28.3^m	+13° 46′	April 13
4.97 m	3.68 M	G5V	1 planet	59 l.y.

This planet is so large that it may be reclassified as a brown dwarf. This is an object that is intermediate between a planet and a star. The planet also has a very eccentric orbit, with an eccentricity of 0.4. A value of 0 would be a perfect circle, while a value of 1.0 is a long flattened oval. Mercury and Pluto have the largest eccentricities in our Solar System, with values around 0.2.

τ Boötis	HD 120136	13^h 47.2^m	+17° 27′	April 18
4.50 m	3.53 M	F6IV	1 planet	51 l.y.

This is another of the 51 Peg planets. It is the only system (so far) that has had a probable detection of the starlight reflected by the planet. This, the albedo, is claimed to be detected only in the wavelength range from 456 to 524 nm. The star has a companion (GJ 527B) about 240 AU away.

See also:

Star	Planet(s)	Month
47 Ursae Majoris	3	March
ρ Coronae Borealis	1	May
14 Herculis	1	May

May

ρ Coronae Borealis	HD 143761	$16^h\ 01.1^m$	+33° 18′	May 22
5.41 m	4.18 M	G2V	1 planet	57 l.y.

Recent observations using infrared techniques have led astronomers to believe that there is a circumstellar disc of gas and dust around the star. From the disc inclination (46°) a planet of mass 1.5 that of Jupiter's can be inferred; however, this value differs from other results. The orbital period and amplitude imply a mass of around 1.1 Jupiter masses, and a semi-major axis (which is half the distance across the long axis of an ellipse, usually referred to as the average distance of an orbiting object) of around .23 AU, or roughly half the distance between the Sun and Mercury. In situ formation of such a planet is thought to be unlikely. A more plausible scenario is that the planet formed at several AU from the parent star by means of gas accretion onto a rocky core and then migrated inward. This could have happened by interactions with another giant gas planet that was ejected in the process, through interactions with the protoplanetary gas disc, or by interactions with planetesimals – the building blocks of planets, formed by accretion in the solar nebula.

14 Herculis	HD 145675	$16^h\ 10.4^m$	+43° 49′	May 24
6.46 m	5.32 M	K0V	1 planet	59 l.y.

14 Herculis (Gliese 614) is a star somewhat less massive than the Sun (80%), and its sole planet has a slightly elongated orbit of 4.4 years. Its mass is about 3.3 times that of Jupiter, and it is at a distance of 2.5 AU from 14 Her. This giant planet is twice as close to 14 Her as Jupiter is to our Sun. The content in heavy chemical elements of 14 Her is rather large compared with that of the Sun, a discovery that reinforces the suggestion that giant planets are more frequently observed around metal-rich stars. Heavy chemical elements are needed to form dust or ice particles, and then, by agglomeration, planetesimals and the cores of giant planets. If the quantity of dust is large enough, this is certainly a factor in favor of the formation of giant planets.

See also:

16 Cygni B	HD 186427	$19^h\ 41.8^m$	+50° 31′	July 17
6.25 m	3.40 M	G5V	1 planet	70 l.y.

June

See:

Star	Planets	Month
70 Virginis	1	April
τ Boötis	1	April

July

See:

Star	Planets	Month
ρ Coronae Borealis	1	May
14 Herculis	1	May

The star is a visual binary, and the companion, 16 Cyg A, is about 700 AU away. The planet also has a very large eccentricity, value 0.6, which is causing some concern among astronomers, as they cannot explain it!

August

See:

Star	Planets	Month
51 Pegasi	1	September
Formalhaut	1	September

September

51 Pegasi	HD 217014	22^h 57.4^m	+20° 46′	September 5
5.49 m	4.52 M	G5V	1 planet	50 l.y.

This is a peculiar type of system characterized by orbital periods shorter than 15 days. The orbits are small, with radii less than 0.11 AU, which is about a tenth the distance between Earth and the Sun. Such an orbit is in fact much smaller than that of Mercury's (radius 0.38 AU, period 88 days). However, these planets are

similar in mass to that of Jupiter and in some cases even larger. Research indicates that the planets have circular orbits. The 51 Peg planets are a problem because they do not fit current planet formation theory. This predicts that giant planets like those in our Solar System (Jupiter, Saturn, Neptune and Uranus) should be formed in the colder, more distant parts of a proto-planetary disc, some 5 AU from a star. It seems that a possible solution to this problem may be the rotation of a young star. Such a star spins very rapidly, perhaps making one complete revolution in about 5–10 days. As a planet approaches the star, tides will be raised on the star. However, the star is spinning quicker than the planet orbits around it, and so the bulge caused by the planet on the star will move in front of the motion of the planet, rather than staying directly in line with the planet. The net result will be that the gravitational pull from the tide on the star pulls the planet closer. The temperature of the planet is calculated to be in the range of 1,200–1,400 K.

Formalhaut	Pisces Austrini	$22^h\ 57.6^m$	−29° 37′	September 5
1.16 m	1.74 M	A3 V		25.07 l.y.

This system is important in extra-solar planetary research for two reasons. The star is surrounded by a dusty torus of material, often referred to as Formalhaut's own "Kuiper Belt" and is believed to be a proto-planetary disc. In addition, a planet was located just within the dust ring and was the first ever to be seen in visible light, when the Hubble Space Telescope imaged it on November 2008.

See also:

Star	Planets	Month
υ Andromedae	4	October

October

υ Andromedae	HD 982	$01^h\ 36.8^m$	+41° 24′	October 15
4.1 m	3.45 M	F8V	4 planets	44 l.y.

This is another of the 51 Peg-type planets and was the first multiple-planet system discovered. formation of these planets has posed several problems. The usual picture is that gas giant planets form at least 4 AU away from a star, where temperatures are low enough for ice to condense and start the process of planet formation, but all three giant planets around Upsilon Andromedae now reside inside this theoretical ice boundary.

See also:

Star	Planets	Month
51 Pegasi	1	September
Formalhaut	1	September

November

See:

Star	Planets	Month
υ Andromedae	4	October