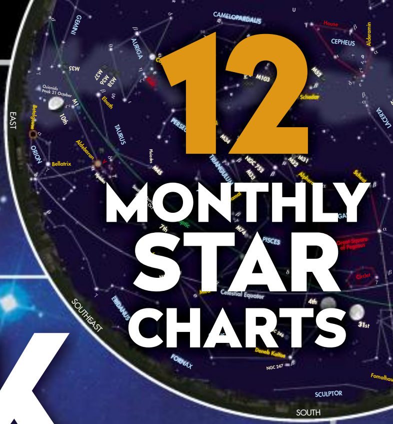
BBC

Sky at Night MAGAZINE

DISCOVER SPACE

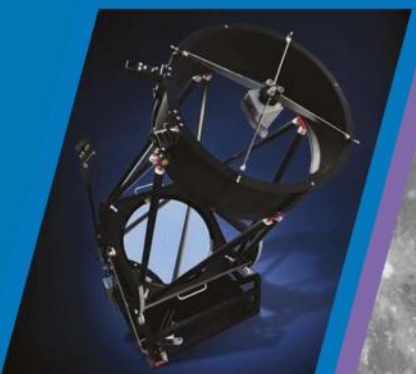
YEARBOOK 2017



12 MONTHLY STAR CHARTS

Your handbook to the best stargazing from January to December

THE BEST SCOPES OF 2016 REVIEWED



FASCINATING ASTRO IMAGING PROJECTS

EXPERT GUIDE TO SOLAR OBSERVING

HOW TO FIND THE NEXT SUPERNOVA

SEASONAL TARGETS FOR SCOPES AND BINOCULARS

PRACTICAL ADVICE TO GET MORE FROM YOUR KIT

TAKE BETTER ASTROPHOTOS FROM UNDER CITY SKIES

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WELCOME

It takes Earth 365 and a quarter days to complete one orbit of the Sun. And during that time our planet's movements are choreographed with the other seven planets in our Solar System, the comets and meteors that orbit alongside them and galaxies that populate space beyond.

This is good news for anyone with an interest in the night skies as it means that not only do we know what to look for but also where and when, which is exactly what *BBC Sky at Night Magazine's 2017 Yearbook* tells you. The following 114 pages are packed with easy-to-follow instructions on how to see all the best celestial events that will be passing across the UK's skies during the coming 12 months.

But just because we know what the skies will be presenting us with doesn't mean they don't harbour any surprises. No matter how familiar you are with the constellations, nebulae and planets that come into view, there's always something new to notice – especially as there are so many different ways to look for them. Whether you're using a telescope or binoculars, a camera or filters, or just relying on your eyes alone, the skies always have something unexpected to reveal. And in the *2017 Yearbook* you'll also find essential tips on what equipment to use and the best ways to use it to give you the greatest chance of capturing the striking views this year's skies have in store.

"No matter how familiar you are with the sky, there's always something new to notice"

Not only will the stars, planets, comets and galaxies that are on show each month keep your gaze turned upwards but we also have three long-term imaging projects to keep you busy from January to December. So here's looking forward to an amazing year of stargazing.

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VISUAL OBSERVING GUIDE

SUPERNOVAE

Paul Abel explains how to use your telescope to hunt for exploding stars

PAUL WHITFIELD, ISTOCK X 2

In 1054 Chinese astronomers noticed the arrival of a new star in the sky. Back then, such objects were known as 'guest stars'. Today, we know this 'guest' wasn't a new star at all, but an old one that had exploded in a cataclysmic event known as a supernova.

Supernovae are among the most destructive events that nature can produce. When they happen, a single star, previously lost in the glare of the combined light of a billion Suns, will flare up and outshine its entire galaxy. Studying supernovae not only provides important clues about star death, but also tantalising details about the expansion of the Universe and the origins of heavy elements.


All that remains of the 'guest star' seen by Chinese astronomers is the Crab Nebula, M1

There's a wonderful mystery surrounding supernovae. You never quite know when the next one will be, and when one does occur you have to be quick. You only have a small amount of time before it fades back into obscurity.

Supernovae occur for two reasons: either as the final death throes of a massive star or because a white dwarf has attempted carbon burning. It is inside these cosmic fireworks that heavy elements are made, and in their afterglow, these elements are returned to the interstellar medium where they will eventually become part of new stars, planets and possibly life.

Although spectacular, supernovae are rare. In our own Galaxy we would expect between one to three supernovae per century, and the last one that was visible to the naked eye occurred in 1680. Stars like Betelgeuse (Alpha Orionis), Antares (Alpha Scorpii) and Rho Cassiopeiae are all candidates. All of these stars have started their journey towards a violent death – it's not a question of if, just when.

Supernova observation falls into two categories: searching and monitoring. And as visual observers, we are well placed to make valuable contributions to this exciting field of amateur astronomy. Since supernovae are so rare, we have to search long and hard to find them. The way to do this is to examine as many galaxies as possible, searching their elusive patchy glows for new faint pin-pricks of light. Spring is a particularly good time to start since at that time Earth is turned away from the centre of the Milky Way and facing out towards extragalactic space. Over the spring, the galaxies of Leo, Virgo and Coma Berenices are well on view.

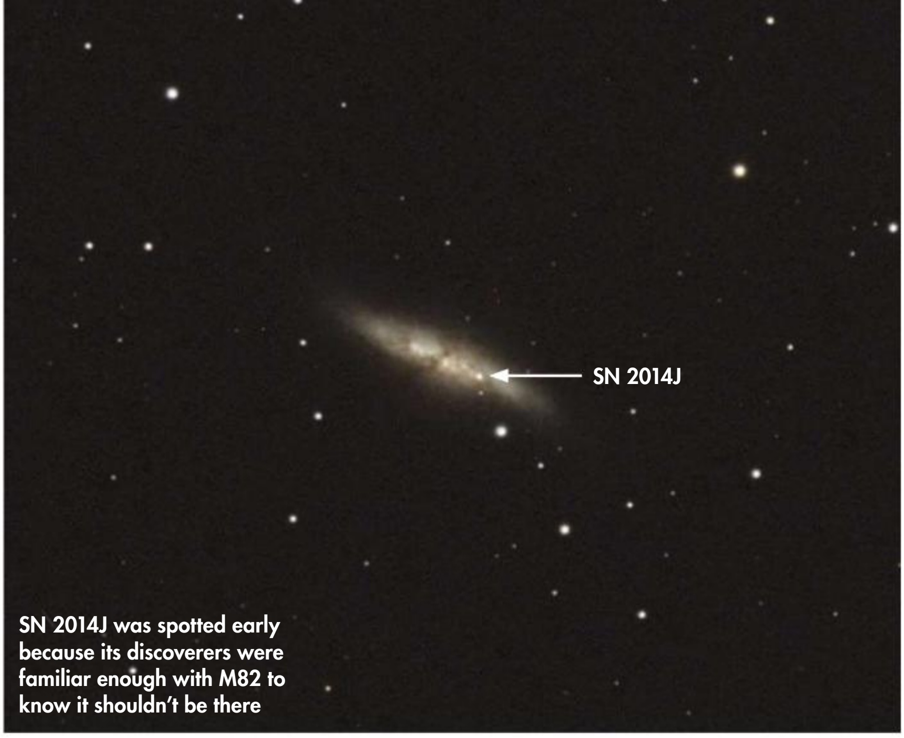

Betelgeuse, the red star in the shoulder of Orion, is a good candidate for going supernova

"You never quite know when the next supernova will be, and when one occurs you have to be quick"

Beginning your hunt

To visually hunt for supernovae, you'll need a telescope that can see a reasonable number of galaxies, so an instrument with a 6-inch aperture at least. You'll also need to be familiar enough with the sky that you can find them fairly quickly. Fortunately there are a number of bright galaxies out there – see the starter list on page 9 – and you should survey as many as you can in one night. You'll need to become familiar with how these galaxies look if you are to detect any faint supernovae in the future. Making sketches is extremely helpful in this regard. Examine each galaxy at a medium power (100x, for example) and make repeat observations of it as often as possible.

It has to be said that imagers have had a great deal of success here for one simple ▸



SN 2014J was spotted early because its discoverers were familiar enough with M82 to know it shouldn't be there

‣ reason: the more galaxies you can survey in a night, the better your chances of scoring a supernova. Veteran hunter Tom Boles has clocked up a staggering 155 discoveries from his observatory in Suffolk using CCD imaging. But occasionally, supernovae are discovered by accident.

In January 2014 Doctor Steve Fossey of University College London was training four undergraduate students in imaging M82, the Cigar Galaxy in Ursa Major. In the process they discovered SN 2014J, a supernova that was just beginning to become visible. However you find it, if you do suspect that you've discovered a supernova alert Guy Hurst, the British Astronomical Association's (BAA's) supernova patrol coordinator at editor@theastronomer.org.

If a supernova is reported and it's within the magnitude range of your telescope, you should begin observing at once. Your main goal is to make as many magnitude estimates of the supernova as often as possible so that a light curve can be obtained. For this, you'll need a star chart that has suitable comparison stars and their magnitudes listed. When SN 2014J was reported the American Association of Variable Star Observers (AAVSO) produced an excellent comparison chart showing the location of the supernova in M82 and a number of good comparison

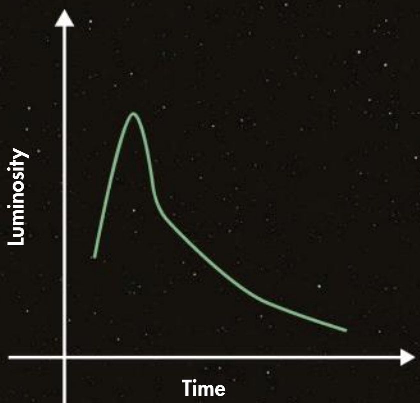
TYPES OF SUPERNOVAE

We can classify supernovae into two distinct types

TYPE I

These occur in binary star systems when a white dwarf star is able to accumulate material from a nearby companion, causing the temperature of its core to start rising. If it can attract enough material, carbon fusion will start in the core. A few seconds later a runaway fusion reaction occurs and the star explodes, producing a supernova.

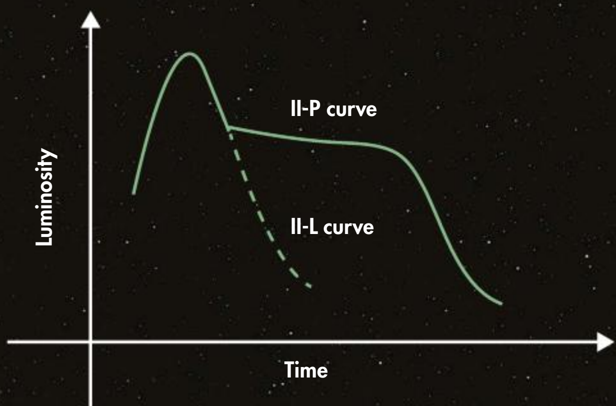
The light curve of this type of supernova is very distinctive: there's a peak in magnitude and then the luminosity slowly drops off. Due to the nature of the explosion, Type Ia supernovae are considered excellent 'standard candles' for measuring distances in space.



TYPE II

This type of supernova is produced when a star that is at least eight solar masses begins to collapse. Once stars of this size run out of hydrogen, they start burning other elements: first carbon, then neon, oxygen and finally silicon. Eventually the core becomes too heavy and collapses, producing a supernova.

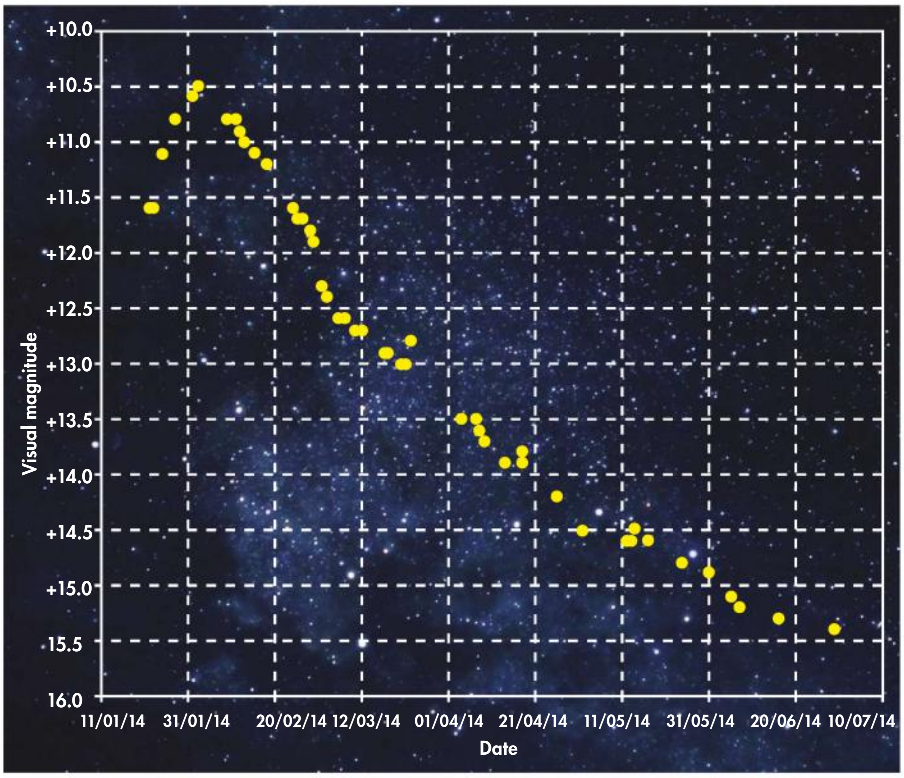
Type II supernovae fall into two subcategories depending on the light curves they produce. A II-L curve shows a linear falling off, while a II-P curve shows a distinctive plateau and the luminosity drops off at a much slower rate.



THE VALUE OF LIGHT CURVES

The reason we want to make as many magnitude estimates of a supernova as possible is so that the data can be plotted on a graph to produce a light curve like the ones above. Not only does the light curve allow us to classify the type of supernova, with enough data professional astronomers can estimate the mass of the progenitor – and therefore determine the type of star that produced the original explosion.

You can generate your own light curve by simply plotting your magnitudes against time in a spreadsheet. Alternatively, the BAA and AAVSO websites can do this for you if you enter your observations online.



▲ With a sharp peak and steady drop, this light curve reveals SN 2014J to be a Type Ia supernova

▲ The author's rendition of SN 2014J; sketches are useful as they can reveal gradual changes

stars to use. To estimate a supernova's magnitude, you need to judge it against a comparison star of fixed brightness and evaluate the difference to one tenth of a magnitude. It's best to use two comparison stars, one brighter than the variable star and one fainter. You should record your observations in the same way each session: in a log book note down the date, time, estimated magnitude and deduced magnitude. It's wise to draw it too, to show the supernova's location and how it changed as it faded. For example, SN 2014J had a distinctly yellowish hue that got a little stronger as it started to diminish in brightness.

Remember, your observations are of no use if they just sit on a bookshelf. Both the BAA (www.britastro.org) and the AAVSO (www.aavso.org) will be very happy to see them. Your data can be added to the growing body of observations used by professional astronomers. Despite the prevalence of digital cameras, visual observing still has a place in modern amateur astronomy. There are plenty of ways in which to make meaningful contributions: all that's needed is a telescope, dedication and clear skies.

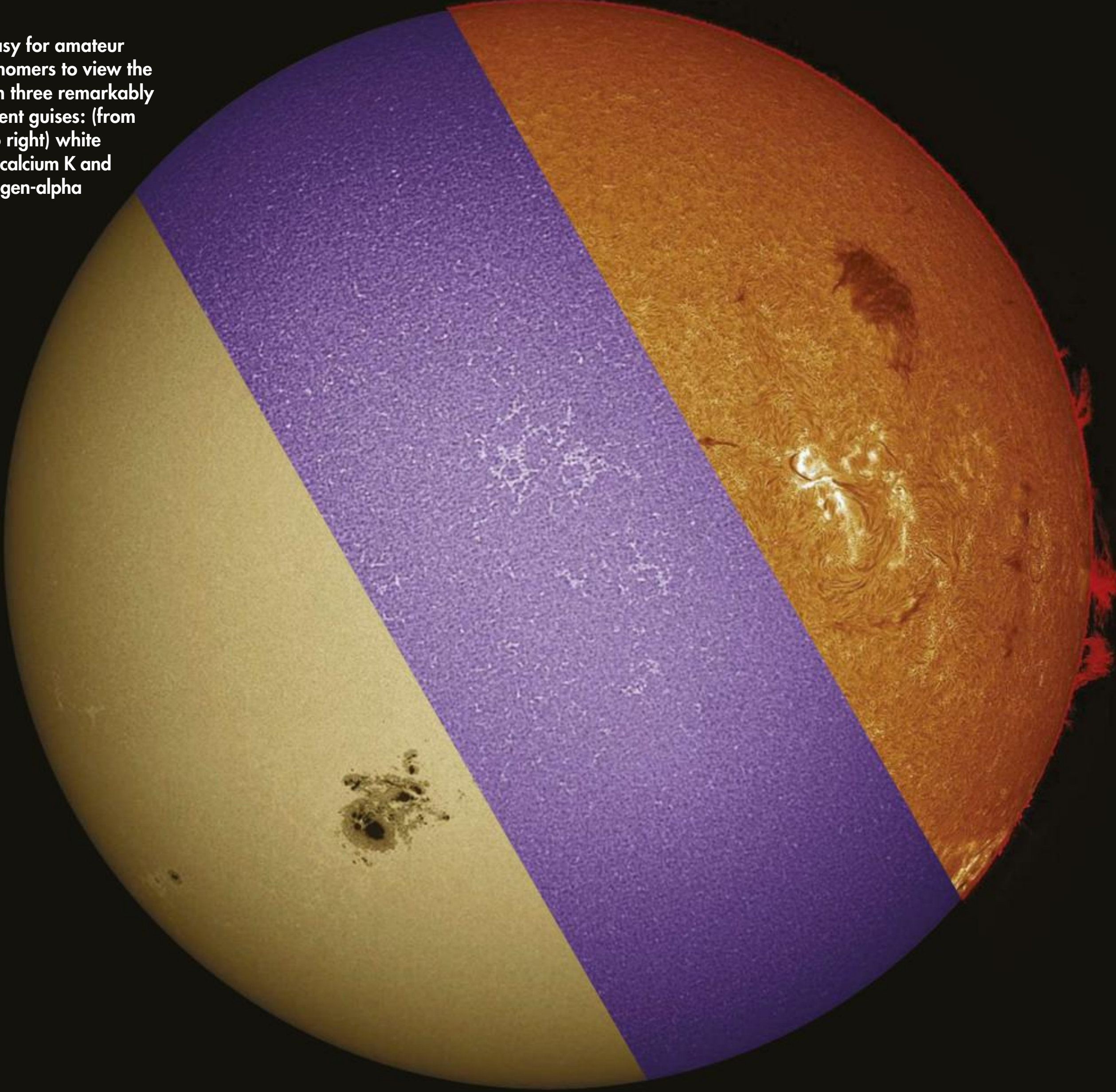
ABOUT THE WRITER

Dr Paul Abel is an astronomer at the University of Leicester. Listen to him on our Virtual Planetarium each month.

START WITH THESE GALAXIES

Many galaxies worth patrolling are visible in the spring; the ones marked with an asterisk have produced supernovae in the recent past

GALAXY	LOCATION	MAGNITUDE	TYPE	APPROXIMATE DISTANCE
M81* (Bode's)	Ursa Major	+6.9	Spiral	12 million lightyears
M82* (Cigar)	Ursa Major	+8.4	Starburst	12 million lightyears
M65	Leo	+10.3	Spiral	35 million lightyears
M66	Leo	+8.9	Spiral	36 million lightyears
M61*	Virgo Cluster	+10.2	Barred spiral	52 million lightyears
M64 (Black Eye)	Coma Berenices	+9.4	Spiral	24 million lightyears
M101* (Pinwheel)	Ursa Major	+7.9	Spiral	21 million lightyears
M51* (Whirlpool)	Canes Venatici	+8.4	Spiral	23 million lightyears
M104 (Sombrero)	Virgo	+9.0	Spiral	29 million lightyears
M84*	Virgo	+10.1	Elliptical	60 million lightyears
M85*	Coma Berenices	+10.0	Elliptical	60 million lightyears
M60*	Virgo	+9.8	Elliptical	55 million lightyears



It's easy for amateur astronomers to view the Sun in three remarkably different guises: (from left to right) white light, calcium K and hydrogen-alpha

PEELING BACK THE LAYERS

With such a wide variety of telescopes, cameras and filters available, anyone can capture breathtaking images of our host star in different wavelengths, writes **Mark Townley**

Observing and imaging the Sun has never been easier or more accessible, thanks to an increasing number of solar telescopes and filter systems. This kit isolates specific wavelengths of light coming from the Sun – white light, calcium K or hydrogen-alpha – at the same time as blocking the other wavelengths, making solar observing safe and easy. Here we look at what these three different views will show you of the Sun's internal structure and features, things that would be otherwise hidden by our star's overwhelming brightness.

WHITE LIGHT

What you can see

When observing in white light you're actually viewing a range of wavelengths across the visual spectrum. This allows you to see a layer of the Sun called the photosphere, where you can observe familiar sunspots, the darker and cooler regions where magnetic field lines are concentrated. With their darker central umbra and lighter surrounding penumbra, sunspots are the easiest feature to see. Smaller dark spots without developed umbra and penumbra are known as pores. In active regions you can observe faculae: brighter patches best seen from an oblique angle near the limb of the Sun where limb darkening allows them to stand out easier. Through larger apertures and at higher magnifications polygonal granules are visible, which are giant convective cells of plasma. Solar transits, where an object passes in front of the Sun, can also be seen. Commonly these are birds or planes, but on rare occasions the International Space Station will also pass over.

White light reveals sunspots, including their umbra and penumbra, along with brighter faculae

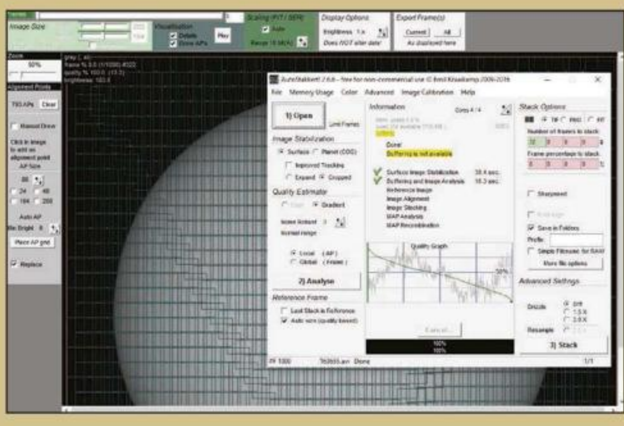
▲ A typical white light setup: a Sky-Watcher ED80 Pro apo refractor, Lunt solar wedge and a PGR Chameleon 3 camera

How to see it

Any telescope can observe the Sun in white light by using a suitable front-mounted glass or solar-film filter. Be sure to get these from a dedicated astronomy retailer rather than attempting to improvise a filter yourself – the safety of your eyes is paramount. A green or continuum filter at the eyepiece end will allow a higher contrast view or image to be achieved by reducing the effects of the poor daytime seeing. For the highest contrast view, a Herschel wedge used in conjunction with a continuum filter, an ultraviolet/infrared-cut filter and a refractor is the best option.

Imaging advice

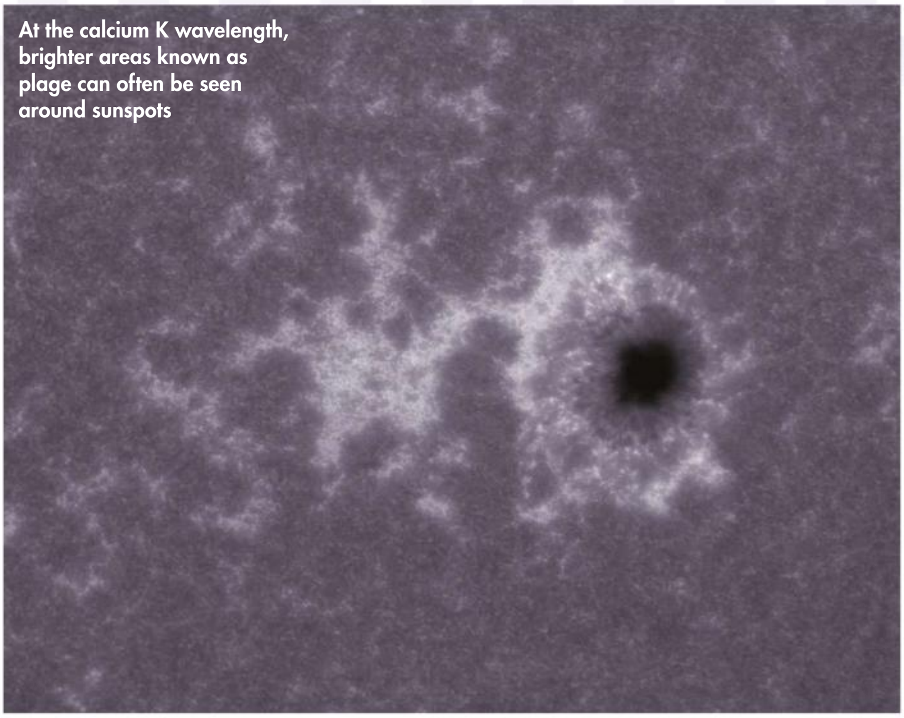
Imaging the Sun in white light is easy and a wide range of cameras can be used. With a dedicated solar filter over the front of your telescope, results can be captured and viewed instantly by holding a camera phone or compact camera afocally to the eyepiece, with a DSLR camera at prime focus or even by projecting the image of the Sun onto a white screen. The best results are achieved using a Herschel wedge and digital CCD camera, where many hundreds of individual frames are captured in video format. Using freely available software that can be downloaded from the internet, such as RegiStax or Autostakkert, the sharpest frames are automatically selected and digitally stacked into one final image which has less noise and better quality than the individual frames. This can then be coloured to individual taste using freeware such as GIMP. ▸



▲ Autostakkert automatically selects the best frames from a large imaging run to produce a final image of higher quality

PETE LAWRENCE X 3, MARK TOWNLEY X 3

CALCIUM K



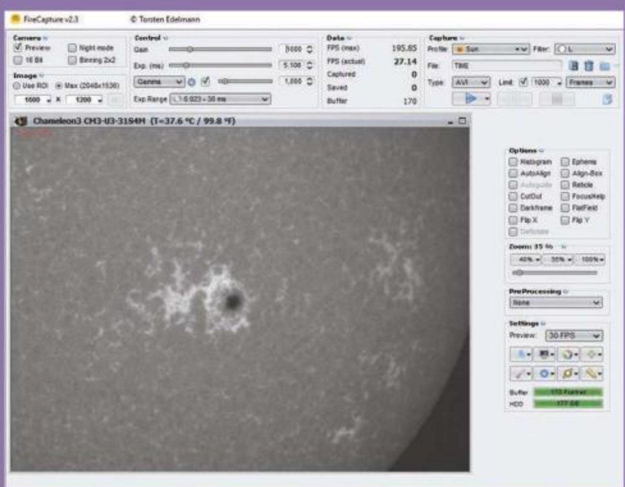
At the calcium K wavelength, brighter areas known as plage can often be seen around sunspots

What you can see

When you observe the Sun in calcium K light you're viewing our star at 393 nanometres, the ultraviolet end of the spectrum. This reveals the solar chromosphere, a layer some 1,000km above the photosphere at a temperature of about 12,000 Kelvin. Most people struggle to see anything at this wavelength, so it's better suited to imaging. Some of the features seen in white light are visible, such as sunspots with their associated umbra and penumbra, and also faculae, but now you can also see the bright white plage; areas of hot, magnetically frothy plasma that extend above the photospheric faculae. In calcium K, the influence of magnetic fields gives a bright white appearance, with the exception of the very strong magnetic fields around sunspots, which appear dark. Rarely, solar flares can be seen in calcium K and, rarer still, are darker filaments, which can be seen on the disc.

Imaging advice

Calcium K imaging is a form of narrowband imaging, as only a very narrow spike of light at a certain target wavelength or colour is allowed to pass through the filter. A mono CCD or CMOS camera is the best choice for capturing images; with a colour camera, only a quarter of the Bayer matrix (the blue component in this case) that covers a colour chip would be utilised, resulting in a loss of image resolution. Freeware program FireCapture is a great choice for capturing images. Try to keep exposure times fast, as shorter calcium K wavelengths are more susceptible to poor seeing and shorter exposure times allow the moments of best seeing to be captured. Use the histogram function in the capture software to avoid overexposing the image and losing precious detail.



▲ FireCapture offers a wide range of intuitive and user-friendly features to make capturing images as easy as possible

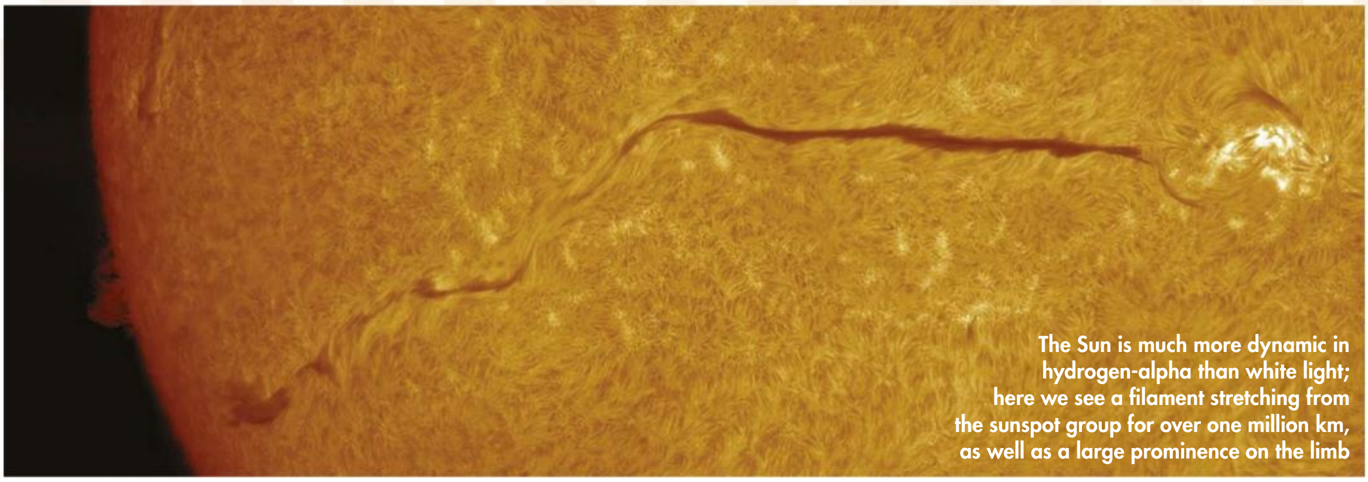
MARK TOWNLEY X 6

▲ A Lunt B1800 calcium K filter on a Sky-Watcher Evostar ED80 Pro apo refractor and Pentax Zoom eyepiece

How to see it

Observing or imaging in calcium K requires a refractor, and better results are achieved with longer focal ratio scopes as they are less susceptible to spherical aberration, which can cause a softening of the image at calcium K wavelengths, particularly in budget telescopes. A calcium K filter is needed and a number of different sizes are available from Lunt, plus a blocking filter. Be sure to check with your dealer which size of blocking filter is best suited to your telescope. If you're observing visually, try different eyepieces from your collection as the coatings on these can affect light transmission and image brightness.

HYDROGEN-ALPHA



The Sun is much more dynamic in hydrogen-alpha than white light; here we see a filament stretching from the sunspot group for over one million km, as well as a large prominence on the limb

What you can see

Hydrogen-alpha gives the best all-round views of the Sun. It's easy to see in the eyepiece and shows an ever-changing view of various features that never ceases to amaze: from flame-like prominences on the limb to long, snaking dark filaments that hover above the disc, both of which are clouds of plasma held aloft by intense magnetic fields. Again you're looking into the Sun's chromosphere in this wavelength, albeit at a slightly different temperature and height above the photosphere than calcium K. Sunspots and the bright plage around active regions are still visible, with solar flares noticeably brightening and then fading over a period of minutes to hours. In the best conditions a layer of spicules can be seen around the solar limb; a fine layer of dancing, hair-like jets of hot plasma that shoot out of the chromosphere.

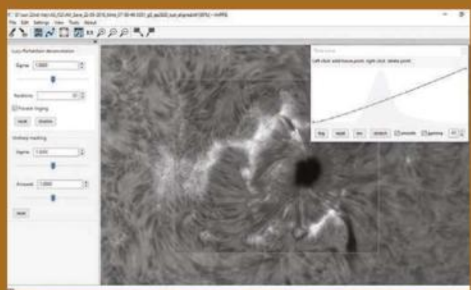
▲ A Sky-Watcher ED80 Pro apo refractor plus a Daystar Quark hydrogen-alpha eyepiece filter provides detailed and high-contrast views

How to see it

Hydrogen-alpha offers you the largest choice of equipment. There are options to suit all budgets, from front-mounted etalon filters that fit on existing refractors or compound telescopes used in conjunction with a blocking filter, to dedicated hydrogen-alpha telescopes or rear-mounted filters that go before an eyepiece or camera. Options such as double stacking front etalon filters provide higher contrast views. The different sizes of blocking filters can seem bewildering to a novice, so it's best to seek advice from your local astronomical society or dealer to see if you can try different options before buying.

Imaging advice

As in calcium K imaging, it's better to image with a mono CCD or CMOS camera to get the best results. Early in the morning is often the ideal time to image; before the heat of the day has built up causing the seeing conditions to blur the finer details. Always make sure you have a crisp focus by observing the limb or a high-contrast feature like a sunspot or a dark filament. Exposure times can take a while to master in hydrogen-alpha, as too much can make the prominences on the limb stand out, but at the same time can wash out disc detail. Conversely, too little exposure can give nice contrast on the disc, but then the prominences are underexposed. Capture separate images of the disc and prominences then combine them into a composite to get the best of both worlds.



◂ Freeware ImPPG allows complete flexibility with sharpening and other post processing activities at all solar wavelengths

ABOUT THE WRITER

Mark Townley is solar astrophotographer and expert on solar telescopes, outreach and all things concerning our host star.

Secrets of Selene

Astronomer **Will Gater** looks at 20 lunar targets for beginners who want to take their Moon watching further

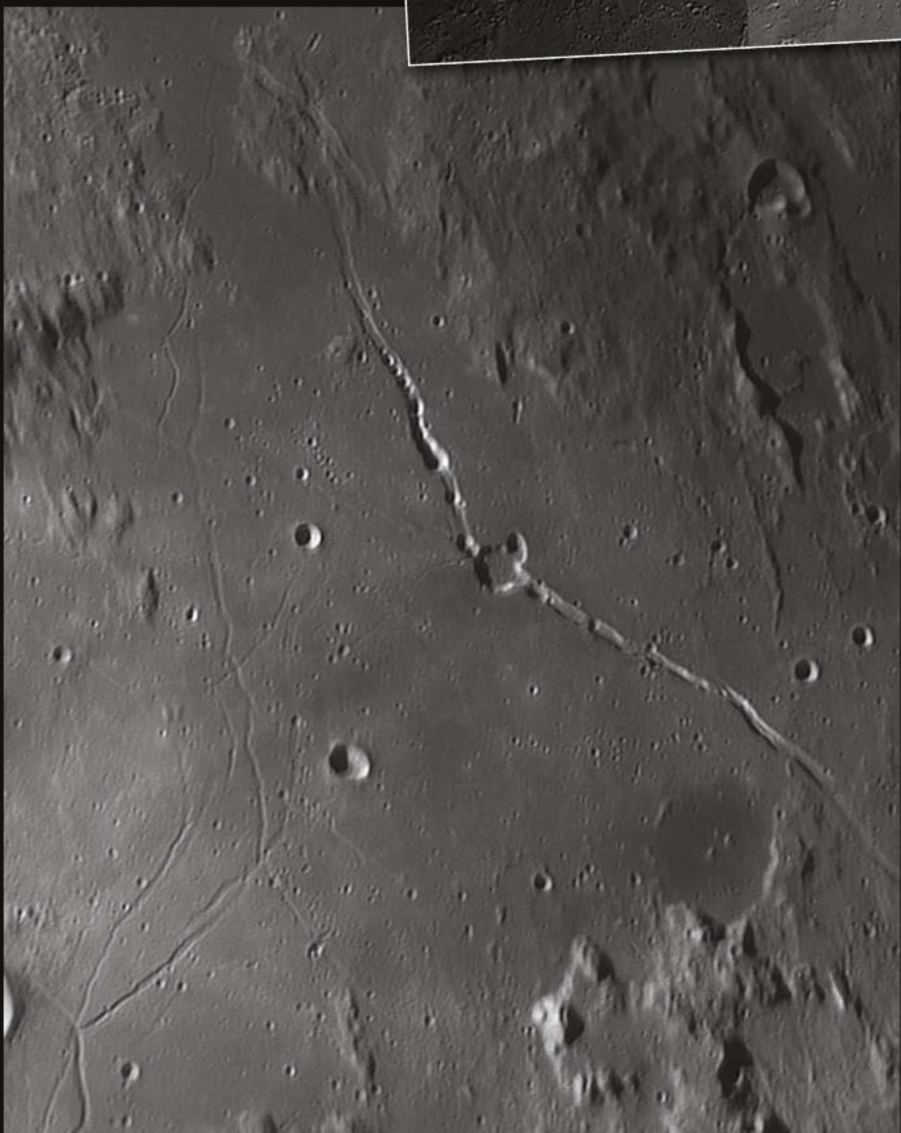
If you've just got your first telescope and are beginning to explore the night sky, there can be no better object to start your journey with than the Moon. Easy to find and brimming with hundreds of fascinating features to observe, our natural satellite ticks all the right boxes. But what if you've already looked at all of the most famous craters, imposing mountains and handful of more obvious rilles? Where do you go from here? Well, we reckon we've got the answer. On the following pages we've selected 20 lunar targets or phenomena that we think you'll probably not have seen yet. They include intriguing volcanic features and magnificent craters, as well as several sights that you'll need to catch at just the right time to see. Most are visible in a 6-inch scope, but a few will require a larger aperture. So read on and let us introduce you to some of the secrets of Selene.

ABOUT THE WRITER
Will Gater is an astronomy journalist, author and astrophotographer. Follow him on Twitter: @willgater

WILL GATER X 2, CHRISTIAN FRIEBER/CCDGUIDE.COM, MICHAEL KARRER/CCDGUIDE.COM, ISTOCK

Sunrise over Copernicus ▼

Copernicus has to be one of the most observed craters on the Moon. You'll no doubt have already seen its spectacular terraced walls and central peak mountains. But one of the joys of lunar observing is that the illumination of any one feature changes night by night and even, much more subtly, hour by hour. The first simple challenge on this list, then, is to watch – over a few nights – the sunrise over Copernicus. Why not try a sketch to record what you see?



Changing illumination

As the Moon orbits Earth we see its changing phases, with the terminator (the boundary between light and dark on the disc) moving night after night. The best time to observe most lunar features is when they're close to the terminator and hence obliquely lit. This provides contrasting lighting and can help highlight subtle textures and topography.

▼ The Marius Hills

We now move to the western side of the Moon, to a collection of features that you really do need the right illumination to see well. The Marius Hills are situated within the vast Oceanus Procellarum and although they're referred to as 'hills', they're actually volcanic features known as domes. Through a telescope they look like pimples poking up from the smoother surrounding surface. The best time to see them is when they're very close to the terminator around two days before full Moon.

▲ The Hyginus and Triesnecker rille systems

Our next targets are two of the finest rille systems visible on the lunar surface. They're a wonderful sight under steady seeing. The tentacle-like Triesnecker rille system appears to extend out from the 25km-wide Triesnecker crater, which is very close to the centre of the lunar disc, as seen from Earth. While the long Hyginus rille, a little way northeast, seems to slice right across the crater for which it is named. Look for them around a day after the first quarter Moon.

WILL GATER X 4, MICHAEL KARRER/CCDGUIDE.COM X 2, ROBERT SCHULZ/CCDGUIDE.COM, CHRISTIAN FRIEBER/CCDGUIDE.COM

▲ Earthshine lit seas

When the Moon is a thin crescent the unlit portion of its disc is illuminated by a faint light – 'Earthshine' – that's been scattered off our planet. While you may well have admired this sight with the naked eye, it's even more breathtaking through a telescope. Use an eyepiece that fits the whole Moon within the field of view and wait until twilight has faded to a deep blue. Under these conditions you'll see the lunar seas in shadow as well as some of the bright craters.

◀ The shadows of Archimedes and its surroundings

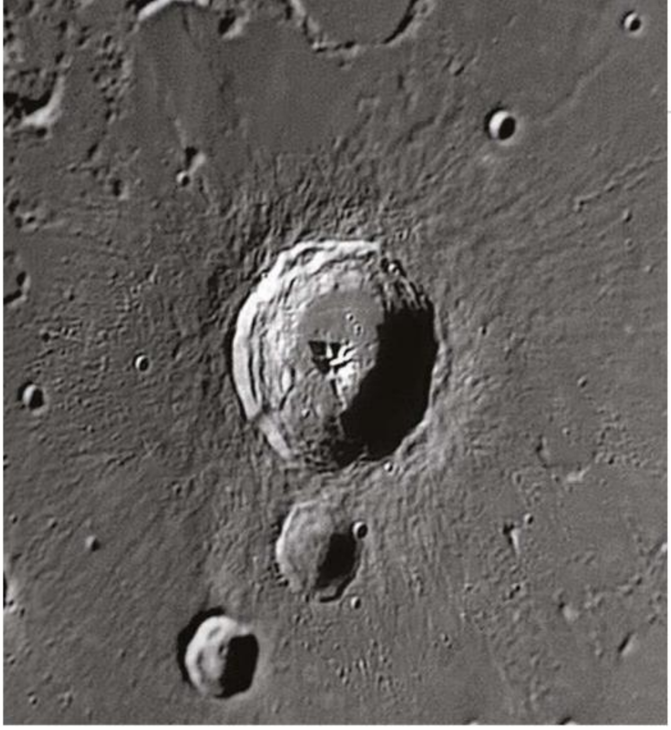
Moving around to the eastern edge of the Mare Imbrium we come to the Archimedes crater. You'll likely have seen Archimedes when the Sun's relatively high over it. But it's worth observing it when it's almost on the terminator. Then the crater walls cast spectacular shadows across its floor and the nearby mountains do the same onto the surrounding landscape. See if you can also spot the two peaks to Archimedes's west throwing pointy shadows out over the sea.

◀ Rille near Plato

Situated on the rugged northern shore of the Mare Imbrium is the beautiful crater Plato. With its smooth, dark floor it's instantly recognisable. Your next target is not the crater itself, though, but a rille that meanders through the terrain east of it. The rille is part of Rimae Plato and you'll need a large scope and good conditions to see it, so you may find that this is one feature you need to visit a public observatory or astronomical society to tick off.

Steady seeing

Look at the Moon with a telescope and you'll probably notice the surface appears to gently wobble or sometimes even shimmer. This effect is caused by air movements in the atmosphere above. Such seeing conditions can vary from minute to minute and night to night, but the best views will always be had when the seeing is steady and these undulations are less intense.



Crater Bullialdus

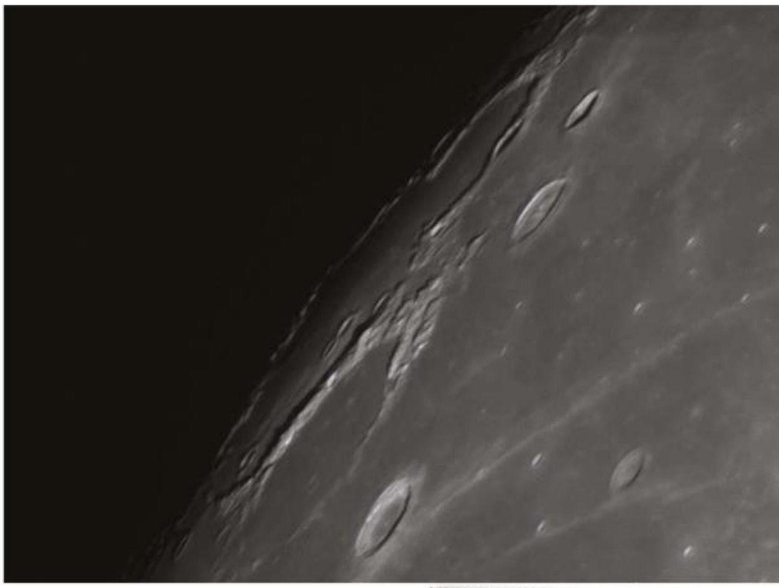
If you ask us, Bullialdus is one of the most underrated lunar craters. Perhaps it's because it's often well-lit when the more prominent Copernicus is on show. Just like Copernicus, it has an impressive undulating ejecta blanket, a striking central mountain and terraced walls. The crater is located on the western side of the Mare Nubium in the Moon's southern hemisphere. It's nicely illuminated around three days after the first quarter Moon when the Sun will be catching the western walls of the crater.

Ray ejecta from crater Proclus

On a night when the Moon is full there are few shadows on the lunar disc to give contrast and highlight the texture of our natural satellite's surface. You might think therefore that it's not worth observing the Moon then, but think again. The ray ejecta around Proclus look best when they're illuminated from on high. The unusually shaped streaks consist of material blasted out when the crater was formed. You'll find this bright scar near to the western edge of the Mare Crisium.

Craters Eddington, Russell and Struve

Some of the Moon's most interesting features aren't situated near the centre of the disc but in regions close to the limb. As the disc of the Moon appears to wobble during its orbit around the Earth – an effect known as libration – some of these areas become better placed for observation. Eddington, Russell and Struve are good examples of features that benefit from libration. Lunar phase and libration combine to show off these three craters best in June and July this year.

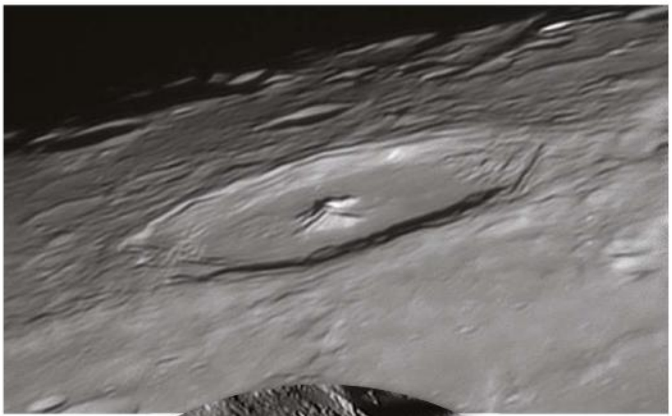


Rimae Hippalus

If you've managed to observe crater Bullialdus (above left) you may well have already spotted our next set of features. The Rimae Hippalus lie nestled among the mountains to the southwest of Bullialdus. Catch them at the right illumination – close to the terminator and with their floors just in shadow – and you can't fail to be impressed by the three main, curved, rilles gouging their way through the lunar landscape. Like Bullialdus, they're interestingly lit around three to four days after the first quarter Moon.

The Hortensius Domes

Cast your eye west of the crater Copernicus and you'll come across a small scrap of lunar 'sea', known as the Mare Insularum. Close to its eastern edge is a crater called Hortensius. And just north of the crater is where you'll find the wonderful Hortensius domes, a small cluster of volcanic domes that are a fine sight in amateur equipment. To catch these raised bumps on the lunar surface at their optimum illumination look for them on about nine days after new Moon.



Crater Pythagoras and its central mountains

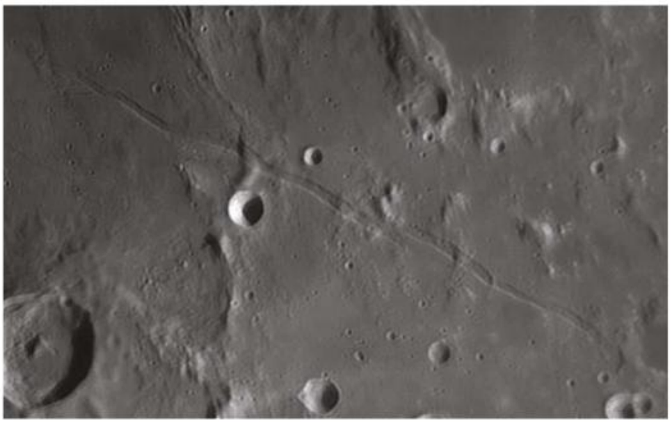
Eratosthenes and Copernicus are good examples of craters with central mountains, formed when the lunar surface rebounded in response to the impact that made the crater. Because of their position on the lunar disc, though, our view of these craters' mountains is from almost directly above. Crater Pythagoras, on the other hand, is very close to the northwest limb of the Moon and so we see its central mountains at an oblique angle, providing the spectacular sight of the peaks rising out of the crater floor.

Craters Atlas and Hercules

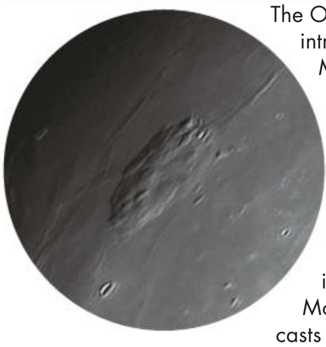
Atlas and Hercules are two truly exceptional craters in the northeastern part of the Moon's disc. Hercules is about 70km across and appears to have a relatively smooth floor that contains the pockmark of another crater: Hercules G. Atlas meanwhile is somewhat larger, about 87km wide, and you may be able to spot the rilles on its floor with a large aperture telescope under the right lighting conditions. Look for them both when the Moon is a crescent, around five days after the new Moon.

Rima Ariadaeus

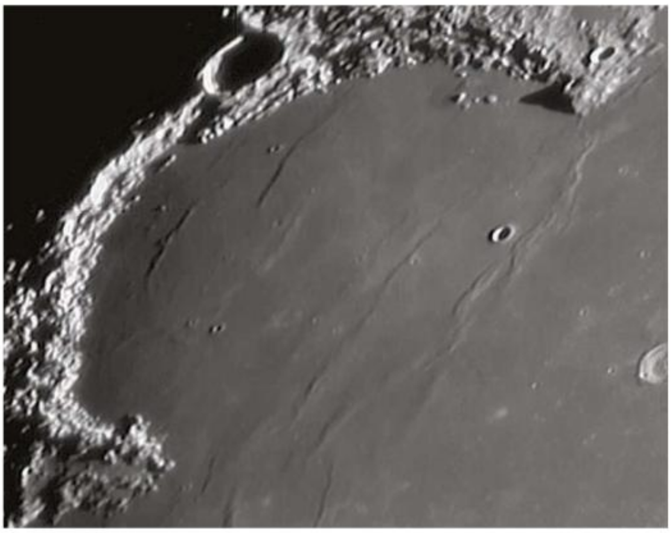
There are many rilles on the Moon but few are as striking as Rima Ariadaeus. This fault in the lunar surface stretches roughly 250km from one end to the other. A small telescope should show it well – you'll find it cutting through the rough terrain between the craters Julius Caesar and Agrippa. Like all lunar rilles, Rima Ariadaeus's appearance alters dramatically with the Moon's changing phase; for a good view of the rille, seek it out on nights around first quarter Moon.



Mons Rümker



The Oceanus Procellarum is littered with intriguing selenological features and Mons Rümker is one them. It's a wide, relatively flat, volcanic peak that rises out of the smooth basalt plains in the far north of Oceanus Procellarum. It's situated close to the limb of the Moon, west of the famous Bay of Rainbows, Sinus Iridum. Ideally you want to observe it six days after the first quarter Moon, when the angle of the Sun casts shadows that show it off best.



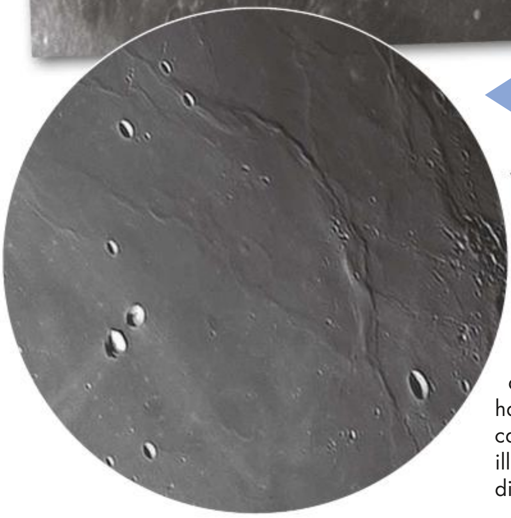
Wrinkle ridges in Oceanus Procellarum and Mare Imbrium

While we're exploring the northwest sector of the Moon let's concentrate on some other, subtler, features in this region. Wrinkle ridges are perfectly named – through a telescope they appear like giant creases in the smooth lunar seas. It's thought they were formed when the Moon's surface contracted. There are many wonderful examples in the Oceanus Procellarum and the nearby Mare Imbrium. You'll find one of the finest southeast of the western tip of the Sinus Iridum – look for it around 10 days after new Moon.

WILL GATER X 5, MICHAEL KARRER/CCDGUIDE.COM X 2, OLIVER SCHNEIDER/CCDGUIDE.COM, ROBERT SCHULZ/CCDGUIDE.COM

◀ Reiner Gamma

When it comes to intriguing lunar features, they don't come much more intriguing than the enigmatic Reiner Gamma. This bright marking in the Oceanus Procellarum resembles a tadpole with a long, wriggling tail. A 2015 study suggests it might be the result of a comet smashing into the Moon. It's located about halfway between the craters Marius and Cavalerius. To see it you'll need to observe it six to seven days after the first quarter Moon, when it's not washed out too much by direct illumination.



◀ Wrinkle ridges in Mare Fecunditatis

If you enjoyed observing the wrinkle ridges in the Oceanus Procellarum and the Mare Imbrium, both mentioned earlier, it's worth turning your attention to the Mare Fecunditatis roughly two days after new Moon. Here there are some particularly beautiful wrinkle ridges that wind their way across large parts of the lunar sea. If you have clear skies for a number of nights, you can watch day by day as the changing illumination causes the ridges to seemingly dissolve from view.

▼ Kies Pi

No discussion of the secret treasures of the Moon's surface would be complete without a mention of the lunar dome Kies Pi. You'll find this fascinating volcanic feature – essentially a lunar shield volcano – very close to the crater Kies in the Mare Nubium. Through a telescope it appears to resemble a raised blister in the smooth surface around it. Since it's such a subtle feature, you do need steady seeing conditions to see it well. It's particularly well illuminated roughly four days before the full Moon.

▲ Rimae Janssen

The 20th feature in our list takes us south to crater Janssen. This 200km-wide depression sits among the mass of craters in the Moon's south-eastern sector. Janssen can be tricky to make out under some illuminations as, despite being relatively large, there are several smaller craters that break up its outline. It's the rille that arcs across Janssen's floor that we're most interested in here though. You'll need a large scope to see it clearly – look for it about five days after new Moon.

Magnification magic

To change the magnification of a telescope setup – and thus get either a 'closer' or wider view – you need to use different eyepieces; the shorter the focal length of the eyepiece the more magnification you'll get. But remember, it's easy to push the magnification too far, so try to match the eyepiece you use to the seeing conditions and capabilities of your scope.

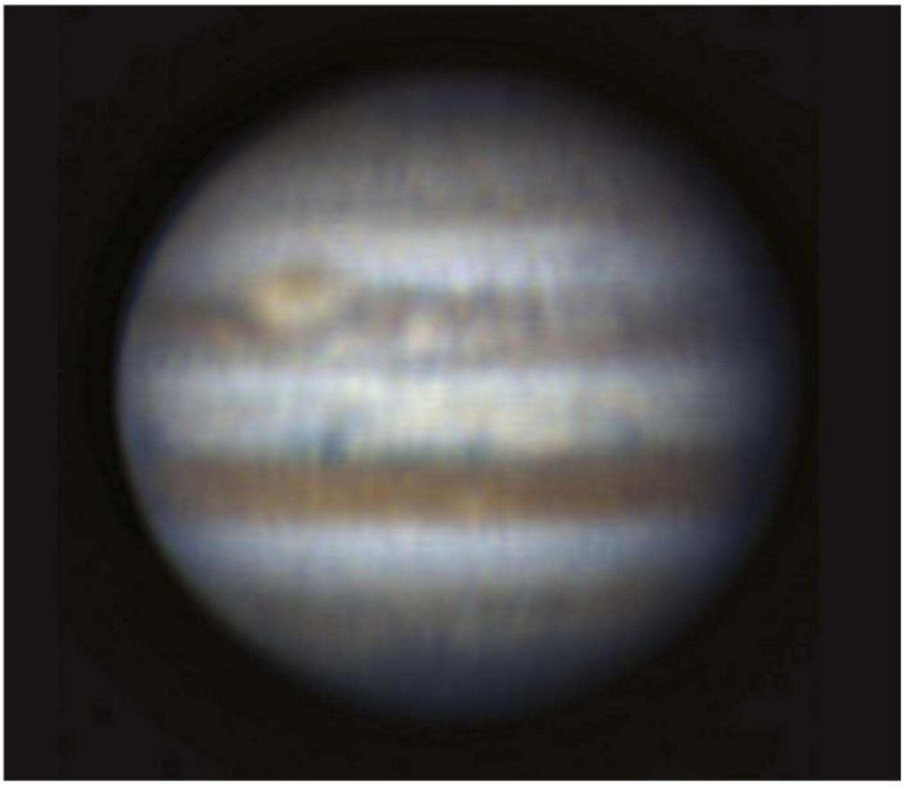
CAPTURING PLANETS
THE DOBSONIAN WAY

Dobsonian scopes can be adapted for effective planetary imaging – **Martin Lewis** explains how

Jupiter, Mars, Saturn and Venus imaged through the author's Dobsonian scopes

Dobsonian-mounted Newtonian telescopes are very popular due to their ease of use and value for money – they give the largest aperture possible for the lowest cost. The Newtonian design is simple. Being a pure reflector there are no issues with colour fringing and the central obstruction also tends to be smaller than in other reflectors, such as Schmidt-Cassegrains. This means that large-aperture and low-cost Dobsonians can often yield great planetary images. Their big aperture makes the images bright and contrasted, and provides extra resolving power to see surface detail.

The Dobsonian mount was intended to be a simple push-to altaz mount for visual observing, and by far and away the majority of Dobsonian telescopes are operated like this. However, some astronomers have found ways of using their Dobsonian reflectors to take great photos of the planets by recording video and then stacking individual frames using software such as RegiStax or Autostakkert!, reducing the blurring effects of the atmosphere. Sharpened in a graphics editor, the final image shows a wealth of surface detail.



▲ The gas giant Jupiter imaged with a 8.7-inch Dobsonian using the drift method

▲ Jupiter imaged with the same scope but mounted on a driven equatorial platform

MARTIN LEWIS X 6, WWW.THESECRETSTUDIO.NET

Drift or driven

The simplest way of capturing videos is the drift method, which requires no driven mount. Just capture multiple short video sequences as the planet drifts through the field and then combine the videos into one image. Each second a planet drifts about 15 arcseconds, so exposures of 30 milliseconds will lead to drift smearing of only about 0.5 arcseconds, similar to the level of detail you would see on a good night. The true window over which you can gather videos is also limited by rotational smearing. The following list lets you know how long you can image the planets before rotational smearing of about 1 arcsecond becomes evident:

- ▶ Venus: no real limit over one session
- ▶ Mars: five minutes
- ▶ Jupiter: five minutes
- ▶ Saturn: 10 minutes

You'll probably need to use a Barlow lens to enlarge the planet's image, and the best magnification Barlow depends upon a number of factors. Too low and you'll lose detail by undersampling, but if it's too high you'll have to manually reposition your telescope frequently. Start with a power that gives a focal ratio of f/10 and experiment around there. If you can, use a camera with a bigger chip to maximise the percentage of time that the planet is in the frame.

Although you can get reasonably pleasing photos with the drift method, driven methods really let you pull out significant planetary detail. With a driven scope you eliminate drift smearing and can increase the magnification to boost the image scale without worrying about getting very short drift runs. Also, you can gather more frames to help reduce image noise because you don't need to waste time repeatedly moving your telescope to the start of the drift run. ▸

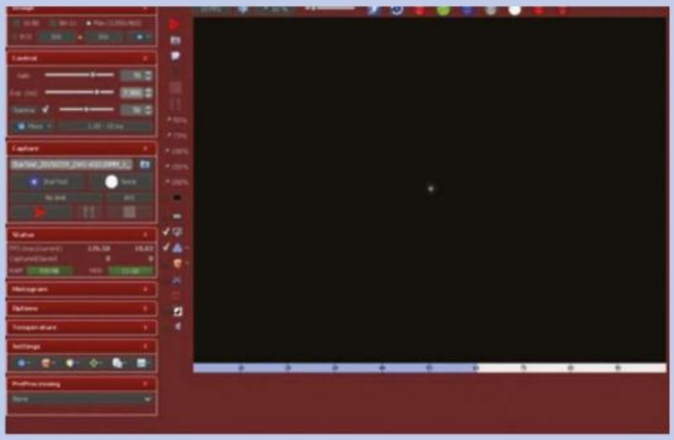
▸ But if Dobsonians are supposed to be push-to scopes, how do you get them to track a planet? One method is to fit a Go-To drive system and the other is to place the scope on an equatorial platform. Neither of these methods would probably be good enough for long-exposure deep-sky photos, but because planetary images are generally a few tens of milliseconds long, and because of the frame-to-frame alignment capability of the stacking programs, both types are good enough for planetary imaging.

Go-Tos generally use friction drives on the altitude and azimuth axes, which can be engaged or disengaged to change between 'go-to' and 'push-to'. Equipped like this, a Dobsonian should be able to keep the planet in frame and allow you to record videos to process into detailed pictures later. The Go-To will make finding your target easy and you should be able to compensate for any inaccuracies by using the motors manually to recentre the planet. Because you're using an altaz system, however, in time the planet will rotate relative to the frame of the camera. This is less of a problem for planets than for deep-sky imaging because the videos tend to just be a few minutes long, limiting the amount of rotation during a video. Over the course of 10 or 20 minutes, however, the field rotation could become noticeable if you're combining images from different videos. Fortunately the useful derotate function in WinJupos (jupos.org/gh/download.htm) will not only compensate for the rotation of the planet on its axis, but also for orientational drift due to this field rotation effect.

The equatorial approach

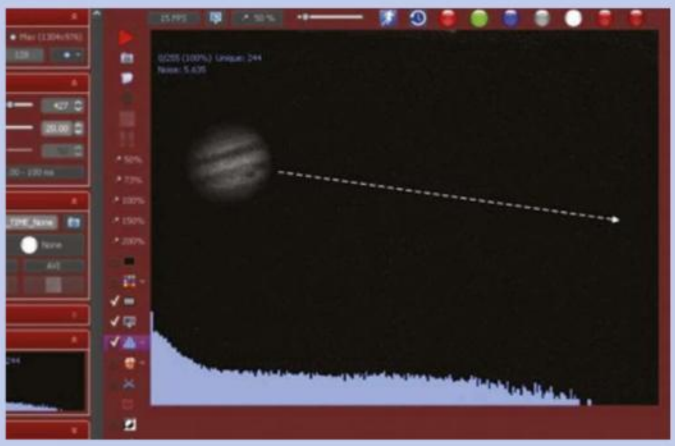
Mounting your Dobsonian on an equatorial platform is your second option and gives your scope true equatorial

How to capture images with the drift method



Step 1

Set up your scope and allow it to cool to reduce thermal currents, then collimate as normal. Connect a digital video camera to the telescope and, looking at your laptop, focus critically on a star. Polaris is a good choice for the star as it won't move while you are focusing.

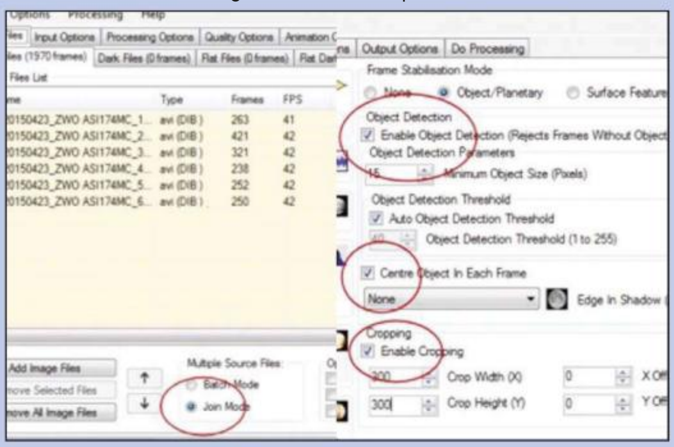


Step 2

Line up your finderscope so that Polaris is near the middle of the camera frame. Align on the planet and check the chosen exposure settings. Planet brightness should be about 70-80 per cent of the saturation level and the gain about 50-75 per cent of maximum.

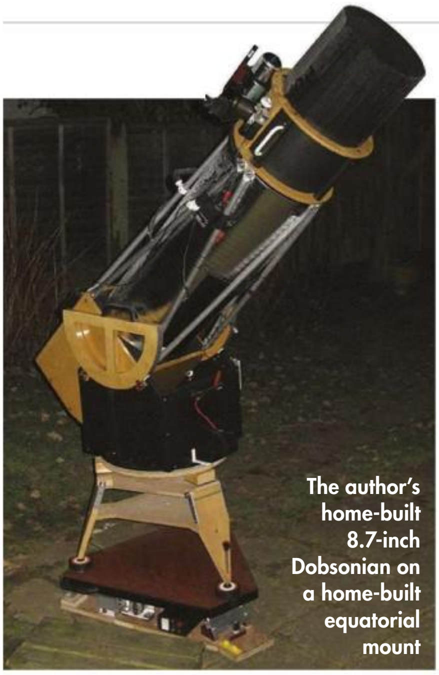
Step 3

Reposition the scope so the finder cross hairs are just ahead of the planet. As soon as the planet enters the camera frame, hit record. Keep recording until the planet drifts out of the frame. Quickly repeat. Keep going until you've gone outside the time window for your target.



Step 4

Join your videos together using PIPP's (sites.google.com/site/astropipp) 'Join' mode. Use the 'Object Detection' and 'Centre and Crop' functions to keep the planet centred and eliminate the empty frames. Process this output video in RegiStax or Autostakkert! to finish.



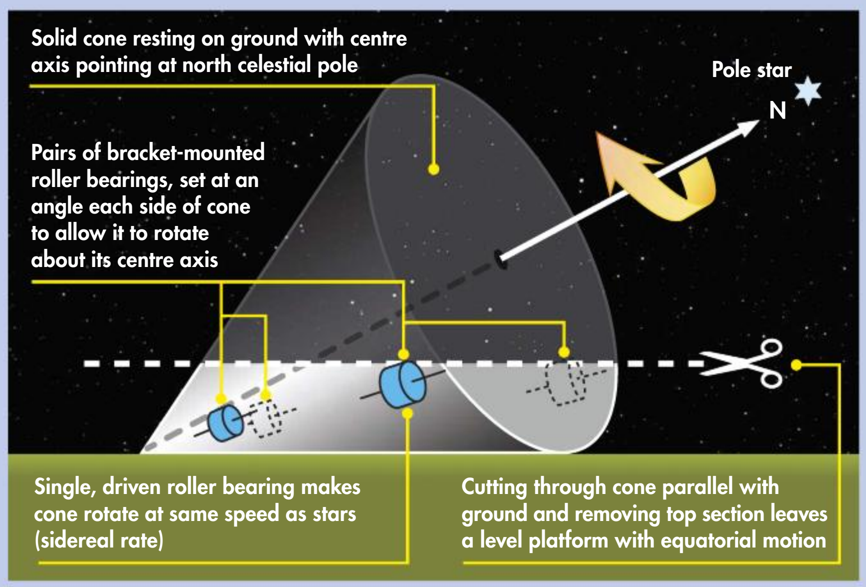
The author's home-built 8.7-inch Dobsonian on a home-built equatorial mount

Equatorial platforms

How this setup tracks like a German-equatorial mount

Understanding how an equatorial platform works can be confusing – they look so different from most other types of equatorial mount and don't seem to have an obvious rotation axis. To help with understanding imagine this:

▶ There is a large solid cone on the ground with its centre axis pointing at the North Celestial Pole.
▶ Two pairs of roller bearings are fitted on brackets running against the outside surface of the cone, one pair near the narrow end and the other pair near the wide end, angled so their axes point towards the apex of the cone. These should restrict the cone to rotating about its axis.
▶ One roller is driven so the cone rotates to follow the stars.
▶ Cut through the cone parallel with the ground and dispose of the top section. The flat platform that's left will have equatorial tracking properties.
▶ Anything placed on this platform will automatically follow the stars as it will have an axis pointing at the Pole Star and be rotating at the same rate as the night sky.



movement for an hour or so before the platform needs to be repositioned back to the start. Like the Go-To drive method, it maintains the low, stable centre of gravity of the Dobsonian design. With it you can continue to use the normal push-to altaz movements of the Dobsonian mount that are so much more in tune with the human frame of reference, but as soon as you've found the target it stays put in field as the equatorial platform tracks it. An equatorial platform can be moved between scopes and even used to place a normal camera tripod on to turn your DSLR into a fully tracked camera.

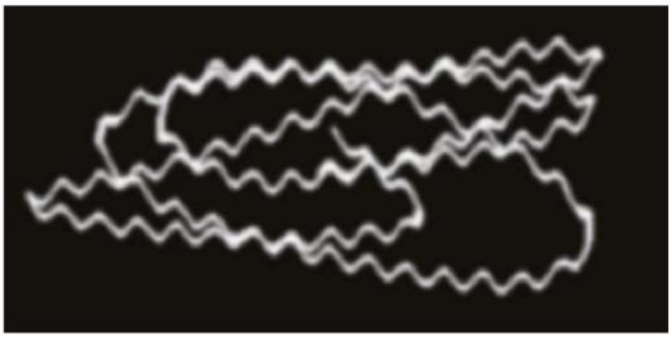
Commercial equatorial platforms are available from a number of different suppliers and are generally made for a specific latitude. For planetary imaging, absolute tracking accuracy from the drive system is not essential but it is useful to be able to adjust the drive speed slightly to keep the target in the field. Some platforms also have a screw jack on the southern end to help move the object up and down in the field.

One of the most important characteristics of a telescope drive system, if you want the highest resolution images, is that vibration should have an insignificant effect on the image. Equatorial platforms are prone to such vibration as they often use stepper motors as the main drive. You may not see signs of this vibration in normal use at the eyepiece but if it's there it will prevent you from achieving full high-resolution imaging.

You can check for vibration by inserting a high-power eyepiece and checking the smoothness of the twisted track of a bright star when you firmly tap the eyepiece to shake the scope. Vibration will be seen as a sawtooth on the smooth path.

ABOUT THE WRITER
Martin Lewis is a keen astronomer. He has in-depth knowledge of observing with all sorts of equipment.

▲ A tapped eyepiece at high power; the star path is smooth as it settles down again



▲ If the star path shows a sawtooth pattern, it indicates that drive vibration is present

MARTIN LEWIS X 7

IMAGING UNDER CITY SKIES

Jaspal Chadha reveals how you can capture quality deep-sky images under light-polluted skies

For the last few years I've been taking images of the night skies. But there's a problem: I live in London, one of the most light-polluted areas in the UK. This makes it hard to achieve one of the main requirements for a good astro image – a high signal to noise ratio. While the best way to increase that ratio is to reduce the noise by imaging from a site with darker skies, there are various things you can do to capture decent images from under the urban lights in the middle of a city.

After months of trial and error I finally settled upon a setup that works for me. When I started I used a DSLR and colour single shot CCD. The results weren't what I expected. The images lacked detail and were often filled with the orange glow of light pollution, despite my best attempts to reduce it. Even with exposures of four hours I wasn't happy with the amount of detail being captured and trying to remove the glow with photo-editing software was a long process that still didn't get me the results I wanted.

Sacrifice colour for clarity

Things improved when I switched to using a monochrome CCD camera, an option that retains the main advantage of a CCD: its sensitivity. The more sensitive the camera, the shorter the exposure required to detect faint detail. CCD cameras have a greater dynamic range than DSLR cameras, meaning there's a larger range of luminosity that they can detect. The CCD can more easily capture both faint and bright detail in a single exposure, rather than needing several images to bring out different elements.

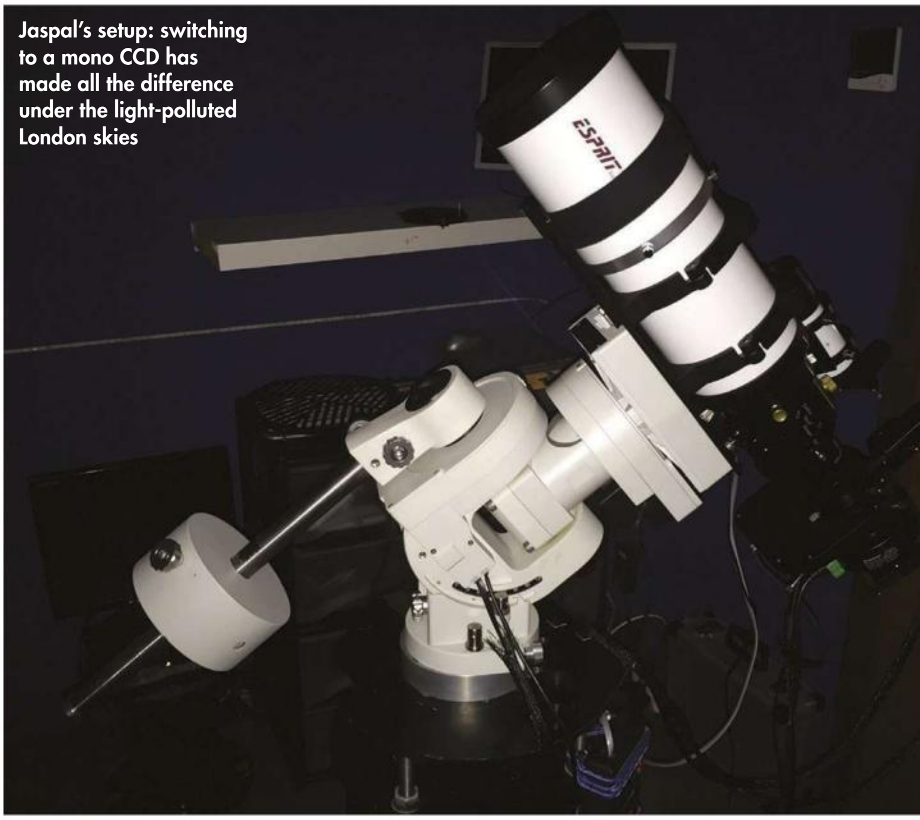
However, a mono CCD only detects the brightness of the light, not its colour. If you want to bring out the colour of images you have to use filters. In normal colour imaging, three filters are used to separate the primary colours of the visual spectrum. Red, green and blue (RGB) filters are designed to approximate the colour sensitivity of the human eye, so that the resulting image is true colour.

When using RGB filters to create a broadband image, all types of wavelengths are captured across the entire visible spectrum so this picks up a lot of light pollution from the surrounding

> ***"My images lacked detail and were often filled with the orange glow of light pollution"***

If you live in the city, the full Moon is far from the only source of irritating sky glare – but it's possible to capture wonderful images all the same city lights. This is usually most visible as green and magenta gradients in the images. To reduce this I use a simple CLS CCD light-pollution filter.

There are a few things to remember when using light-pollution filters, however. First is that they're not 100 per cent foolproof when it comes to light suppression. These filters are helpful, but they have their drawbacks. All of them are designed to block out only particular wavelengths of light and there's one overriding factor to consider when deciding how effective they'll be for you. They're designed to block the wavelengths emitted by low-pressure sodium-vapour lamps – the orange type. If the location where you make your observations from is lit by newer LED street lamps, then light-pollution filters will be useless. They also cut down the total light getting to the sensor, so the exposures required will be longer. But they should increase the ratio of useful image information compared to background glow, so overall should result in an improvement.



Jaspal's setup: switching to a mono CCD has made all the difference under the light-polluted London skies

Go deeper by narrowing down

For those times when I want to bring out the finer detail of a deep-sky object, I attach narrowband filters: the light-pollution filter's green tint is easy to remove in photo-editing software during the image-processing stage. These filters enhance the contrast of emission objects by accepting only a narrow range of wavelengths around the emission lines of certain gasses within the objects, such as hydrogen-alpha (Ha), doubly ionised oxygen (OIII), ionised sulphur (SII) and others. During the image-processing stage, data from each emission line is assigned a certain colour band – red, green or blue – and these are combined later in a graphics editor to create the most stunning images.

As narrowband filters only pick up a tiny portion of the available light, they can be used to take astrophotos even when the Moon is up as well or from locations that are usually plagued by light pollution. Narrowband filters commonly come with a bandwidth of 5nm or 3nm at the emission line they let through; you can expect to pay a higher price for the lower bandwidth filters.

Much time and effort will be required to capture data from all three filters. So little light gets past the filter that imaging requires very long exposure times. Typically I'll spend at least three to four hours' imaging time on each filter, with some single exposures of up to an hour. The most rewarding results come from the Ha filter. The image is readily visible and has much detail. The OIII and SII filters produce dim, noisy images that are frustrating to work with, but are needed for a complete image.

Staying on target

Keeping the telescope on track when narrowband imaging takes some practice too. I use an autoguider, and finding a stable guide star can be a challenge thanks to the fact that so little light reaches the ▸

▲ The night sky before (left) and after (right) processing – the amount of sky glow that can be removed with editing software is tremendous

▸ guide camera's sensor. Some narrowband imagers choose to use a separate camera on a guidescope. This has several advantages, the biggest being that since the guide CCD is not looking through the narrowband filter, the stars appear considerably brighter and finding a suitable guide star is easy.

The drawback to a guidescope though is flexure, where different parts of the telescope setup move by different amounts over the course of the night. This means that the main telescope may not be perfectly aligned with the guidescope during the course of the exposure. I use an off-axis guider that allows you to guide your telescope through the same optics that are taking the picture. This eliminates any possibility of guiding error.

However, the main difference between narrowband and broadband images comes when you combine the colours for the first time using image-editing software. Generally I use the standard Hubble palette combination where SII is red, Ha is green and OIII is blue. Since the Ha is usually a much stronger emission line, the result comes out very green. So it's a good idea to assign the SII and OIII a stronger combine factor, or do an equivalent in Photoshop to 'push' the SII and OIII data before combining them. Even when that is done, it's likely you'll want to do more colour adjustments, such as

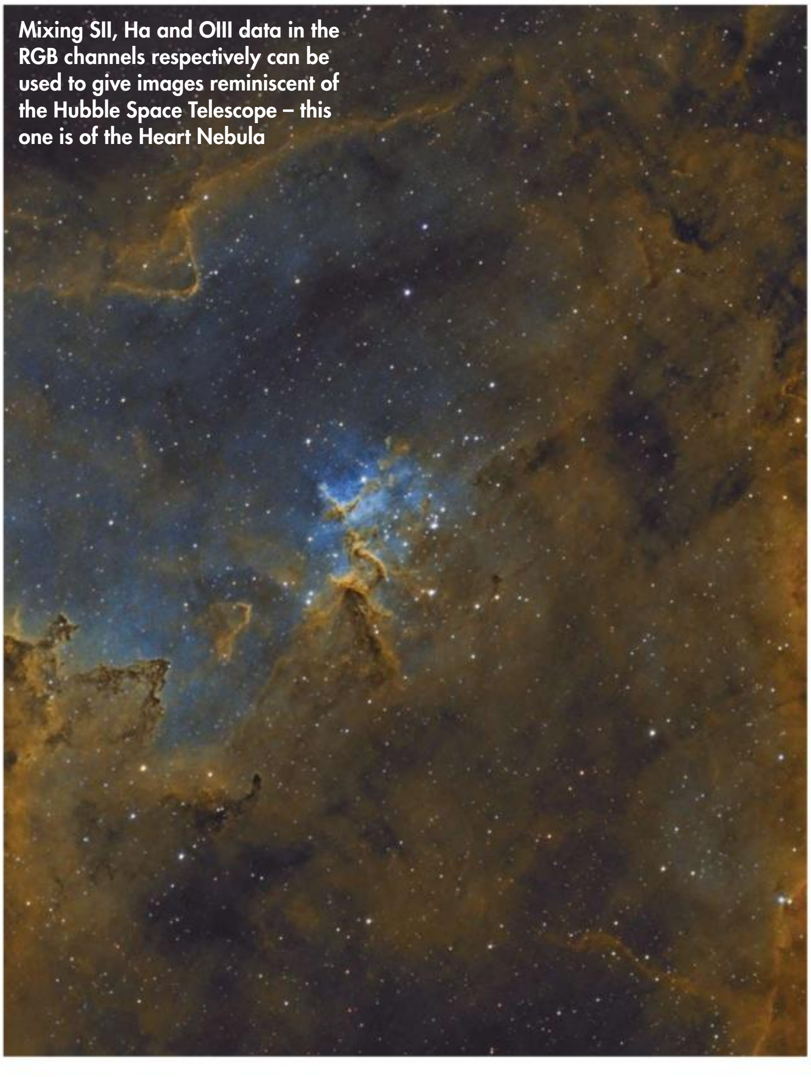
▲ Planetarium programs like Stellarium can help you to plan your sessions

Forward planning

1. Plan your imaging in advance using a planetarium program such as Stellarium (www.stellarium.org) to work out where your target is going to be in the sky and how much time you have to capture it. This will also help you work out where the best place in your garden or observing site will be to both avoid light pollution and get the best view.

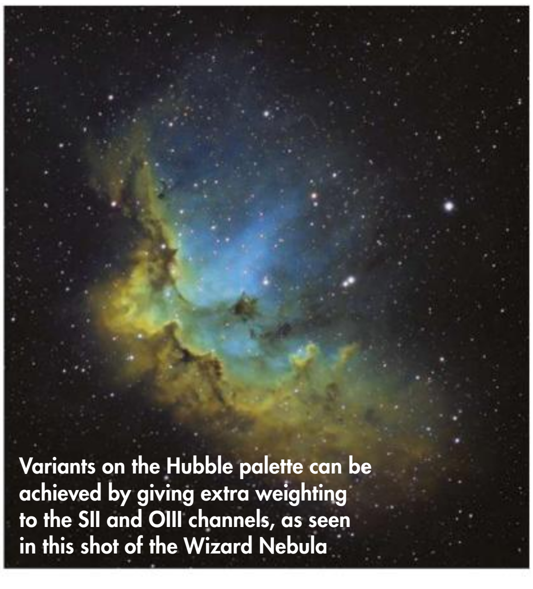
2. Image when your desired object is just past the meridian line in the sky. This will ensure you have the best sky conditions and will help shy away from light pollution.

3. Invest in a decent mount that will allow you to track for a longer period if you're aiming to do long-exposure astrophotography.



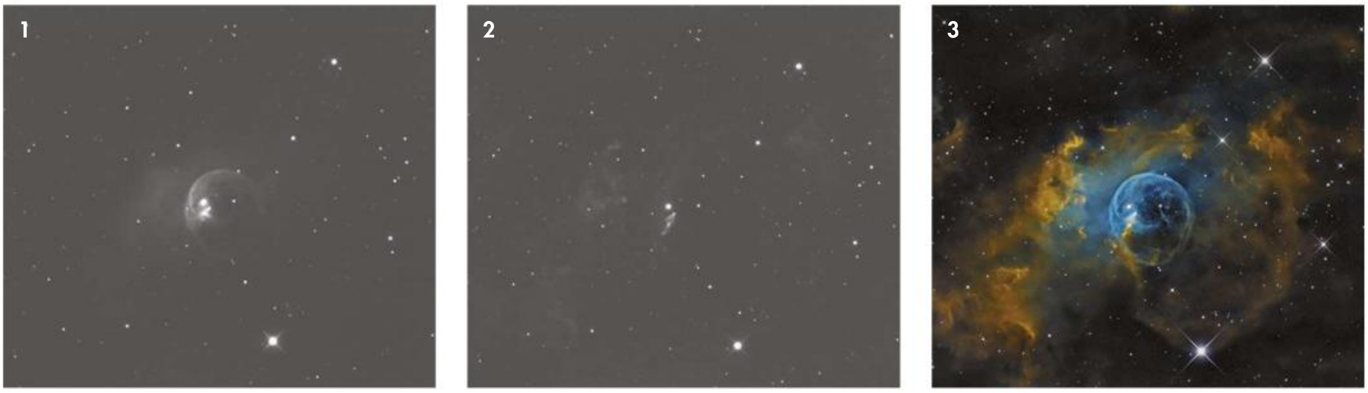
Mixing SII, Ha and OIII data in the RGB channels respectively can be used to give images reminiscent of the Hubble Space Telescope – this one is of the Heart Nebula

Another Hubble palette rendition, this time of open cluster Melotte 15 within the Heart Nebula



Variants on the Hubble palette can be achieved by giving extra weighting to the SII and OIII channels, as seen in this shot of the Wizard Nebula

JASPAL CHADHA X 10, WWW.STELLARIUM.ORG



▲ The Bubble Nebula: OIII (1) and SII (2) filters produce dim and noisy images, but when combined with Ha data the result (3) is great

▲ Even from a polluted sky it's possible to capture great deep-sky shots; clockwise from above: the Whirlpool Galaxy, the Dumbbell Nebula and globular cluster M13

adding a Selective Colour adjustment layer, before the results become pleasing.

Though I try to cut down on light pollution, there's always a little that gets through. To cope with this, I use a powerful program called Gradient Xterminator (**www.rc-astro.com/resources/GradientXTerminator**) when processing data. This Photoshop plug-in destroys light wash and amplifier glow from surrounding lights that may have been introduced while imaging.

Eventually, once all of this is done I arrive at my final image. It might take a bit of work, but you'd be amazed with what you can accomplish even under the skies of a city.

ABOUT THE WRITER

Jaspal Chadha has been an astro-imaging enthusiast for two and a half years. Observing from London, he has to overcome heavily polluted skies.

Reducing light pollution

Hiding away from light pollution is much more effective than editing it out afterwards

Shielding your equipment from stray light can be as simple as adding a cardboard cuff to the end of your scope, or by extending the dew shield.

A lot of stray or unwanted light comes from security lights. If you have them, turn them off while you're observing. If your neighbour's security lights are troublesome, politely ask if they can be turned off during your observing sessions. An offer to show the neighbours what you're looking at can work wonders and you never know, you might convert them to your hobby.

Stray light gradually decreases as the night goes on. More people head to bed, turning off the lights in their homes as they go, and some local authorities turn street lighting down or off after midnight. If you're able to stay out late, you'll probably find that after midnight the amount of stray light around seems to be less than earlier in the evening.

Even if you have streetlights shining into your garden, it's usually possible to find a spot that's not illuminated by them, giving a good view of the sky. Getting into the shadow of a brick wall or a tree can help here, though this can block your view of a large part of the sky, so you may need to hunt around for the best spot in your garden.

One of the most difficult forms of light pollution comes from artificial light being shone directly into the sky and reflecting back off dust and water vapour, filling the night with a haze of light. High humidity or prolonged dry spells when dust can be thrown up into the atmosphere will seem to make the situation worse. Check weather reports and wait for stable conditions with low wind speeds to get the darkest skies.

▲ Jaspal's observatory is at the back of his garden, where trees help to shield it from light pollution

BBC Sky at Night MAGAZINE

EQUIPMENT REVIEWS
BEST OF 2016

Some of the finest astronomical equipment to pass through our testing labs in the past year

NICK ALTAIR/WWW.ALTAIRASTRO.COM, WWW.THESECRETSTUDIO.NET

PrimaLuceLab AIRY APO120 refractor

A surprising scope with a doublet that offers astounding and aberration-free views

Rotatable assembly

The focuser assembly can be rotated or the eyepiece/camera alone can be rotated. This allows for accurate framing of photographic targets and helps you find the most comfortable viewing and focusing position on a variety of mounts.

On-axis locking accessory holder

Instead of the usual thumbscrews to attach a diagonal or camera equipment to the optical tube, there's a simple clamp that locks and loosens with a single twist. The inner rings of the clamp apply even and firm pressure to accessories, holding them centrally.

Focuser

PrimaLuceLab calls this a Hybrid-Drive focuser. The well-engineered mechanism is smooth like a Crayford, yet strong and non-flexing, with rack and pinion-style gearing. Precise focus adjustments are easily managed with the dual-speed action, which firmly locks in place.

User manual

Bucking the trend for online-only manuals, there's a detailed user guide with useful photographic diagrams to help with setting up the telescope for visual or photographic use, and a complete list of available accessories for the AIRY APO120.

Carry case

The rigid and lockable padded case makes a useful accessory, ideal for transporting or safely storing the telescope when it's not in use. The aluminium case is 90x30x29cm and weighs only 4.3kg. There are handles on the top and ends of the case.

PrimaLuceLab's AIRY APO120 refractor arrived on one of the few days of 2016's summer when the weather, Moon and short nights decided to play nicely together. The first target we observed with it was Jupiter, using our own premium 10mm eyepiece and a 2x Barlow lens. The view was remarkable. The equatorial bands were crisp and sharp, the Great Red Spot stood out clearly and there wasn't a trace of colour fringing or chromatic aberration. Jupiter looked superb, like a photograph.

After putting the accurate colour correction to good use by viewing some more vibrant stars – Albireo in Cygnus, Arcturus in Boötes and Mirach in Andromeda – we turned our sights on Mars and Saturn, again with a Barlow lens to increase magnification. Mars was a clear disc with good contrast on the darker regions and the typical dusky pink surface, while Saturn displayed the Cassini Division within its rings and well-defined coloured banding, all without interference from colour halos.

The AIRY APO120 comes in a nice case, with matching tube rings, end cap, focuser and eyepiece holder, full instructions and a four-year warranty. The dew shield extends smoothly without tilting or slipping, and the twist and lock eyepiece holder rounds off a great package. Of course, all of this comes at a price, and the AIRY APO120 is at the premium end of the market. However the combination of almost-perfect views, with a respectable 4.72-inch aperture and a useful 900mm of focal length, in a telescope weighing just 8kg, could place the AIRY APO120 on the radar of astronomers looking for their next or final upgrade.

VITAL STATISTICS

- **Price** £2,497
- **Optics** Multicoated apochromatic doublet
- **Aperture** 120mm (4.72 inches)
- **Focal length** 900mm (f/7.5)
- **Focuser** Dual speed 1:11 Hybrid-Drive
- **Extras** Tube rings, end cap, carry case
- **Weight** 8.0kg
- **Supplier** 365 Astronomy
- **www.365astronomy.com**
- **Tel** 020 3384 5187

VERDICT ★★★★★

Daystar Quark calcium-H eyepiece filter

You've seen the Sun in white light and hydrogen-alpha red; now see it in purple

Ports

The filter accepts power through a female micro-B USB connector. This means you can also power it using an external battery – giving you complete portability – so long as the battery can deliver the 1.5-amp current needed to heat the etalon chamber.

Tuning knob

The tuning knob adjusts the centre wavelength of the filter, allowing you to tweak it to get better views of redshifted or blueshifted material moving towards or away from the Sun. This also allows compensation for any focuser sag present in the telescope.

Nosepieces

The nosepieces thread onto the filter body, so it can be used in a range of star diagonals or directly in the focuser to extend or shorten the amount of back focus. This ensures maximum compatibility with various refractors.

Power

The supplied 90-240V adaptor includes UK, US, Euro and Australian plugs, which along with the Quark calcium-H's compact size makes it ideal for foreign travel. The 1.5m cable is ample length to connect when the Quark is mounted on a telescope.

Case

The supplied plastic bolt case provides a robust and sturdy means of storage. Daystar says keeping the Quark calcium-H in a dry, climate-controlled environment when not in use can extend the lifespan of the filter two or three times.

Daystar's Quark hydrogen-alpha eyepiece filter was a popular item and quickly gained a following after its launch in 2014. Not long after that amateurs began asking for a calcium version. And here is the Quark calcium-H. As the calcium-H wavelength is 396.85nm, in the violet region of the spectrum, the views of the solar chromosphere it delivers are quite different to what you might expect through a hydrogen-alpha filter.

The Quark calcium-H is designed to be used with refractors with a focal ratio of f/7 or greater and, as with any form of solar observing, precautions must be taken. We used the filter with a 100mm f10 Tal100R refractor, placing it in the diagonal with the energy reflection filter. Using a 15mm Plössl eyepiece gave us a rich, well contrasted view of the full solar disc and it was easy to see the brighter areas of plage and faculae set against the violet background. Darker sunspots with their umbra and penumbra could also be seen within the active regions.

It was interesting to note that the brightness and quality of view was eyepiece dependent; this is due to their anti-reflective coatings and designs, rather than the Quark filter. It's therefore worth experimenting with various eyepieces to see which one offers you the best performance.

The simplicity and ease of use of the Quark calcium-H make it suitable both for seasoned solar observers wanting to see our star in a new light and beginners. Given how easy it is to image and observe with this eyepiece filter, Daystar may well have a game changer on its hands.

VITAL STATISTICS

- **Price** £999
- **Tuning range** 5 Angström FWHM (+/– 0.5 Angströmin 0.1 Angström increments)
- **Power requirements** 5V 1.5 amp
- **Extras** 1.25-inch and 2-inch nosepieces, 1.25-inch extension tube, 240V power supply, storage case
- **Weight** 200g
- **Supplier** Altair Astro
- **www.**altairastro.com
- **Tel** 01263 731505

VERDICT ★★★★★

SkyVision 24-inch T600 Compact Go-To Dobsonian

A mighty truss Dobsonian with a colossal aperture and smooth tracking

Focuser

The choice of focuser is one of the decisions to be made at time of purchase, but the default option is a Starlight Feather Touch with normal and slow speed knobs. The beautiful engineering on this focuser complements that of the rest of the telescope.

Truss poles

The carbon fibre truss poles are works of art in themselves and exemplify the attention to detail present throughout the instrument. Each is 27mm in diameter and they link together in a single expandable set, which readily locks into position with quick-release levers.

Thermal management

The large mirror contains a lot of glass, so to help it acclimatise to night-time temperatures there are two 100mm fans in the side of the mirror box. These blow ambient air onto the side and underside of the mirror to cool it down.

Optics

The 24-inch primary mirror is made of low-expansion Suprax glass and possesses high-reflectivity coatings. The mirror sits on an 18-point support cell and is beautifully finished with no visible streaks plus a perfectly ground edge bevel. The telescope has a short focal ratio of f/3.3 to keep the eyepiece height low.

Bearings

The azimuth bearings are PTFE pads riding on an FRP glass board, a standard combination for many large-aperture Dobsonians. The altitude bearings are quite different and are special rollers with a friction preload originally designed for CNC machine tools.

If you want the finest deep-sky views, you need large, photon-grabbing optics of a high quality. The SkyVision T600 Compact Dobsonian with its whopping 24-inch diameter mirror provides them. Even a cursory look at this telescope shows its an elegant piece of engineering. It can be disassembled into manageable parts that fit into a car, has full Go-To capability and motorised tracking to further enhance your observing.

The first object we viewed with it was the Ring Nebula, high overhead, which was big and bright in the 6mm eyepiece. Using the same eyepiece we turned to M13 and M15, two of the finest globular clusters in the sky, which were easily resolved to their cores.

Another memorable view was the Dumbbell Nebula, which we glimpsed through a binoviewer and a pair of 24mm Panoptic eyepieces. The nebula had a mesmerising 3D appearance and was truly wonderful. With this setup we moved on to the Blue Snowball planetary nebula and were able to clearly see the inner structure even at this low magnification. We followed our deep-sky viewing with some star testing, which showed smooth optics but signs of minor overcorrection – this may have disappeared with further cooling of the primary mirror.

The secondary mirror is quite exposed at the top of the secondary cage, and dewed up during our observing session so we had to warm it up using the mirror's 12V rear heater. A lightweight extension to the top of the secondary cage might have delayed such dewing and if fitted opposite the eyepiece would have blocked extraneous light reaching the eyepiece from the sky behind the secondary mirror.

All in all the SkyVision T600 is an advanced scope for serious visual observers. It delivers great performance in a beautifully crafted instrument that's a joy to look at and a pleasure to use.

VITAL STATISTICS

- **Price** Contact Altair Astro
- **Aperture** 600mm (24 inches)
- **Focal length** 1,980mm (f/3.3)
- **Focuser** Starlight Feather Touch
- **Go-To system** StellarCAT and Sky Commander user interface
- **Weight** 99kg
- **Supplier** Altair Astro
- **www.altairastro.com**
- **Tel** 01263 731505

VERDICT ★★★★★

ALL PICTURES: NICK ALTAIR/WWW.ALTAIRASTRO.COM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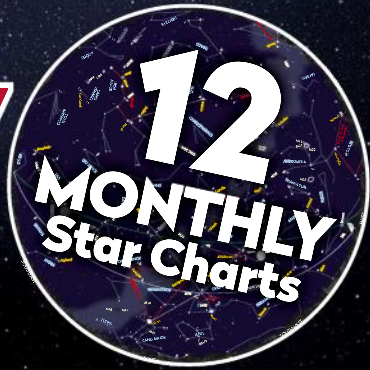


2017 Month by month GUIDE

What to see in the night sky throughout the year

by **Pete Lawrence**

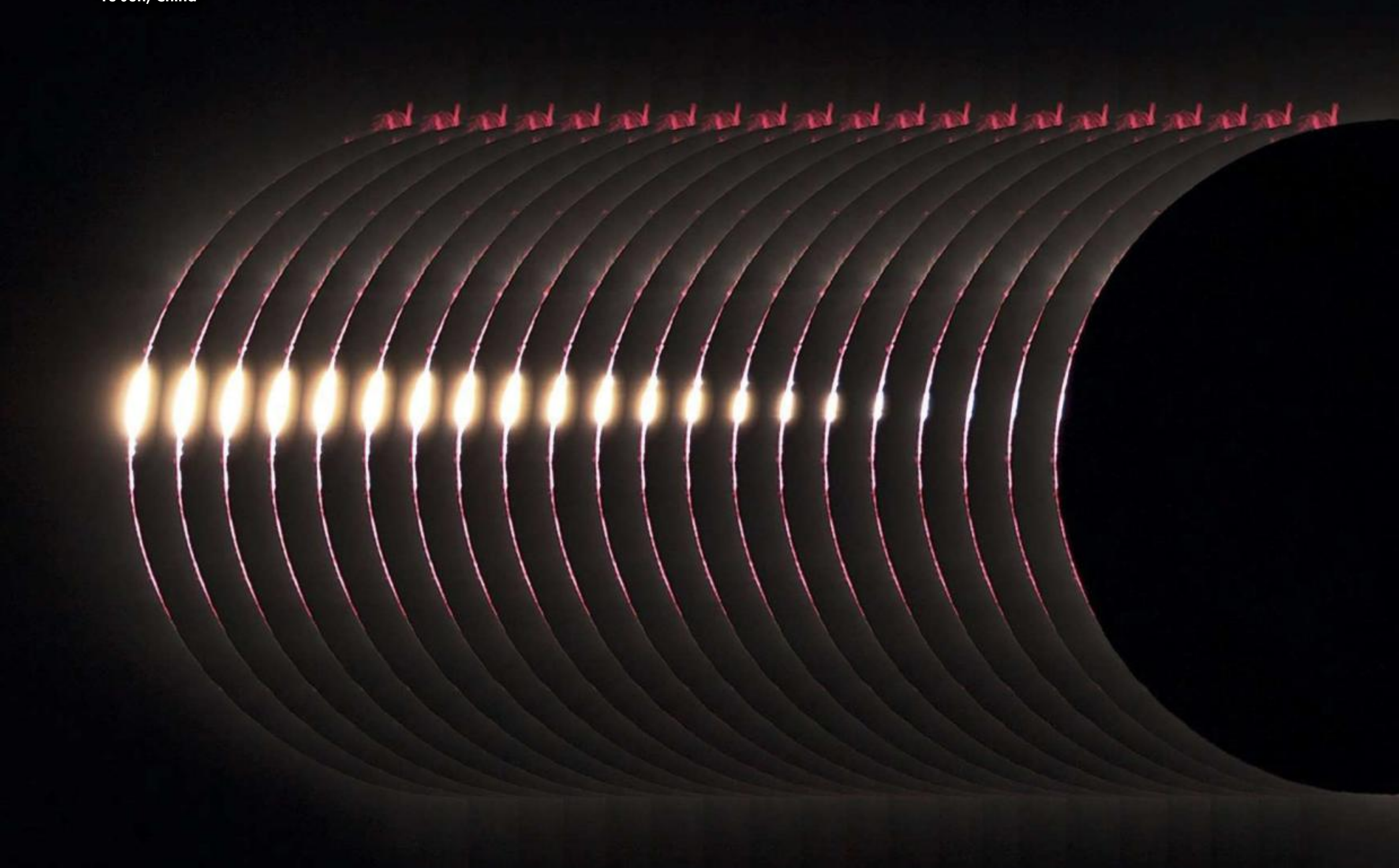
ISTOCK

INSIGHT ASTRONOMY PHOTOGRAPHER OF THE YEAR

OUR SUN WINNER & OVERALL WINNER

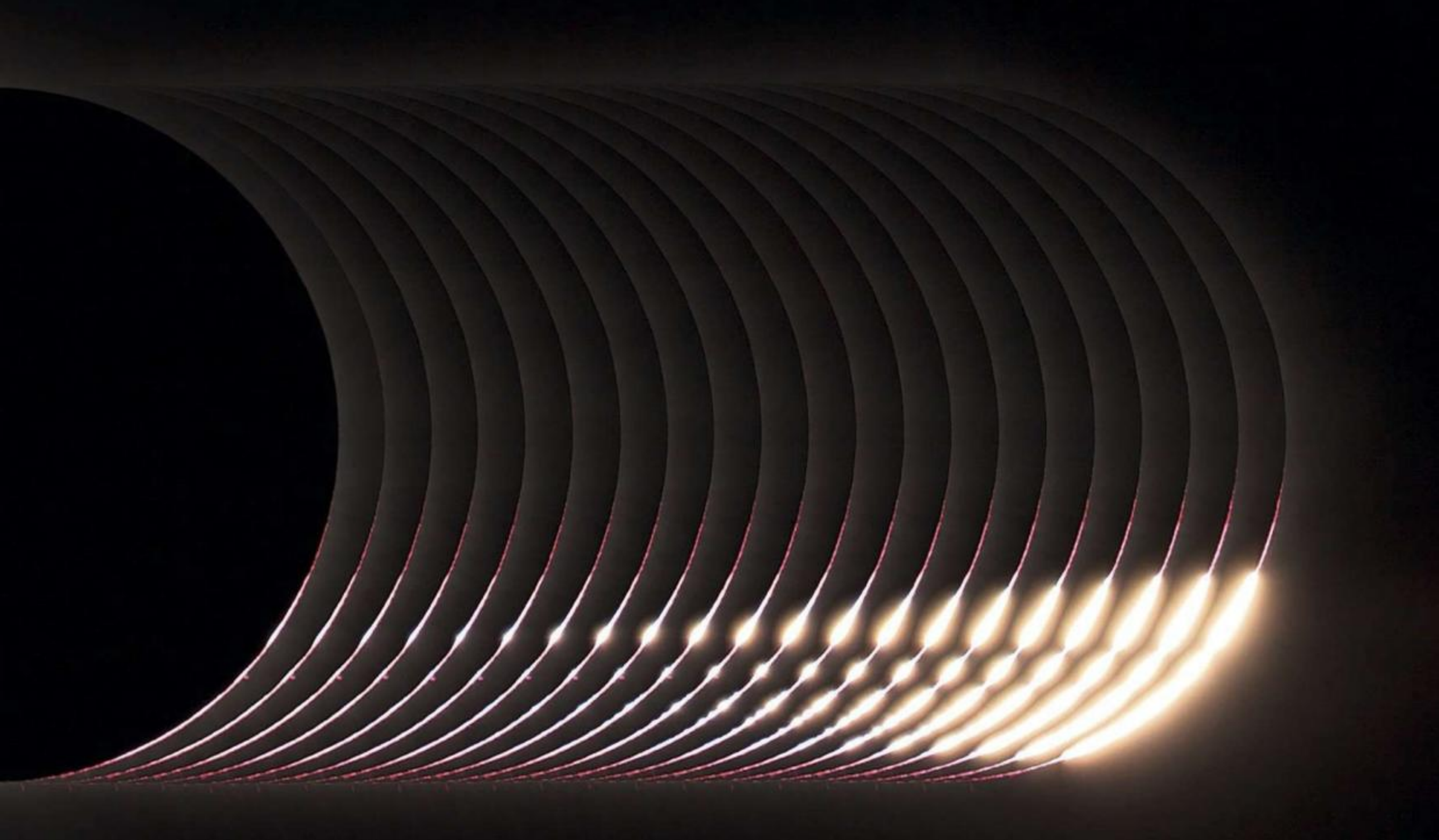
Baily's Beads

Yu Jun, China



JANUARY

Orion's Belt is the first step on a whistle-stop tour of this month's astronomical highlights



KEY DATES

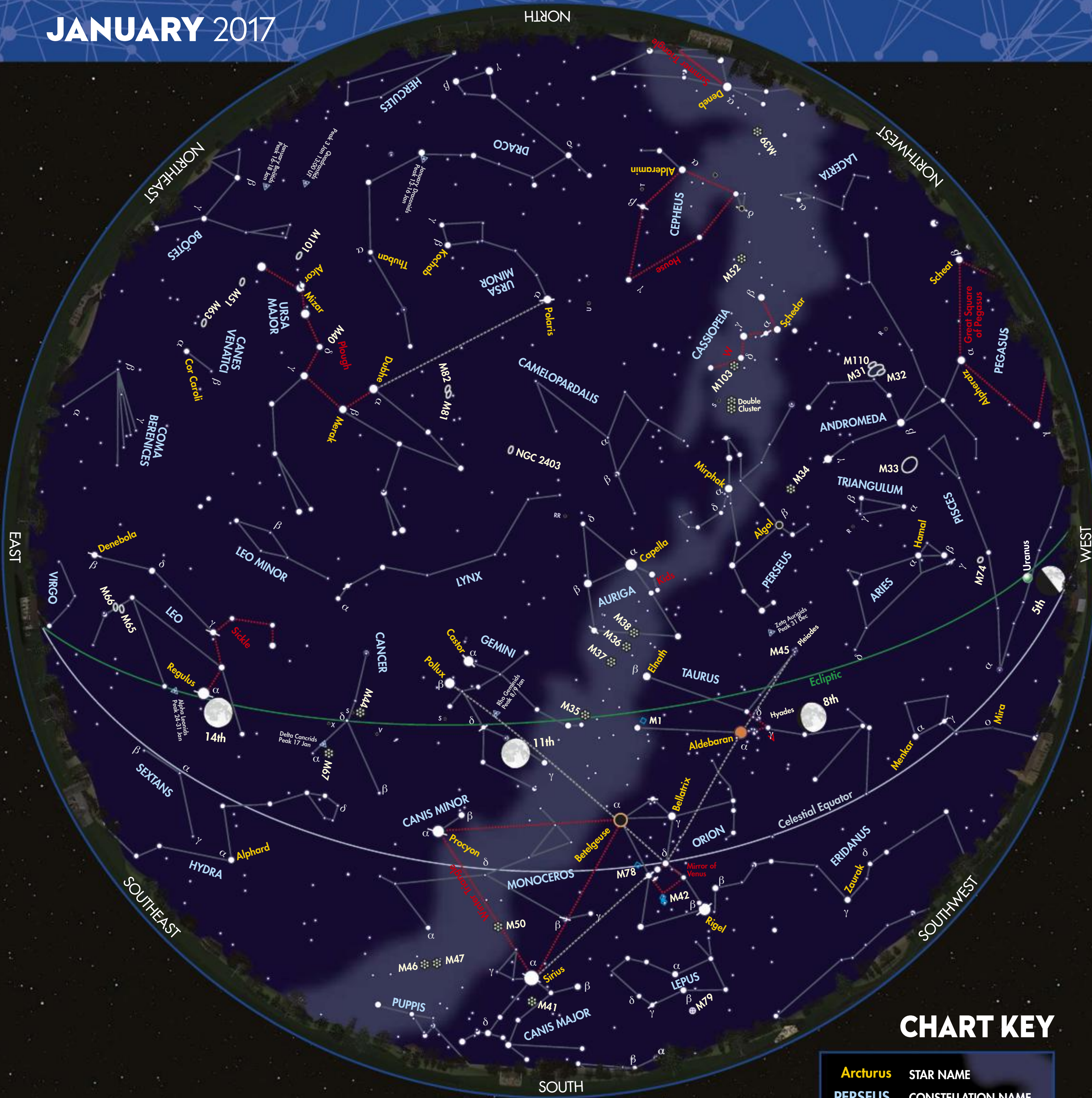
2 JANUARY
Venus, the crescent Moon and Mars form a straight line in the evening sky

3 JANUARY
Peak of the annual Quadrantid meteor shower

5 JANUARY
Seventh magnitude comet 45P/Honda-Mrkos-Pajdusakova close to Theta (θ) Capricorni

18 JANUARY
Asteroid Vesta reaches opposition at mag. +6.1 in Cancer

22 JANUARY
Galilean moon Callisto appears just south of Jupiter at 06:15 UT



MOON PHASES Key stages in the monthly cycle


FIRST QUARTER MOON 5 Jan


FULL MOON 12 Jan


LAST QUARTER MOON 19 Jan


NEW MOON 28 Jan

VISIBLE PLANETS Where to spot the planets this month

MERCURY
Well placed in the morning sky, reaches greatest western elongation of 24.1° on 19 Jan

VENUS
A bright evening object that reaches greatest eastern elongation, 47.1° from the Sun, on 12 Jan

MARS
An evening planet in Aquarius, appears 20 arcminutes from Neptune on 1 Jan

JUPITER
A morning planet in Virgo with the Moon nearby on the morning of 19 Jan

SATURN
A morning planet in Ophiuchus with the Moon nearby on the morning of 24 Jan

URANUS
An evening planet in Pisces best seen at the start of Jan around 18:30 UT

NEPTUNE
An evening planet that has an apparent close encounter with Mars on 1 Jan and Venus on 12 Jan

PETE LAWRENCE X 3

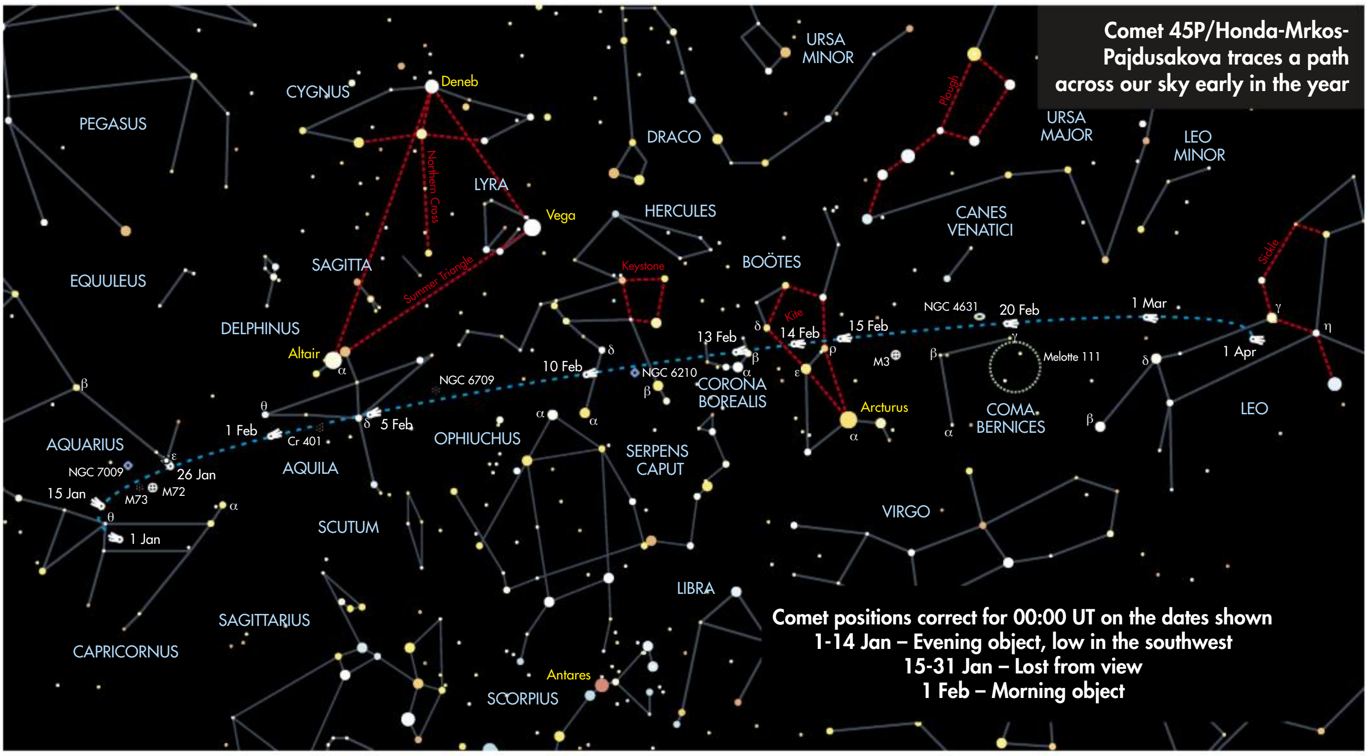
CHART KEY

- Arcturus — STAR NAME
- PERSEUS — CONSTELLATION NAME
- GALAXY
- OPEN CLUSTER
- GLOBULAR CLUSTER
- PLANETARY NEBULA
- DIFFUSE NEBULOSITY
- DOUBLE STAR
- VARIABLE STAR
- THE MOON (SHOWING PHASE)
- COMET TRACK
- ASTEROID TRACK
- STAR-HOPPING PATH
- METEOR RADIANT
- Circlet — ASTERISM
- MILKY WAY
- PLANET

STAR BRIGHTNESS:
MAG. 0 & BRIGHTER · MAG. +1 · MAG. +2 · MAG. +3 · MAG. +4 & FAINTER

JANUARY at a glance

Meteor showers and comets get the year off to a dazzling start



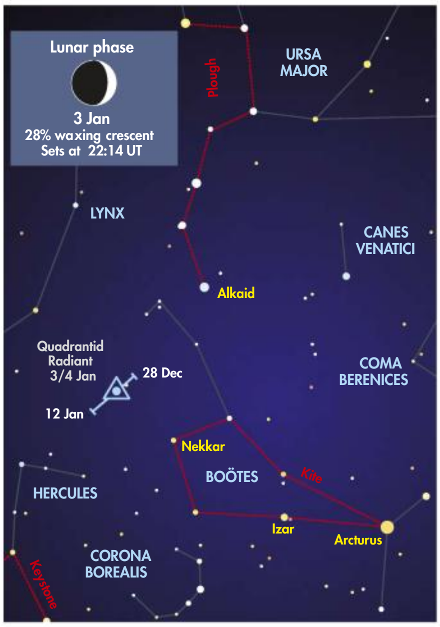
Comet 45P/Honda-Mrkos-Pajdusakova traces a path across our sky early in the year

The January night sky is full of splendour with mighty Orion well placed before midnight. The Hunter's main pattern is unmistakable thanks to the straight line of three stars that form his belt. Follow the belt up and you'll arrive at orange-coloured Aldebaran, the brightest star in Taurus, the Bull.

The V-shaped pattern of stars nearby is the Hyades open cluster. Continue the belt line through Aldebaran to reach the Pleiades, or Seven Sisters, open cluster, which is also part of Taurus.

If you extend the arms of the Hyades, you'll reach two middle-brightness stars representing the Bull's horn tips. The lower star is Zeta (ζ) Tauri. M1, the Crab Nebula, lies 1.1° northwest of Zeta and requires a telescope to see it at its best. The northern horn-tip is marked by Beta (β) Tauri, or Elnath. Charts often show Elnath connecting Taurus to the misshapen pentagon of Auriga, the Charioteer, which lies to the north. This is because Elnath used to belong to Auriga before getting a transfer to Taurus. The brightest star in Auriga is the yellow sun Capella, which sits on top of the 'pentagon'.

Return to Orion and marvel at the difference between the bright white star Rigel in the southwest corner and bright orange Betelgeuse in the northeast corner. Extend a line from Rigel through Betelgeuse for almost twice that distance again to arrive at a pair of similar brightness stars known as Castor and Pollux, the two main stars of Gemini. Look closer and you'll see that Castor is slightly dimmer than the more orange-hued Pollux. Castor and Pollux define one short side of Gemini's rectangular shape, which extends back towards Orion.



▲ **The Quadrantid meteor shower hits it peak in the first week of January**

Comets and meteors

Heading south from Pollux you'll reach solitary Procyon, the brightest star in Canis Minor. There's not much to the rest of the constellation apart from Beta (β) Canis Minoris, or Gomeisa. Canis Major can be found by extending the Belt of Orion southeast towards Alpha (α) Canis Majoris or Sirius, the brightest star in the night sky. Eight apparent full Moon diameters (4°) south of Sirius is the lovely open cluster M41, which may just about be visible with the naked eye on a cold, dark January night.

Keep an eye out for Quadrantid meteors at the start of the month. The shower's activity rises to a sharp peak during daylight on 3 January so the best time to watch will be on the nights of the 2/3 and 3/4 January. Another January highlight will be the appearance of binocular comet 45P/Honda-Mrkos-Pajdusakova visible in the evening sky at the start of January around magnitude +7.1, but switching to the morning sky by the end of the month when it will be around magnitude +8.

INSIGHT ASTRONOMY PHOTOGRAPHER OF THE YEAR

WINNER
AURORAE

Twilight Aurora

György Soponyai, Hungary

FEBRUARY

The Moon takes centre stage this month, passing through Earth's shadow

KEY DATES

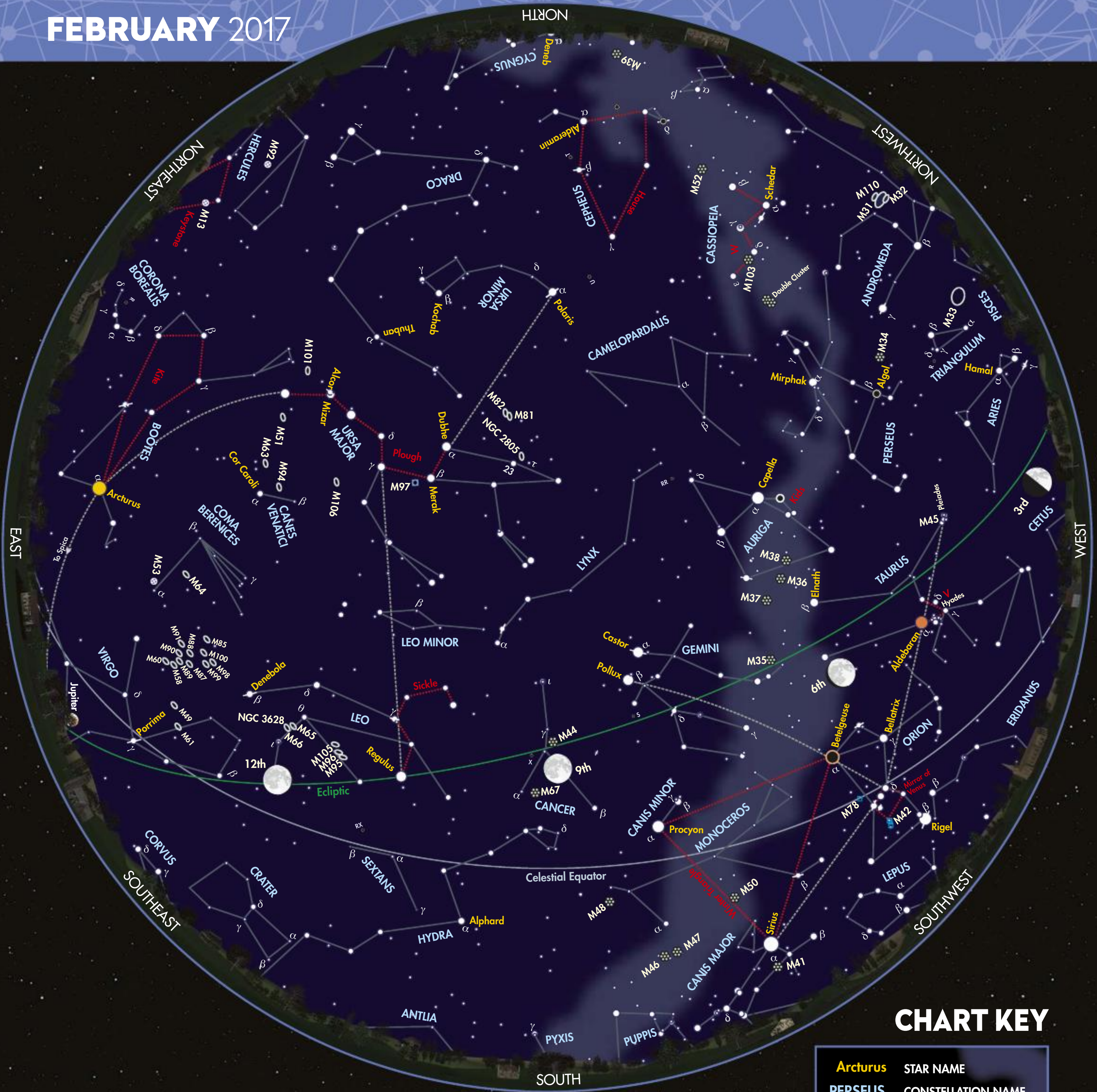
1 FEBRUARY
Venus, Mars and the crescent Moon are aligned from 19:00 UT

5 FEBRUARY
The Moon moves through part of the Hyades cluster, passing very close to Aldebaran at 22:20 UT

10 FEBRUARY
The full Moon undergoes a penumbral eclipse between 22:32 UT tonight and 02:55 UT on the 11th

17 FEBRUARY
Venus is at its brightest, shining at mag. -4.6

27 FEBRUARY
A chance to spot a thin 1% lit waxing lunar crescent in the west at 18:30 UT



MOON PHASES Key stages in the monthly cycle


FIRST QUARTER MOON
4 Feb


FULL MOON
11 Feb


LAST QUARTER MOON
18 Feb


NEW MOON
26 Feb

VISIBLE PLANETS Where to spot the planets this month

MERCURY
A morning planet rising 20 minutes before the Sun on 1 Feb; lost from view after the 10th

VENUS
A magnificent evening planet, which is joined by Mars and a crescent Moon on 1 Feb

MARS
An evening planet close to Venus at the start of the month

JUPITER
A morning planet, improving over the month with the Moon close on 14 and 15 Feb

SATURN
A morning planet moving from Ophiuchus into Sagittarius on 24 Feb

URANUS
An evening planet, losing its favourable position throughout the month

NEPTUNE
Another evening planet, lost to the Sun's glare during Feb

PETE LAWRENCE X 3

CHART KEY

FEBRUARY at a glance

There's a long list of sights to see in the year's shortest month

Orion is slowly starting to drift westward during February so it's a good time to get a look at the fabulous Orion Nebula, a gaseous cloud that sits in the middle of the sword hanging from his belt.

At the time of our chart, the twin stars of Gemini, Castor and Pollux, ride high in the sky. To their south is lonely Procyon, the brightest star in Canis Minor, the Little Dog. Follow the line of Orion's belt southeast to find the brightest star in the sky, Sirius – the Dog Star in Canis Major.

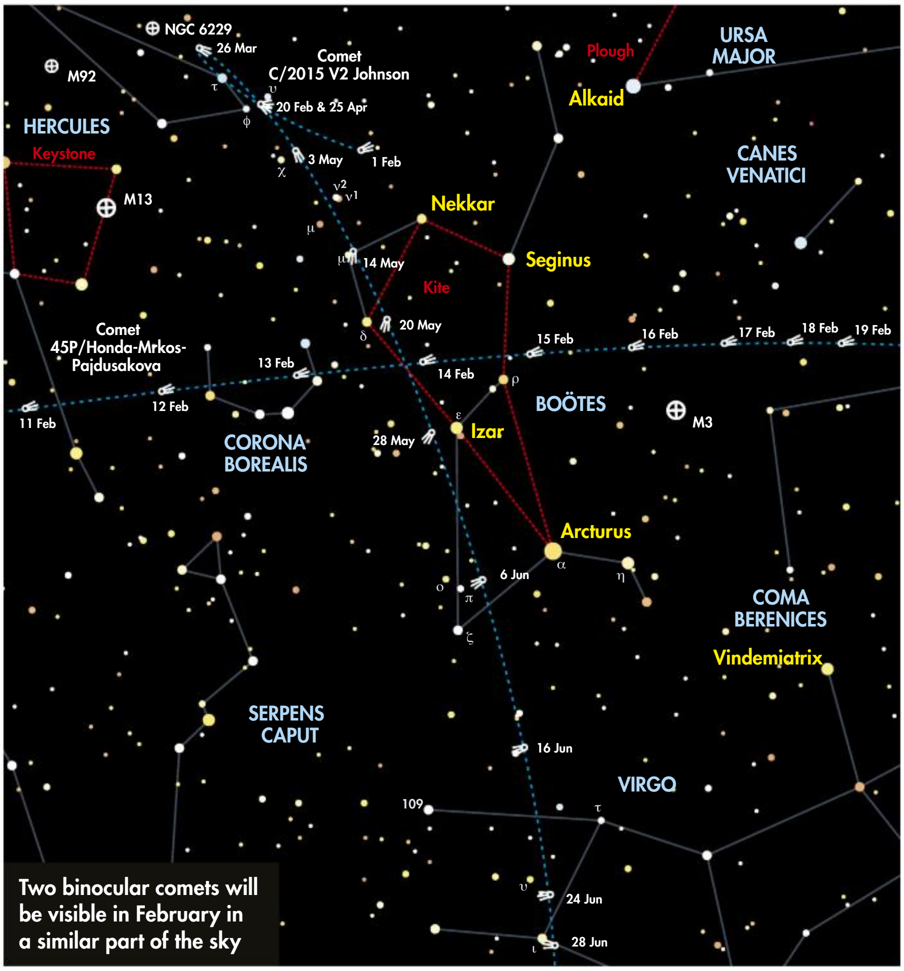
Leo can be seen in the southeast in the period running up to midnight. If you're unfamiliar with Leo's shape, locate the Plough, the saucepan shape that can be found balancing on the tip of its handle in the northeast part of the sky. Find the pan of the saucepan and the two stars that form the side closest to the handle. Extend the line they make down and eventually this will bring you to Regulus, Leo's brightest star.

A backward question mark shape spreads north from Regulus and is known as the Sickle. The rest of Leo's body spreads east of the Sickle appearing rectangular with a pointed triangle for the tail, the end of which is marked by the star Denebola. The tail points into a large semi-circle known as the Bowl of Virgo.

Bees, crabs and snakes

Draw a line between Regulus and Castor and south of its mid-point is a fuzzy patch, just visible to the naked eye. Binoculars trained on this region reveal the Beehive Cluster, M44. This lies at the centre of the faint inverted-Y-shaped constellation of Cancer.

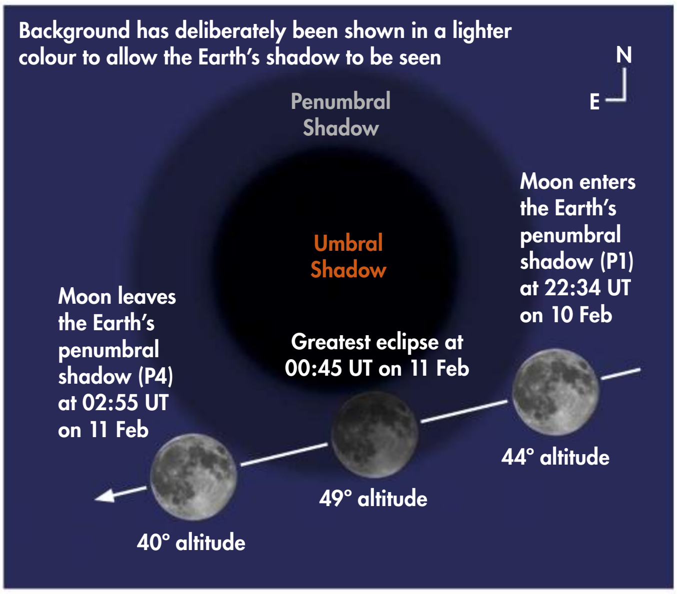
Below the open part of the Y is the sideways tear-drop shape that forms the head of Hydra the Watersnake, the largest constellation in the sky. Despite its size, Hydra isn't that easy to follow, being formed largely from dim stars. These spread off to the southeast of the head. The brightest star in Hydra is Alphard, which lies below the head in an empty part of the sky. Perhaps fittingly, Alphard means 'the Solitary One'.



Two binocular comets will be visible in February in a similar part of the sky

At 22:34 UT on 10 February, the Moon enters the weak outer part of the Earth's shadow in space known as the penumbral shadow. This difficult-to-see eclipse continues through to 02:55 UT on 11 February, with mid-eclipse occurring at 00:45 UT. During mid-eclipse the northern part of the Moon's disc may appear noticeably darker than usual.

There are two reasonably bright comets on view this month. You can find a full chart showing the path of 45P/Honda-Mrkos-Pajdusakova on page 39. It passes close to the bright globular cluster M3 on 16 February, which will make a good photo opportunity. Comet C/2015 V2 Johnson is well positioned to the north of Boötes. This should brighten from 10th magnitude in February to mag. +6.7 during June, remaining well positioned over this period.



▲ The Earth casts its shadow across the face of the Moon on 10-11 Feb

INSIGHT ASTRONOMY PHOTOGRAPHER OF THE YEAR

WINNER
GALAXIES

M94: Deep Space Halo

Nicolas Outters, France

MARCH

Our Galaxy moves out of view to reveal a sea of others

KEY DATES

1 MARCH
A crescent Moon lies close to Mars and Uranus this evening

2 MARCH
Ganymede and its shadow transit Jupiter's disc between 22:39 UT and 04:02 UT on the 3rd

14 MARCH
A bright waning gibbous Moon rises close to Jupiter at around 20:45 UT

28-29 MARCH
Binocular comet 41P/Tuttle-Giacobini-Kresak is close to the star Dubhe in Ursa Major

31 MARCH
Don't miss the crescent Moon sitting close to the Hyades and Pleiades clusters

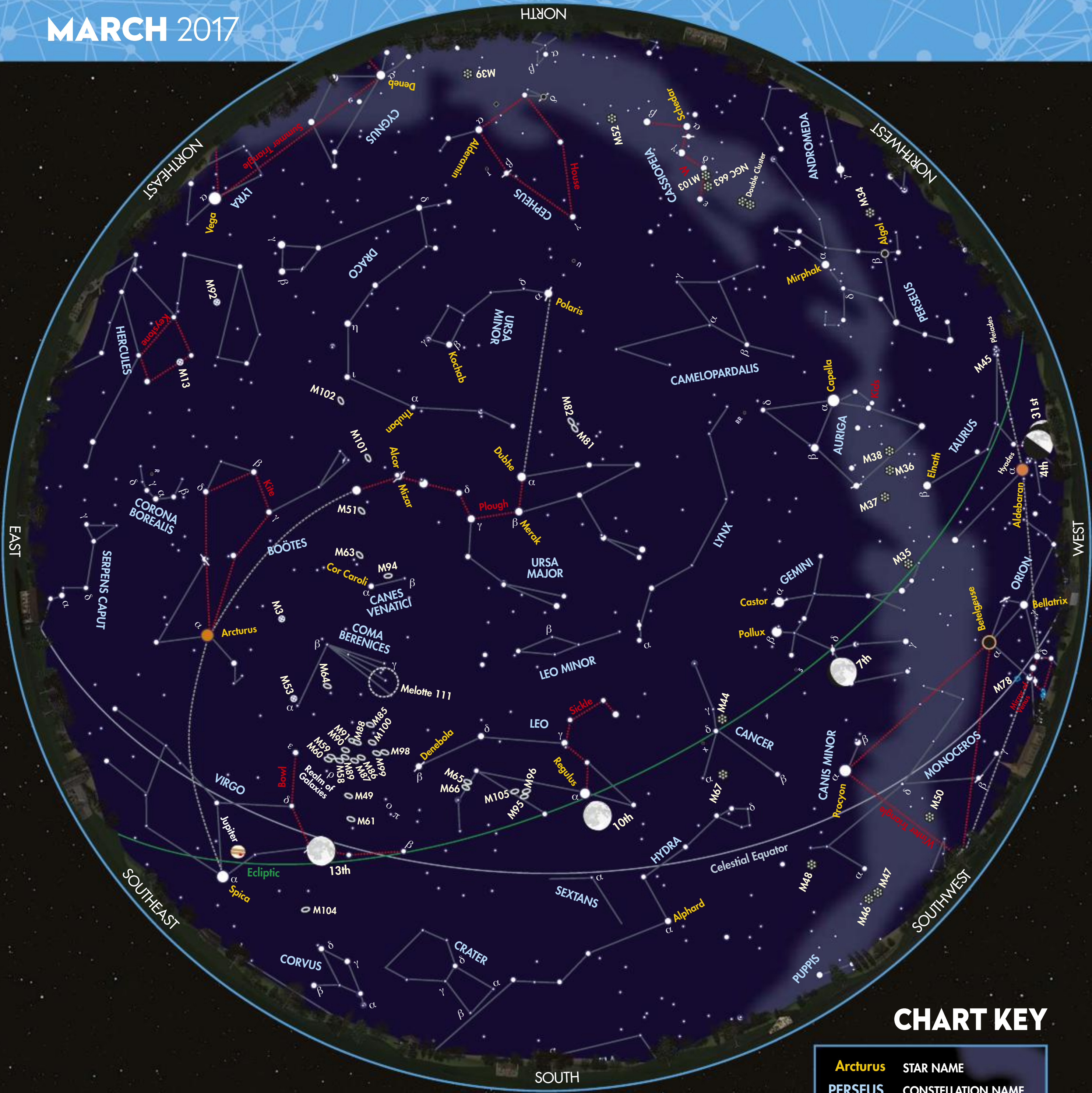


CHART KEY

Arcturus — STAR NAME
PERSEUS — CONSTELLATION NAME
GALAXY
OPEN CLUSTER
GLOBULAR CLUSTER
PLANETARY NEBULA
DIFFUSE NEBULOSITY
DOUBLE STAR
VARIABLE STAR
THE MOON (SHOWING PHASE)
COMET TRACK
ASTEROID TRACK
STAR-HOPPING PATH
METEOR RADIANT
Circlet — ASTERISM
MILKY WAY
PLANET
STAR BRIGHTNESS:
MAG. 0 & BRIGHTER, MAG. +1, MAG. +2, MAG. +3, MAG. +4 & FAINTER

MOON PHASES Key stages in the monthly cycle


FIRST QUARTER MOON
5 Mar


FULL MOON
12 Mar


LAST QUARTER MOON
20 Mar


NEW MOON
28 Mar

VISIBLE PLANETS Where to spot the planets this month

MERCURY
Very well placed in the evening sky from the middle of the month

VENUS
An evening planet at the start of March passing the Sun on 25th after which time it's a morning object

MARS
An evening planet with the Moon nearby on 1 and 30 Mar

JUPITER
Well positioned in Virgo and approaching opposition, which occurs next month

SATURN
A morning planet, low in the constellation of Sagittarius

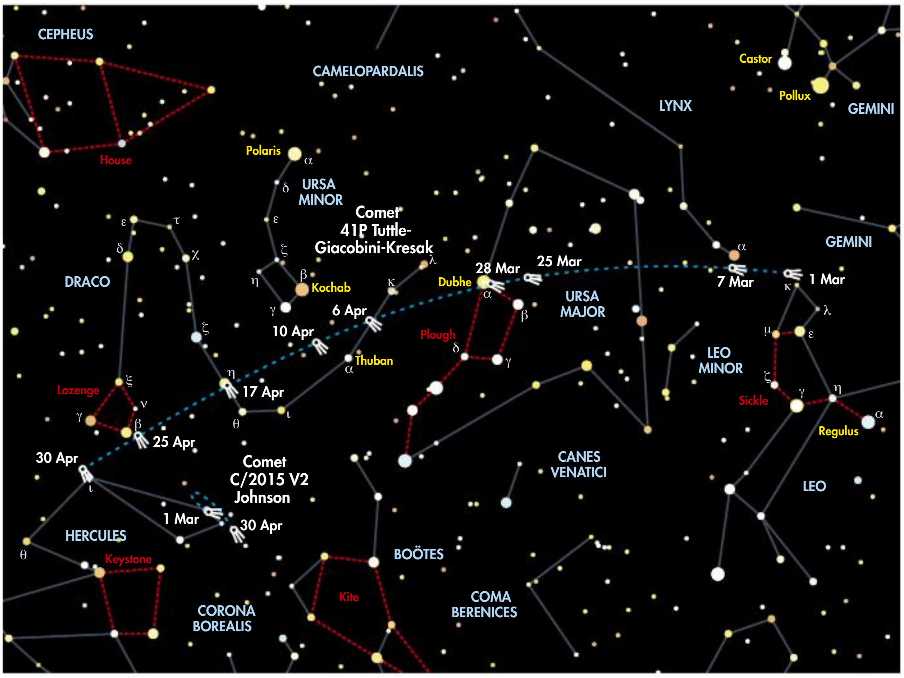
URANUS
An evening planet that is lost from view by the end of the month

NEPTUNE
Not visible this month as it's in conjunction with the Sun on 2 Mar

PETE LAWRENCE X 3

MARCH at a glance

See distant galaxies with the Milky Way out of view



▲ Comet 41P/Tuttle-Giacobini-Kresak crosses the night sky during March and April

The stars of winter gracefully give way to the subtler constellations of spring during March. At the time of our chart Leo, the Lion rides high in the sky. This is one of the rare constellations that actually resembles what its name suggests, in this case a lion facing west. The most distinctive pattern here is the backward question mark shaped 'Sickle' that represents Leo's head and mane. The bright star Regulus sits at the base of the Sickle.

Leo's body is more or less rectangular, heading east from the Sickle. The lion is completed by the star Denebola marking the tip of the tail. In legend Leo's tail was originally more extensive but reassigned to become Coma Berenices, or Queen Berenice's Hair; you can see the hair off to the east of Leo. The stars here are intriguing as much of Coma Berenices is made up of the triangular open cluster Melotte 111. The cluster stars sit on the edge of vision flitting in and out of view.

The crescent Moon cosies up to the Hyades and Pleiades clusters at the end of the month

Running below Leo is the long and difficult to make out form of Hydra, the Watersnake. This is a huge constellation measuring 85° from head to tail. As it slithers into view a number of small constellations appear to ride on its back. Least distinctive and first to appear is Sextans, the Sextant. The main form of this constellation consists of three rather faint stars that aren't terribly easy to pick out. Crater, the Cup is easier to define but by no means bright, located south of Leo's back leg. The most eye-catching is Corvus, the Crow. The four brightest stars of this constellation form a quadrilateral pattern also known as the Sail.

Galaxies gather

Leo is known for several attractive groups of relatively bright galaxies. Midway under the body of the lion are M95, M96 and M105. A better known group is formed from M65, M66 and NGC 3628. Collectively these are known as the Leo Triplet. You'll need a telescope to spot most of these, although M65 and M66 are visible through binoculars.

The disc of the Milky Way rotates out of the way during spring, allowing us to look out at right angles to its plane and into deep space. Here, instead of the myriad of distant stars that produce the Milky Way, we can now see more distant galaxies. The Zodiacal constellation to the east of Leo is Virgo and inside a large semi-circular asterism known as the Bowl of Virgo is a region known as the Realm of Galaxies.

Here you're looking into the heart of several huge galaxy clusters and the number of galaxies in this region is high. You'll need a telescope to spot them but it's definitely worth taking time out to investigate the many Messier and NGC galaxies that pepper the region.

March is a great time to try and find brightening comet 41P/Tuttle-Giacobini-Kresak. It starts the month off to the north of the Sickle at magnitude +10.0. This comet will be visible for quite a while, reaching its peak magnitude of +6.7 around 10 April. Also, don't miss the beautiful spring sight of the crescent Moon close to the Hyades and Pleiades open clusters in Taurus on 31 March.

The Northern Hemisphere's spring equinox occurs on 20 March at 10:29 UT.

"A telescope brings out the true beauty of M35, revealing many of its 400+ members"

Stats

NAME AND CATALOGUE REFERENCE: **Messier 35**
CONSTELLATION: **Gemini**
OBJECT TYPE: **Open cluster**
VISUAL BRIGHTNESS: **Mag. +5.1 (naked eye)**
DISTANCE: **2,800 lightyears**
APPARENT SIZE: **28 arcminutes**
PHYSICAL SIZE: **24 lightyears across**
BEST TIME TO SEE: **1 Jan 23:30 UT. 1 Feb 21:30 UT. 1 Mar 20:00 UT**

A relatively young cluster at a mere 100 million years old, means there's still dust left behind from the collapse of the cloud that formed M35, which can make it appear as a hazy patch

SEASONAL TARGETS
WINTER

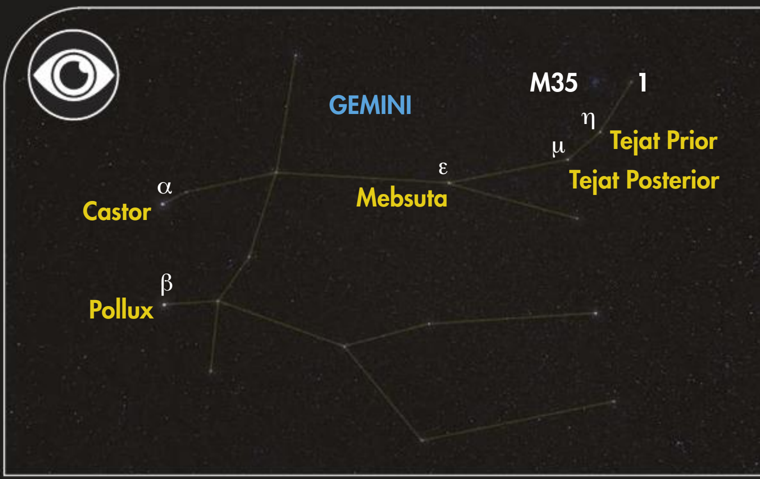
M35

Open cluster in Gemini

A hazy patch at the foot of one of the twins becomes a triangular formation filled with stars as you get a better view

NAKED EYE The view from the ground

Messier 35 is an open cluster in Gemini close to the foot of the twin Castor. The top of Castor's legs begin at mag. +3.0 Epsilon (ε) Geminorum or Mebsuta. Proceed down the right leg to mag. +2.8 Mu (μ) Geminorum or Tejat Posterior. Head west by 1.5° to mag. +3.3 Eta (η) Geminorum or Tejat Prior, also known as Propus. Finally, locate mag. +4.2 1 Geminorum, a star, which incidentally is occulted by the Sun during the June solstice. M35 can be found 1.5° to the northeast of 1 Geminorum. The cluster marks the right angle in a right-angled triangle that has Eta and 1 Geminorum as its hypotenuse. M35 is on the threshold of naked-eye visibility but should be visible on a clear, dark night as a hazy patch.

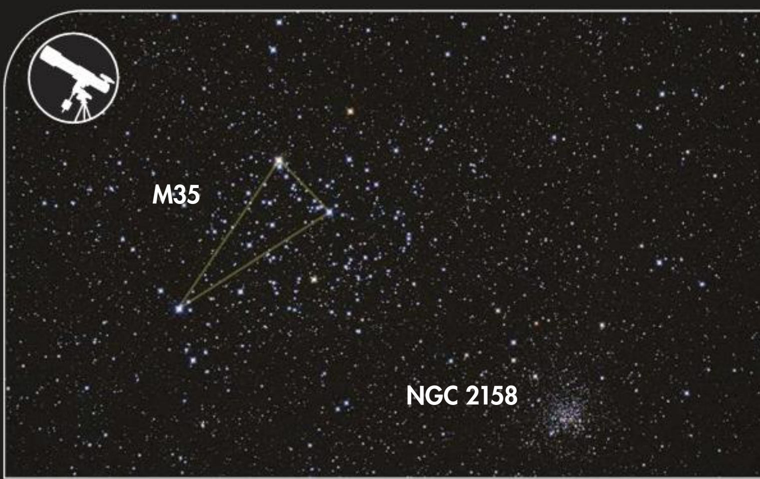


BINOCULARS Getting a closer look

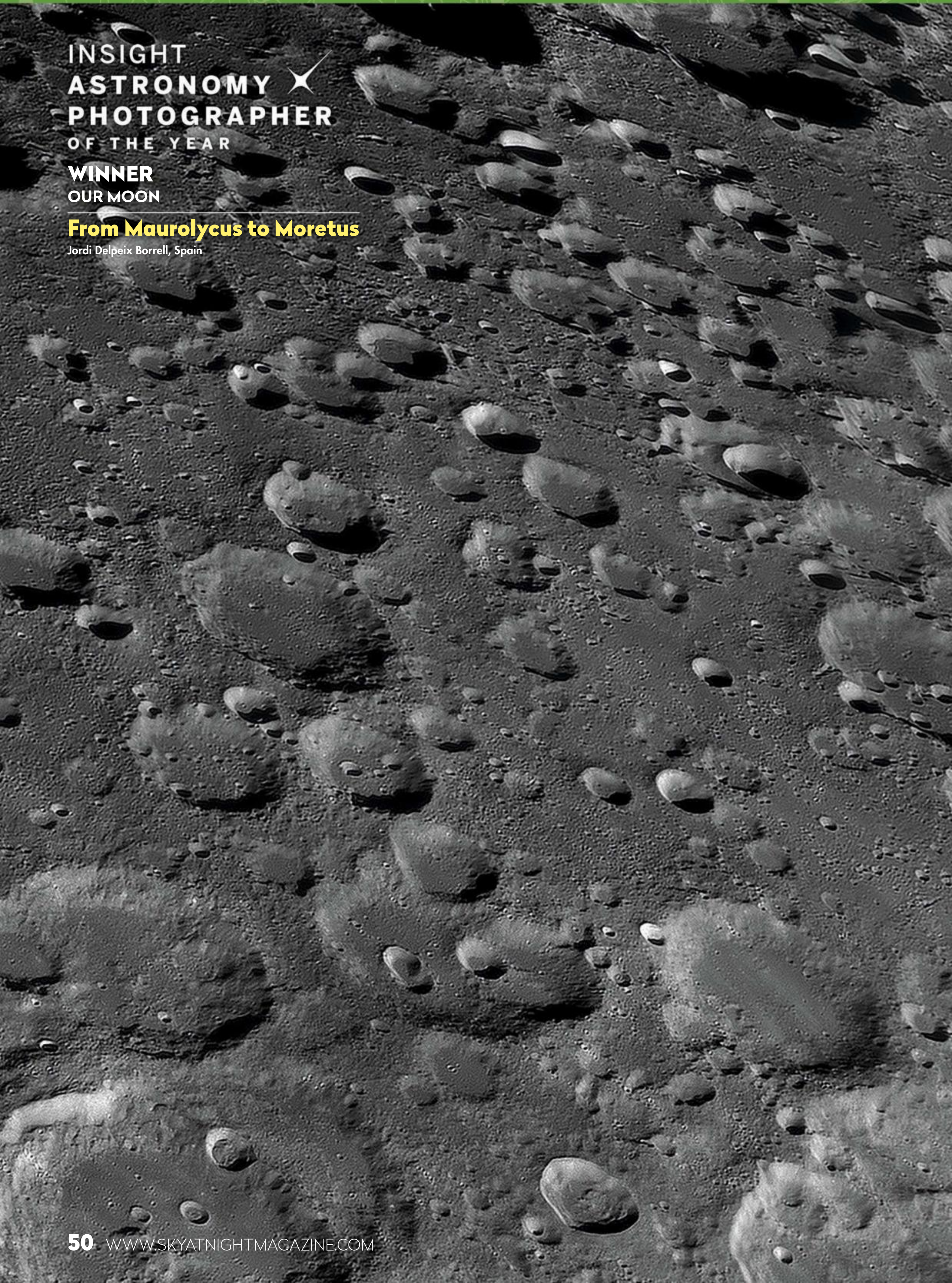
Despite having a large apparent diameter of half a degree, about the same as the full Moon, many of the stars of M35 sit at a brightness threshold, which subdues their appearance through binoculars. This has the effect of reducing the cluster's overall impact, especially if there's any light pollution around. Magnitude +5.8 5 Geminorum sits half a degree east of the cluster and acts as a good visual anchor. The two brightest stars close to the core are of magnitudes +7.4 and +8.2 with a third mag. +7.6 star visible to the southeast. Most of the other cluster stars reside in a region roughly between these three, spilling over to the west. A general haze permeates the region but it's easily lost with increased light pollution.

TELESCOPE Seeing all the detail

A telescope brings out the true beauty of M35, revealing many of its 400+ members. Start with a low-power eyepiece, increasing magnification gradually to get the best view. The triangular framework is enhanced by two mag. +8.5 orange stars nearby. A string of faint stars passes between the two northern stars. This is complemented by a less obvious line of stars from the southern point of the triangle towards the west-northwest. Both strings appear to converge at a small, faint arc pattern to the west. Also look out for the fainter, mag. +8.6, open cluster NGC 2158, located 25 arcminutes southwest of the centre of M35. This cluster is over five times more distant than M35, hence its more compact appearance.



ISTOCK, PETE LAWRENCE X 3



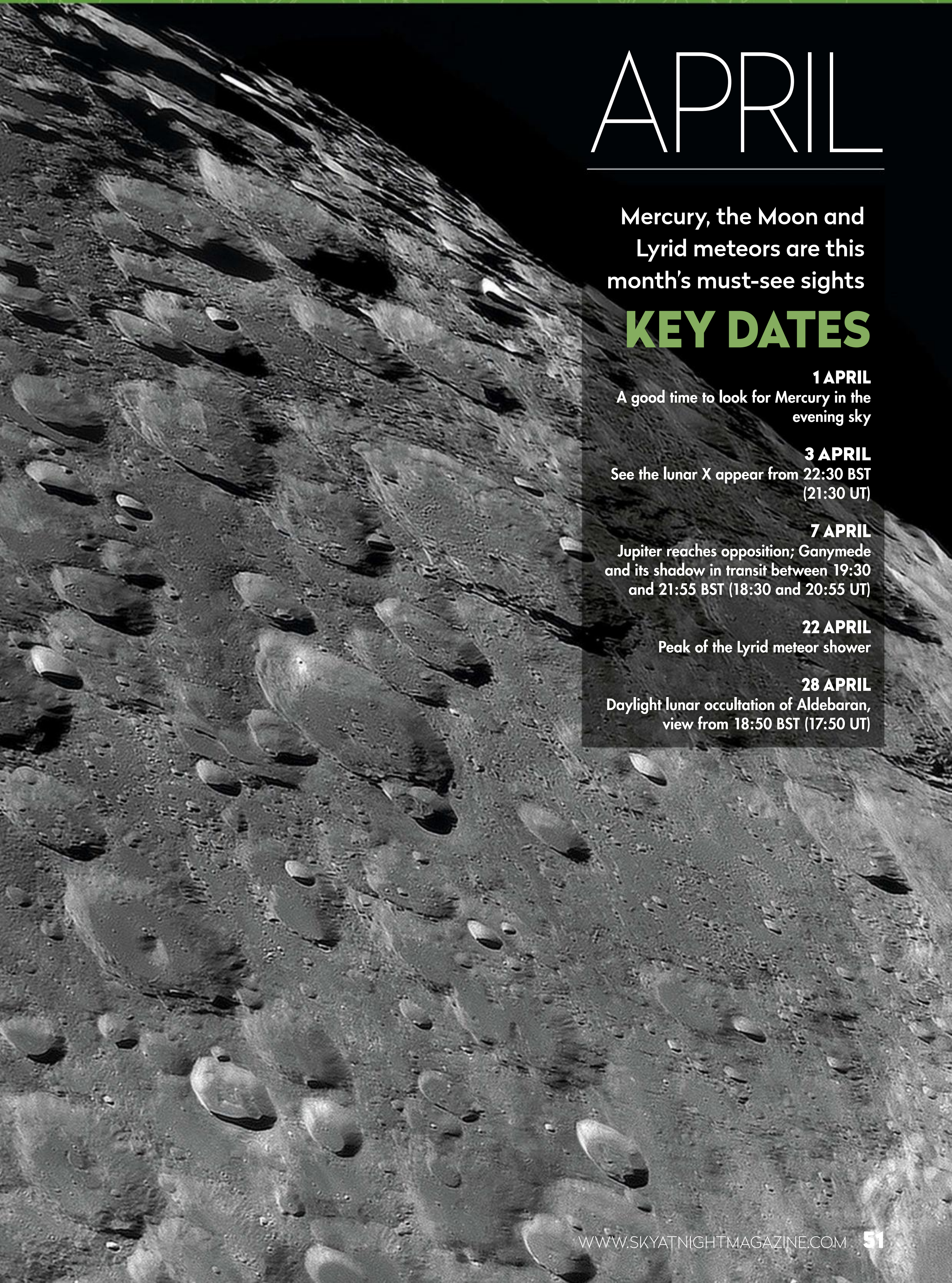
INSIGHT ASTRONOMY PHOTOGRAPHER OF THE YEAR

WINNER

OUR MOON

From Maurolycus to Moretus

Jordi Delpeix Borrell, Spain



APRIL

Mercury, the Moon and Lyrid meteors are this month's must-see sights

KEY DATES

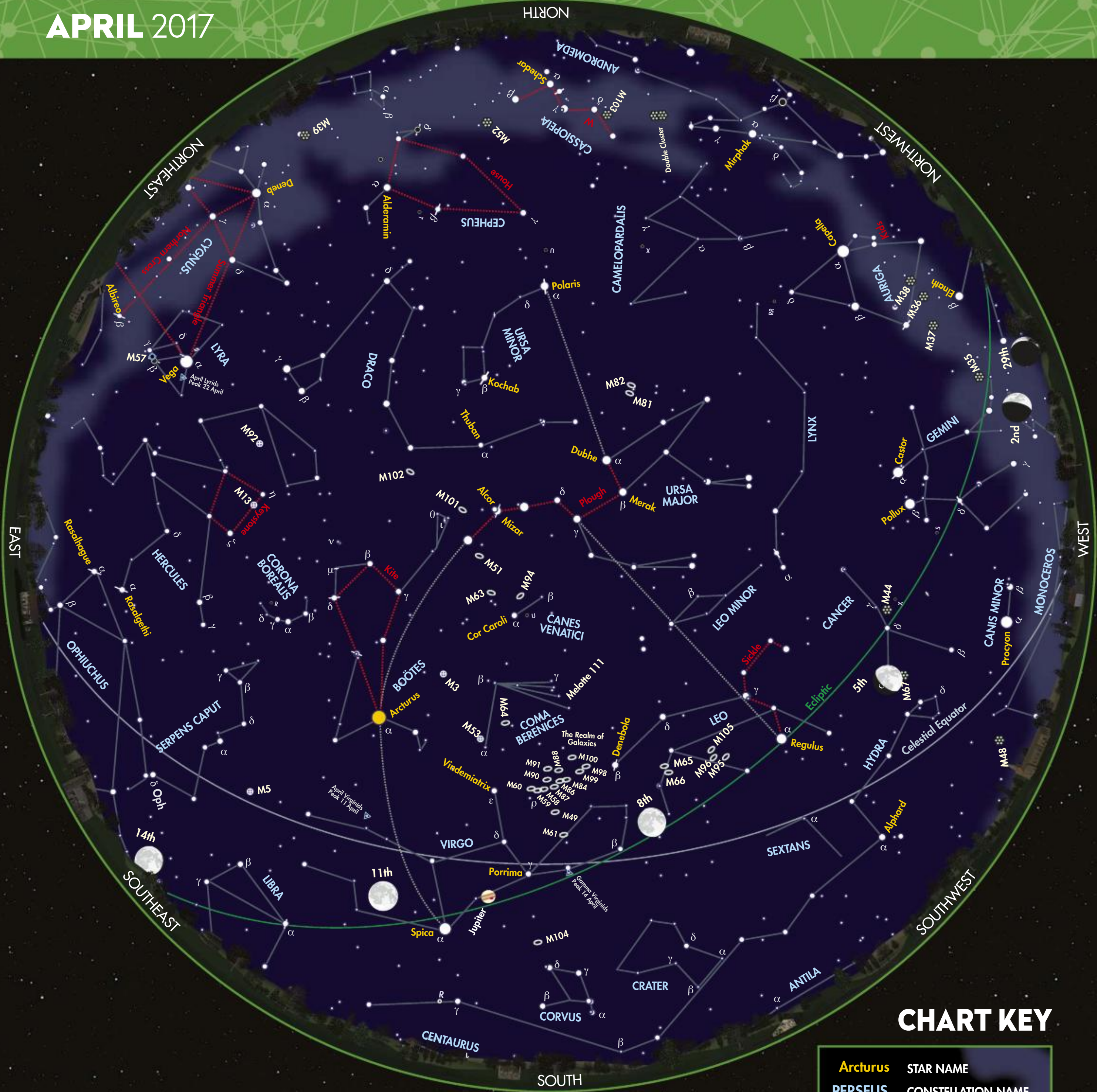
1 APRIL
A good time to look for Mercury in the evening sky

3 APRIL
See the lunar X appear from 22:30 BST (21:30 UT)

7 APRIL
Jupiter reaches opposition; Ganymede and its shadow in transit between 19:30 and 21:55 BST (18:30 and 20:55 UT)

22 APRIL
Peak of the Lyrid meteor shower

28 APRIL
Daylight lunar occultation of Aldebaran, view from 18:50 BST (17:50 UT)



MOON PHASES Key stages in the monthly cycle

FIRST QUARTER MOON 3 Apr

FULL MOON 11 Apr

LAST QUARTER MOON 19 Apr

NEW MOON 26 Apr

VISIBLE PLANETS Where to spot the planets this month

MERCURY
A well positioned evening planet at greatest eastern elongation on 1 Apr but invisible after the 10th

VENUS
A morning object best seen around 12 Apr

MARS
An evening planet not particularly well positioned

JUPITER
Best time to view, reaching opposition on 7 Apr. Moon appears close on 10 Apr

SATURN
Morning planet in Sagittarius with the ring system nicely presented

URANUS
In conjunction with the Sun on 14 Apr and not visible this month

NEPTUNE
Not visible this month

PETE LAWRENCE X 3

CHART KEY

Arcturus — STAR NAME
PERSEUS — CONSTELLATION NAME
GALAXY
OPEN CLUSTER
GLOBULAR CLUSTER
PLANETARY NEBULA
DIFFUSE NEBULOSITY
DOUBLE STAR
VARIABLE STAR
THE MOON (SHOWING PHASE)
COMET TRACK
ASTEROID TRACK
STAR-HOPPING PATH
METEOR RADIANT
Circlet — ASTERISM
MILKY WAY
PLANET

STAR BRIGHTNESS:
MAG. 0 & BRIGHTER, MAG. +1, MAG. +2, MAG. +3, MAG. +4 & FAINTER

APRIL at a glance

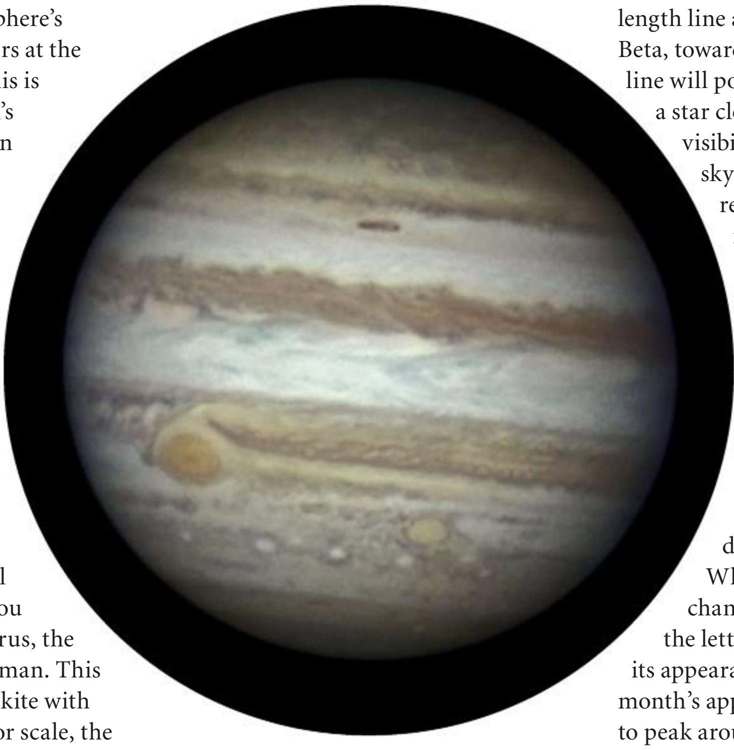
X marks the spot on the Moon and Lyra the radiant for meteors

The Northern Hemisphere's spring equinox occurs at the end of March and this is a time when the Sun's apparent increase in declination is changing at its fastest for the year. Consequently, the period of daylight gets longer and the nights get noticeably shorter. This is most apparent during the month of April.

Let's start our look at the April sky by first locating the Plough, which to modern eyes resembles a saucepan and is almost overhead during the early evening. Follow the handle away from the pan maintaining its natural arc as you go. This will bring you to the bright orange star Arcturus, the alpha star of Boötes, the Herdsman. This constellation resembles a large kite with Arcturus at the sharper end. For scale, the kite is as high as the Plough is long.

Continue the arc through Arcturus to eventually arrive at brilliant white Spica, the brightest star in Virgo, the Virgin. Virgo is a large and sprawling constellation. Its most distinctive pattern is an asterism known as the Bowl of Virgo, resembling a semi-circle of medium-bright stars. Currently, bright Jupiter can be seen south and slightly to the east of the bowl.

Inside and to the north of the Bowl is a region of sky known as the Realm of Galaxies. A small telescope will show numerous examples of the hundreds of galaxies that litter this region. Go north from the Bowl to arrive at Coma Berenices or Queen Berenice's hair, a largely faint constellation notable because part of it is made up of the triangular open cluster known as Melotte 111. On a clear, dark night the cluster sparkles as the faint stars that constitute it appear to jump in and out of view.



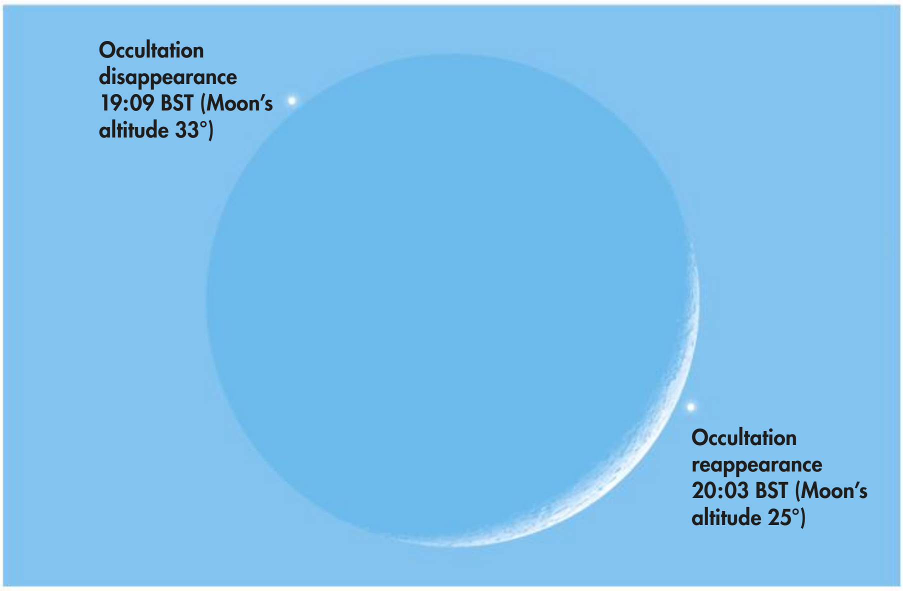
▲ Jupiter and its distinctive spot can be seen near to the Bowl of Virgo during April

Going to the dogs

Between Coma Berenices and the Plough lies Canes Venatici, the Hunting Dogs. This is a small constellation represented by two main stars; Cor Caroli the alpha star and Chara the beta star. Despite its seemingly diminutive size, the boundaries of Canes Venatici contain some superb deep-sky objects. Here the list includes M51, the Whirlpool Galaxy, and the impressive globular cluster M3, which lies at the mid-point of a line drawn between Cor Caroli and Arcturus. Imagine a line from Alpha (α) to Beta (β) Canum Venaticorum. Draw a similar length line at right-angles to this from Beta, towards the Plough. The end of this line will point at Y Canum Venaticorum, a star close to the limit of naked-eye visibility from an average dark-sky site. Point a telescope at it to reveal its true beauty as a very red-coloured star. Its informal name is La Superba and when you see it through the eyepiece you'll realise why.

If it's clear on 3 April around 22:30 BST (21:30 UT) take a look at the Moon's terminator, approximately one-quarter of the way up the Moon's diameter from the south. What you're looking for is a chance illumination that resembles the letter X. Known as the 'lunar X', its appearance is short lived. This month's appearance of the X is set to peak around 00:20 BST on 4 April (23:20 UT, 3 April).

The Lyrid meteor shower peaks on 22 April and with the Moon largely out of the way, this is a good time to look for Lyrid meteors. The shower has a ZHR of 18 meteors per hour but this can vary considerably. If the sky is very clear on 28 April use a telescope to see if you can catch the crescent Moon moving in front of the star Aldebaran in broad daylight.



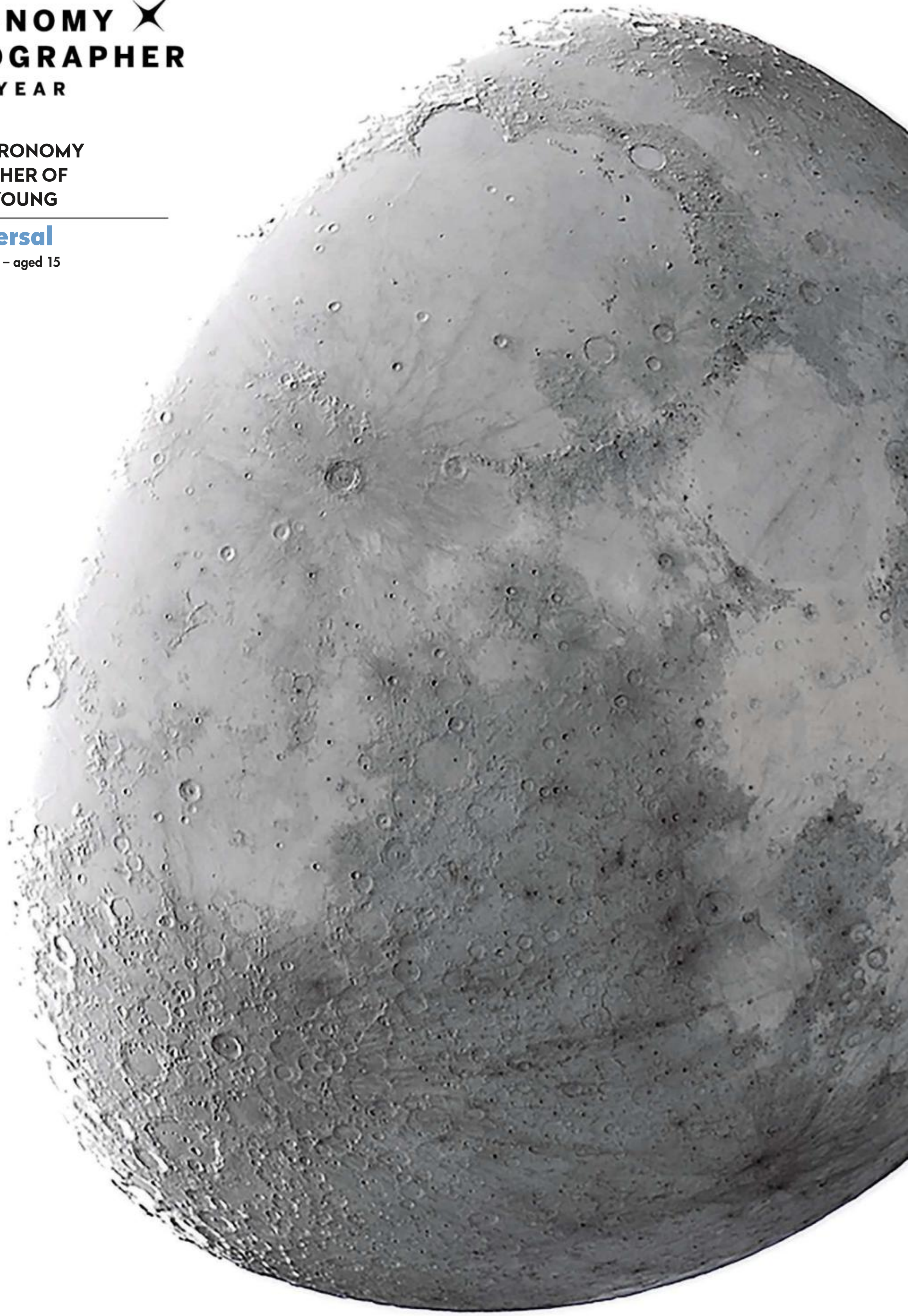
▲ Daylight lunar occultation of Aldebaran, 28 April 2017. Times correct for centre of UK, aim to observe at least 15 minutes before

INSIGHT ASTRONOMY PHOTOGRAPHER OF THE YEAR

WINNER
INSIGHT ASTRONOMY PHOTOGRAPHER OF THE YEAR – YOUNG

Lunar Reversal

Brendan Devine, USA – aged 15



MAY

Libra bears its claws this month and Venus puts in a daytime appearance

KEY DATES

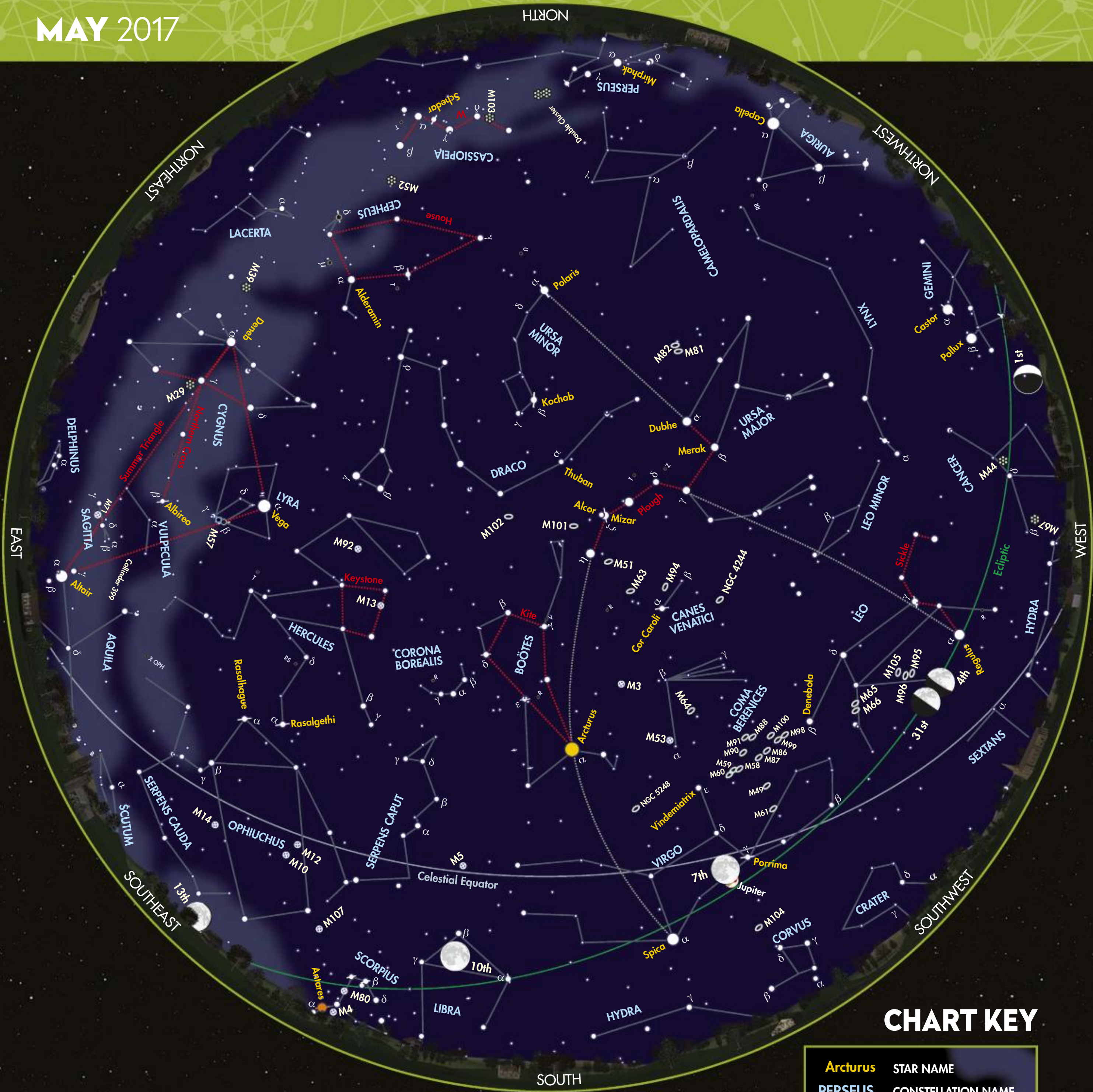
1 MAY
Favourable libration for the east and northeast limb of the Moon

5 MAY
Peak of the Eta Aquariid meteor shower (ZHR 50 meteors per hour)

21 MAY
Time to start looking for noctilucent cloud displays (see p61)

22 MAY
A 16% lit waning crescent Moon paves the way to finding Venus during the day

31 MAY
A 41% lit waxing crescent Moon lies close to Regulus in the daytime sky



MOON PHASES Key stages in the monthly cycle


FIRST QUARTER MOON
3 May

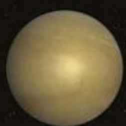

FULL MOON
10 May


LAST QUARTER MOON
19 May


NEW MOON
25 May

VISIBLE PLANETS Where to spot the planets this month


MERCURY
Reaches its greatest western elongation on 17 May, but not well placed this month


VENUS
A bright morning object, rising 90 minutes before the Sun by the end of the month


MARS
An evening object gradually becoming lost from view in the dusk twilight


JUPITER
Well positioned at the start of the month but losing ground to the short nights by the end of May


SATURN
Morning object visible to the northwest of the Teapot asterism in Sagittarius


URANUS
A morning object not well positioned and never appearing in true darkness all month


NEPTUNE
Not visible this month

PETE LAWRENCE X 3

CHART KEY

- Arcturus — STAR NAME
- PERSEUS — CONSTELLATION NAME
- GALAXY
- OPEN CLUSTER
- GLOBULAR CLUSTER
- PLANETARY NEBULA
- DIFFUSE NEBULOSITY
- DOUBLE STAR
- VARIABLE STAR
- THE MOON (SHOWING PHASE)
- COMET TRACK
- ASTEROID TRACK
- STAR-HOPPING PATH
- METEOR RADIANT
- Circlet — ASTERISM
- MILKY WAY
- PLANET

STAR BRIGHTNESS:
MAG. 0 & BRIGHTER, MAG. +1, MAG. +2, MAG. +3, MAG. +4 & FAINTER

MAY at a glance

Shorter nights mean you have to pack more into less time

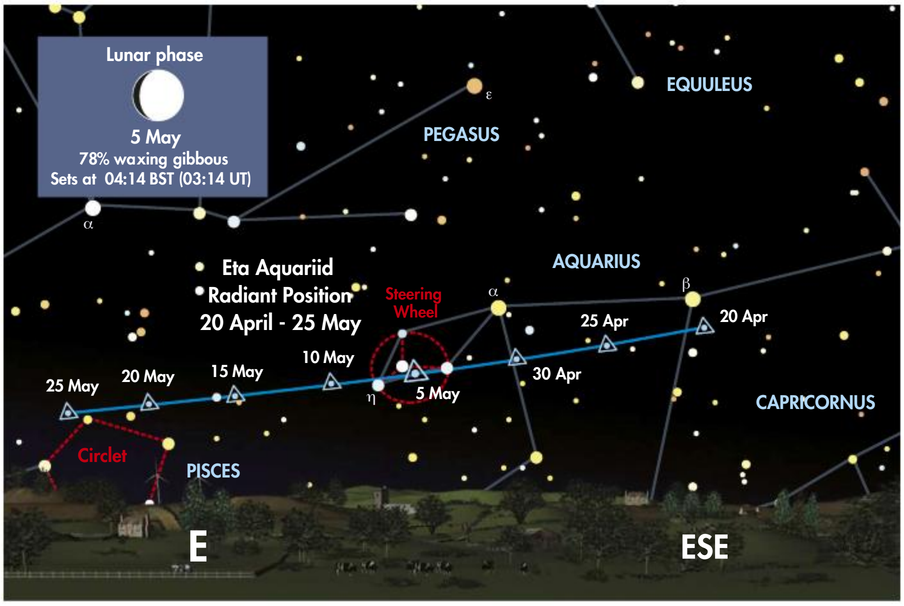
May, June and July are challenging months for astronomy because the nights aren't very long. August also suffers from this but there's something comforting about the fact that the nights are gradually getting longer.

The bright orange star Arcturus dominates the view to the south in our May chart. This is the brightest star in the constellation of Boötes, the Herdsman. When Arcturus is due south, Boötes is almost vertical in the sky. Look east of its eastern 'shoulder' to locate a semi-circle of stars known as Corona Borealis, the Northern Crown. The brightest star in this celestial arc is Gemma.

Draco, the Dragon, sits between Boötes and Polaris, the North Star. The dragon winds itself around the constellation of Ursa Minor, the Little Bear, which has Polaris as its alpha star. Draco's winding body ends with a pattern of four stars representing the dragon's head. This pattern is known as the Lozenge.

The running man

Southeast of the Lozenge lies Hercules, the Strongman, a pattern of stars that on traditional charts looks like an upside-down stick figure running towards Boötes. At first glance, the star Rasalgethi appears to be the stick figure's right foot but actually turns out to be Hercules's head!



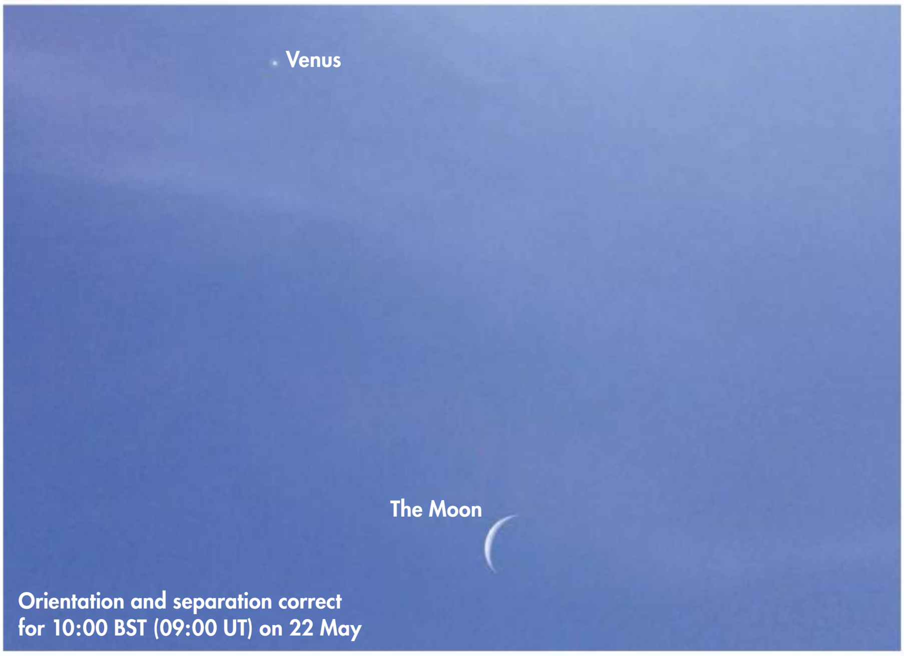
▲ The Steering Wheel, aka Water Jar, asterism crosses paths with the Eta Aquariids in early May

South of Boötes is Virgo, the second largest constellation in the sky. It takes the form of a large semi-circular bowl to the northwest joined to a roughly rectangular body. The stars forming the eastern side of the pattern are Mu (μ) Virginis to the south and 109 Virginis to the north. Both are of similar brightness, which is to say pretty dim. Further southeast is a pair of brighter stars, forming a 45° line – a strange description but the lack of anything else nearby makes it work.

These stars are part of Libra, the Scales. The upper star is Beta (β) Librae, or Zubeneschamali, and the southern is Alpha (α) Librae or Zubenelgenubi. These lovely sounding names translate as the Northern and Southern Claws, a reference to the fact that Libra was once part of Scorpius, which is just rising on our chart, southeast of Libra.

The Eta Aquariid meteor shower peaks on 5 May with a ZHR of around 50 meteors per hour, although this figure can vary. There's a bright 79% lit waxing gibbous Moon up during peak night but this is low in the west as the shower radiant rises around 02:30 BST (01:30 UT).

On 22 May, if you can locate the 16% lit waning crescent Moon in the daytime sky using just your eyes, it should be possible to find Venus nearby too. The Moon is due south around 10:00 BST (09:00 UT), with Venus located 4.2°, or 8 apparent Moon diameters, to the north-northeast of it – that's upper left as seen from the UK. Venus is very clear in daylight, as long as you have a way to find it. If you're successful, how about trying for a star in daylight? On 31 May at 16:00 BST (15:00 UT), look for the 41% lit waxing crescent Moon 40° up in the southeast. Using binoculars or a telescope at low magnification, it should be possible to see Regulus an apparent Moon diameter from the Moon's northern crescent cusp.



INSIGHT ASTRONOMY PHOTOGRAPHER OF THE YEAR

WINNER
PEOPLE AND SPACE

City Lights

Wing Ka Ho, Hong Kong

JUNE

This month sees the strongman pointing the way to the serpent bearer

KEY DATES

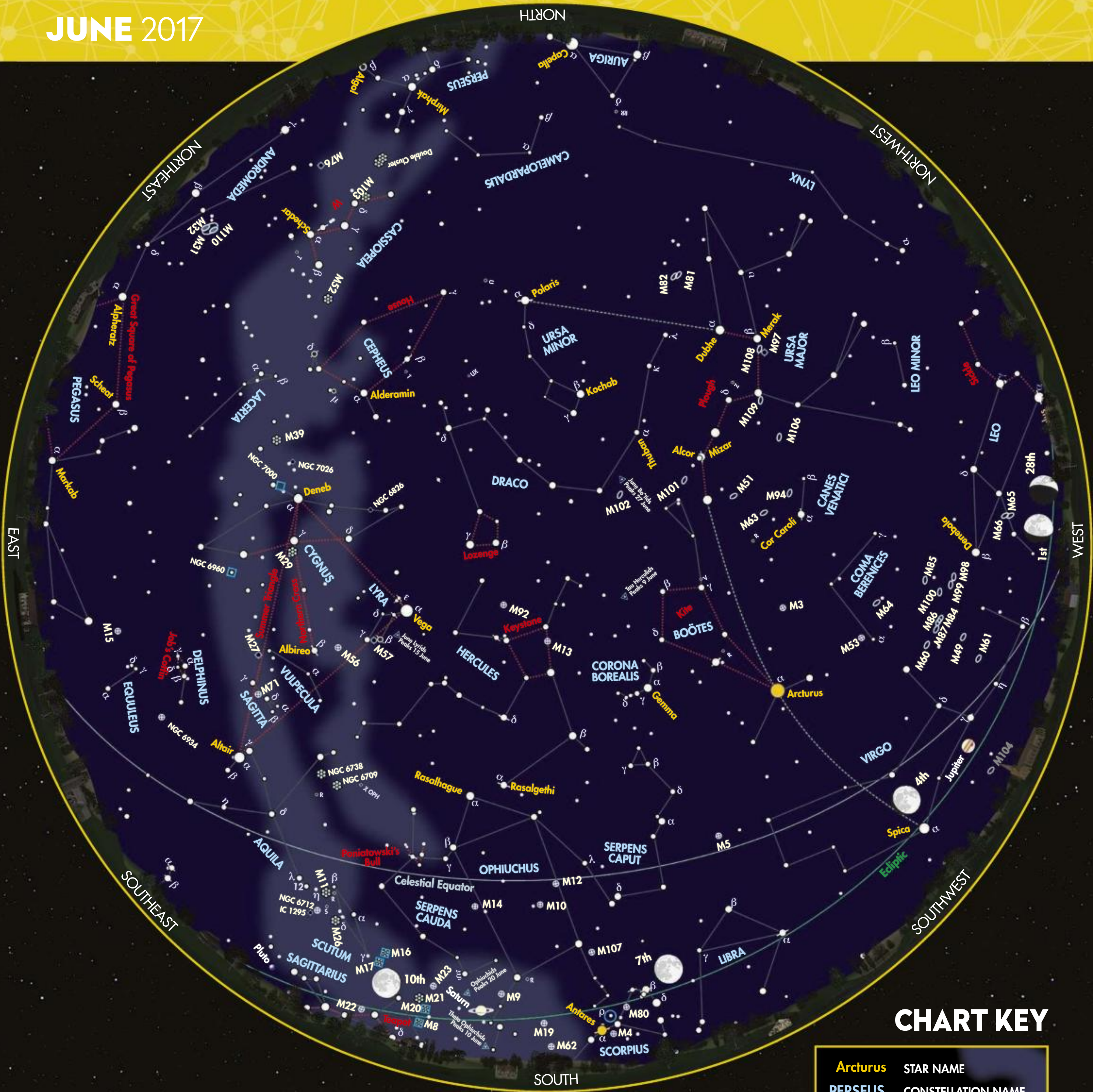
ALL MONTH
Now is the time to keep an eye out for displays of noctilucent clouds

1-15 JUNE
Comet C/2015 V2 Johnson will be at its peak magnitude of +6.7

1 JUNE
Look out for the Lunar X from 22:00 BST (21:00 UT)

3 JUNE
All four Galilean moons are close to Jupiter's disc at 22:30 BST (21:30 UT)

9 JUNE
The Moon illusion may make tonight's rising full Moon look huge



MOON PHASES Key stages in the monthly cycle


FIRST QUARTER MOON
1 Jun

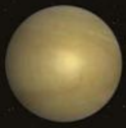

FULL MOON
9 Jun


LAST QUARTER MOON
17 Jun


NEW MOON
24 Jun

VISIBLE PLANETS Where to spot the planets this month


MERCURY
Moves to the evening sky after superior conjunction on 21 Jun


VENUS
Morning planet that reaches greatest western elongation on 3 Jun


MARS
Can't be seen this month as it's an evening object too close to the Sun


JUPITER
Evening planet best at the start of Jun with the Moon close by on 3 and 30 Jun

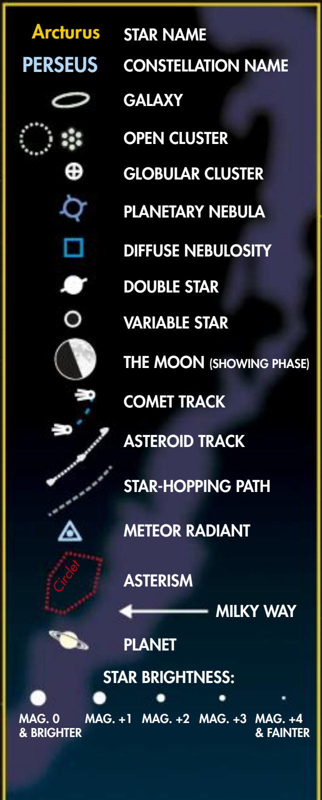

SATURN
Reaches opposition on 15 Jun when it will appear at its best for 2017


URANUS
Uranus is a morning object not very well positioned at present


NEPTUNE
Morning planet best seen low in the east-southeast at the end of the month

PETE LAWRENCE X 3

CHART KEY



JUNE at a glance

Dawn and dusk display the effects left by meteors on Earth's sky

Noctilucent clouds can be seen floating in the upper reaches of the mesosphere during June

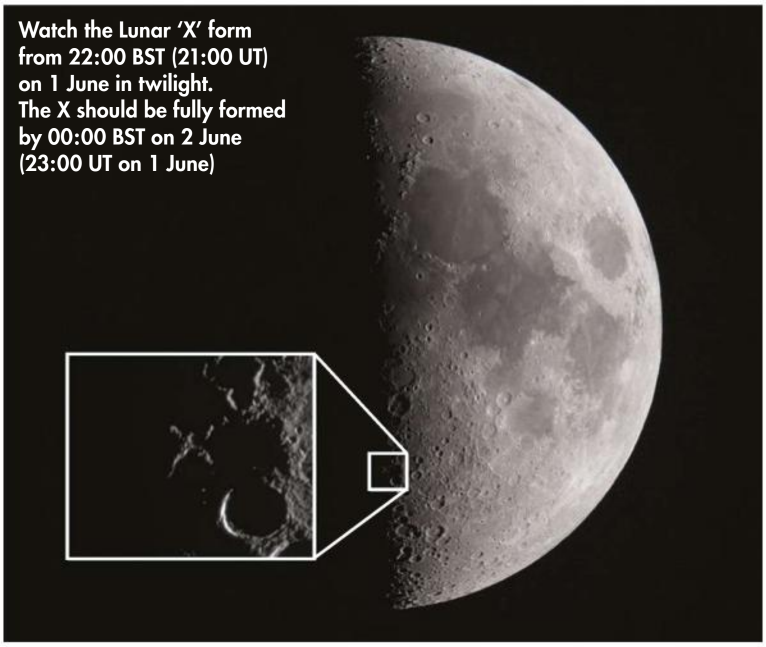
The Sun reaches one of this year's two solstices on 21 June, a point where the rate the Sun changes declination in the sky is zero. The June solstice is when the Sun is at its greatest north declination and is highest in the Northern Hemisphere's sky.

This means that UK nights are at their shortest so it's a tricky month for stargazing. In summer we get to see the Milky Way high in the sky. Its presence brings bright, distinct constellations containing some superb deep-sky objects. During June, this starscape lies to the east of the meridian at the time of our chart. Centre stage is the late-spring constellation of Hercules, a large and sprawling group of stars with the distinctive Keystone pattern lying at its centre.

The Keystone is a useful locator for one of the Northern Hemisphere's brightest globular clusters, M13, the Great Globular in Hercules. This magnificent object can just be seen with the naked eye under dark-sky conditions. Through binoculars it looks like a fuzzy star but its true majesty is revealed through the eyepiece of a telescope. It's estimated that there are between 100,000 and 1,000,000 stars in M13, all gravitationally bound in a sphere 145 light years across.

Hercules's head is at the bottom of the constellation, marked by the star Rasalgethi. Rasalgethi sits near another 'head' star called Rasalhague, representing the head of Ophiuchus, the Serpent Bearer. Ophiuchus is rectangular with a squat triangle on top and although it's a large constellation, it's difficult to make out.

Being a bearer of serpents, Ophiuchus is depicted carrying the snake Serpens. This is a unique constellation because it is split in two. To the east of Ophiuchus lies Serpens Cauda, the Serpent's Tail, with Serpens Caput, the Serpent's Head, to the west. Below Ophiuchus is the beautiful orange star Antares located at the heart of Scorpius. Saturn can currently be seen in the southeast corner of Ophiuchus, looking slightly yellow when compared with orange Antares.



Watch the Lunar 'X' form from 22:00 BST (21:00 UT) on 1 June in twilight. The X should be fully formed by 00:00 BST on 2 June (23:00 UT on 1 June)

High-flying clouds

June and July are the best months for spotting noctilucent clouds. These are the highest clouds on the planet, being 76-85km up. They're thought to form when water freezes around the tiny particulates left after a meteor vaporises in the atmosphere. They can typically be seen 90-120 minutes after sunset, low in the northwest or a similar time before sunrise low in the northeast. Bright displays may last all night passing from the northwest to the northeast as they track the position of the Sun below the horizon.

It's also worth looking out for comet C/2015 V2 Johnson as it tracks from Boötes down into Virgo this month. The comet should be at its highest predicted magnitude of +6.7 during the first half of June making it a good binocular target.

Finally, turn a telescope on the Moon on 1 June to try and spot the letter X roughly one-quarter of the way up the Moon's disc along the terminator from its southern limb. The X forms when sunlight catches sections of the rims of craters Blanchinus, La Caille and Purbach.

“The thin streak of M82 seen with smaller insutruments is awash with fine mottled structure”

Stats

NAME AND CATALOGUE REFERENCE: Messier 81 and 82
CONSTELLATION: Ursa Major
OBJECT TYPE: Galaxy pair
VISUAL BRIGHTNESS: Mag. +6.9/8.4 (binoculars)
DISTANCE: 12 million lightyears
APPARENT SIZE: 21x10 and 9x4 arcminutes
PHYSICAL SIZE: 95,000 & 37,000 lightyears diameter

This pair of galaxies provides gloriously contrasting sights, with clear differences in their shapes and the amount of discernable structure

M81/M82

Bode's Galaxy and the Cigar Galaxy

With the right equipment and light conditions you can fit two striking galaxies in one eyepiece view

BINOCULARS Getting a closer look

Messier 81 and 82 are a pair of relatively bright galaxies near the Plough. Find them by drawing a diagonal line from the star in the southeast of the ploughshare, mag. +2.4 Gamma (γ) Ursae Majoris, or Phecda, through the star in the northwest corner, mag. +1.8 Alpha (α) Ursae Majoris, or Dubhe. Extend this line for the same distance again and both galaxies should be in the field of a pair of binoculars (light pollution and binocular size will make a difference). M81, or Bode's Galaxy, should be the most obvious, appearing as an oval smudge. M82 can be harder to pick out, being both smaller and fainter than M81. Larger binoculars fare better – a 15x70 pair will show both objects well.

SMALL TELESCOPE Get more detail

A small telescope reveals both galaxies well. Despite their proximity on charts, they're 36 arcminutes apart and it's fairly common to see one galaxy while the other is out of view. Using a low power with which the Moon takes up less than 80% of the field of view will give you a decent view of both galaxies together. M81 has a star-like core around which the galaxy's central bulge appears as a glowing elliptical haze. Use a magnification of 50x or more to see its delicate spiral arms. Despite being dimmer, M82's more compact nature helps define it and its thin, linear appearance is most evident. A 100mm telescope should reveal the effects of dark lanes crossing M82.

LARGE TELESCOPE See it all

Large telescopes show the beauty of this pair. The core of M81 appears bright and extensive but doesn't show much visual structure. Increase power to study the knotted, tightly wound spiral arms. Powers between 150-250x work well but pull back if detail gets lost. The spiral arms should appear mottled with reasonable contrast at their edges. M82 is completely different. Here, the thin streak seen with smaller instruments is awash with fine mottled structure. This creates a broken, irregular appearance that's fascinating to study. Unlike M81, M82 doesn't appear to have an easily identifiable core. But the galaxy's central section has more prominence as the non-core sections appear to blend into the black background sky.

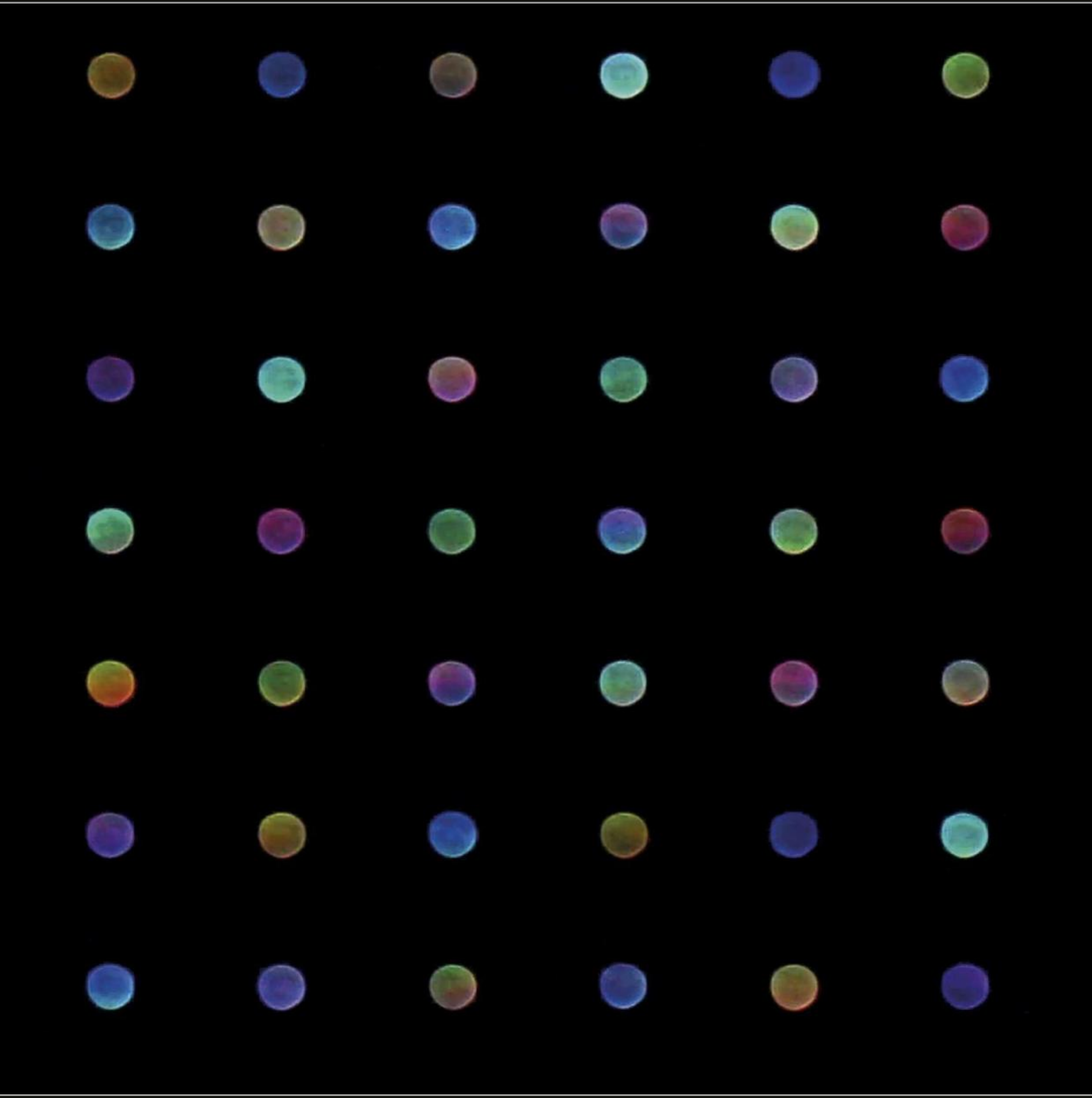
ROCHUS HESS/CCDGUIDE.COM, PETE LAWRENCE X 3

INSIGHT ASTRONOMY PHOTOGRAPHER OF THE YEAR

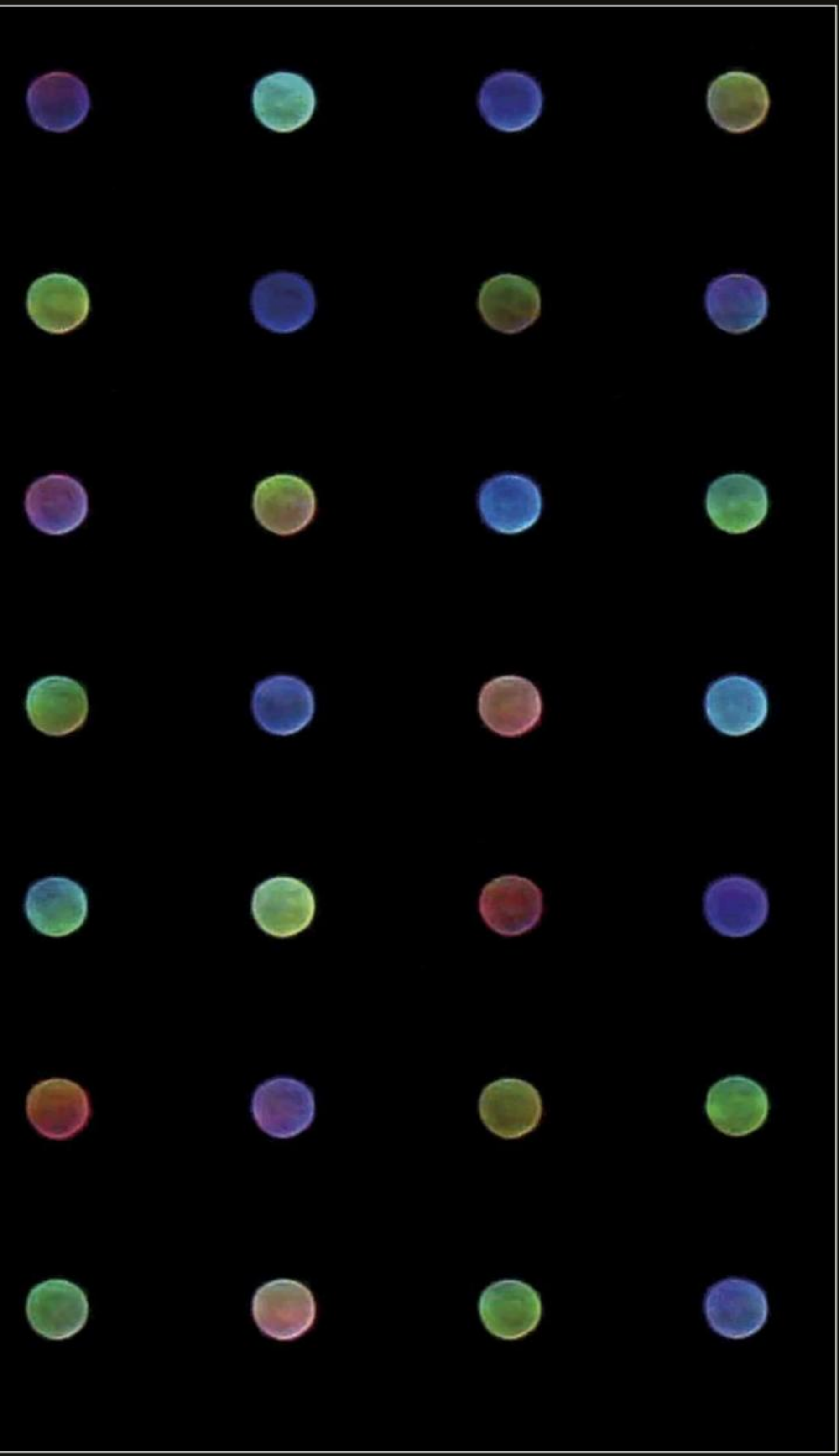
WINNER
STARS AND NEBULAE

The Rainbow Star

Steve Brown, UK



JULY



This month the Moon occults Mercury and the Milky Way dominates

KEY DATES

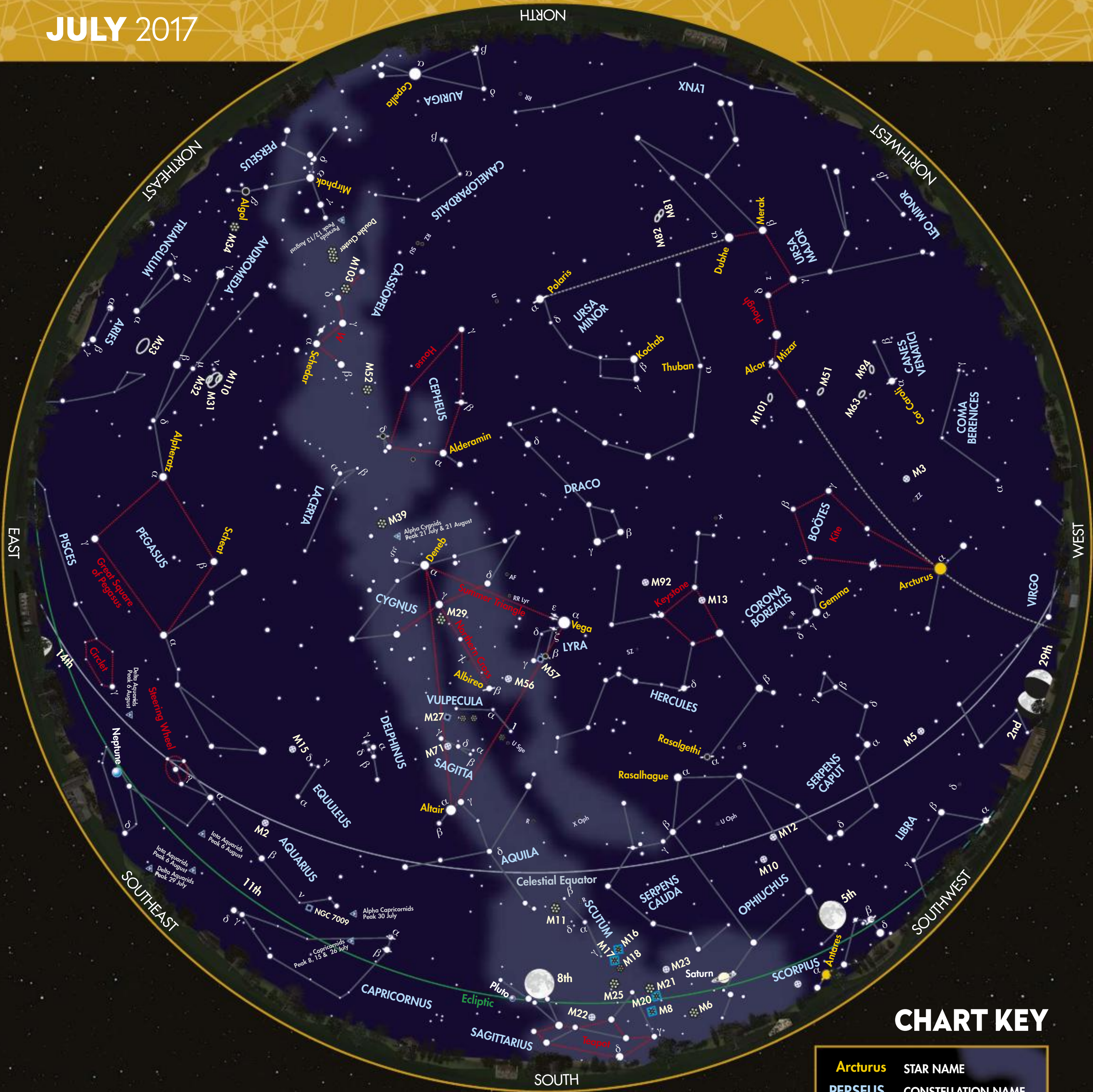
ALL MONTH
Noctilucent cloud season continues throughout the month

2 JULY
Minor planet 3 Juno reaches opposition in Scutum at mag. +9.8

10 JULY
Dwarf planet Pluto reaches opposition in Sagittarius at mag. +14.2

25 JULY
Mercury is occulted by the Moon in daylight

30 JULY
Peak of the Southern Delta Aquariid meteor shower, which has a ZHR of 25 meteors per hour



MOON PHASES Key stages in the monthly cycle


FIRST QUARTER MOON
1 Jul


FULL MOON
9 Jul

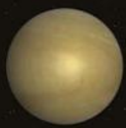

LAST QUARTER MOON
16 Jul


NEW MOON
23 Jul


FIRST QUARTER MOON
30 Jul

VISIBLE PLANETS Where to spot the planets this month


MERCURY
Evening planet, bright at the start of the month, reaches greatest eastern elongation on 29 Jul


VENUS
Morning planet 7° below the Pleiades on 5 Jul. Waning crescent Moon close on 20 and 21 Jul


MARS
Not visible as it is in conjunction with the Sun on 27 Jul


JUPITER
Evening planet now past its best for the year. Moon close on 1 and 28 Jul


SATURN
Low evening planet, close to its best for the year


URANUS
Improving morning planet just on the threshold of naked-eye visibility

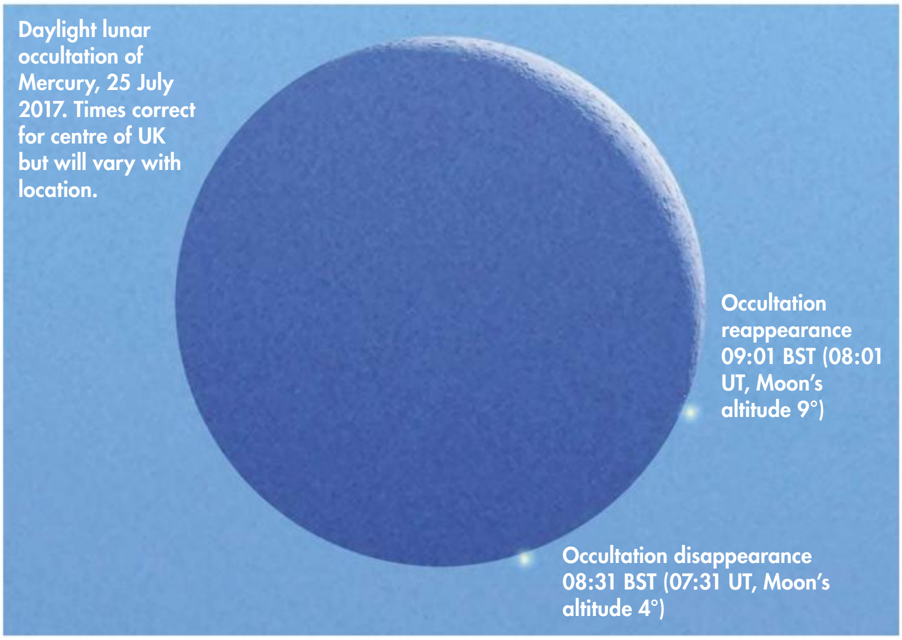

NEPTUNE
Morning object in Aquarius, 11 arcminutes south of 81 Aquarii on 16 Jul

PETE LAWRENCE X 3

CHART KEY

JULY at a glance

The Milky Way makes its presence felt as the month progresses



Daylight lunar occultation of Mercury, 25 July 2017. Times correct for centre of UK but will vary with location.

The summer Milky Way moves into a good position during June but the lack of true darkness around the solstice means that it's hard to get a decent view of it. This all changes during July as the nights start to lengthen. At the beginning of the month the difference is hardly noticeable but by the end the summer the Milky Way glows majestically, flowing through some amazing constellations as it does so.

During the summer we get to look towards our Galaxy's bright core. Sadly this doesn't get very high in UK skies but it's a magnificent sight from more southerly latitudes. Even so, from a dark-sky location, the bright portion of the Milky Way we see passing through Cygnus is a breathtaking spectacle.

Swans, harps and eagles

July's dominant pattern is the Summer Triangle. This is an asterism formed by the three bright stars, Deneb in Cygnus, Vega in Lyra and Altair in Aquila. Of the three, Vega appears brightest and almost overhead at the time of our chart. Below it is a squashed-diamond pattern representing the body of the lyre or harp after which Lyra is named.

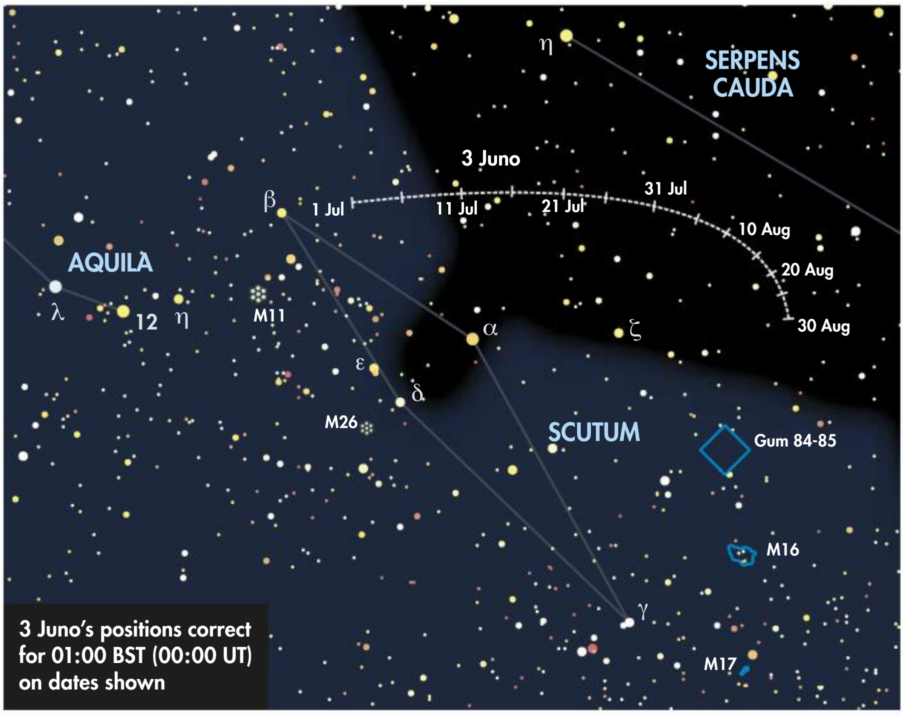
Next in brightness is Altair, the alpha star of Aquila, the Eagle. This is noticeable because it has two fainter stars sitting either side of it. Deneb is the faintest star of the Summer Triangle but appearances can be deceptive. Deneb is the alpha star of Cygnus, the Swan, a large pattern that actually does look like a giant flying swan.

Inside Cygnus is a large cruciform shape known as the Northern Cross. Deneb sits at the top of the cross. Although it looks dimmer than Vega or Altair, it's actually the brightest by a long way, once you factor in distance. Altair is closest at 16.7 lightyears, with Vega next at 25 lightyears. Deneb is so far away that it's difficult to be precise about its distance but it's thought to be around 800 lightyears away. If you placed all three stars at the same distance, Deneb would easily outshine the others.

The Summer Triangle points down towards Sagittarius. From the UK this never fully rises above the southern horizon. The main pattern we see here is another distinctive asterism called the Teapot. The region where steam would be rising out of the spout is full of beautiful deep-sky objects such as M8, the Lagoon Nebula, and M20, the Trifid Nebula.

Two dim worlds come to opposition during July close to the bright Milky Way's core. When something reaches opposition it appears in the opposite part of the sky to the Sun. Minor planet 3 Juno reaches opposition on 2 July, in the star field rich constellation of Scutum, the Shield. Then on 10 July dim and distant Pluto comes to opposition in a region of sky northeast of the Teapot asterism mentioned earlier.

On 25 July a waxing crescent Moon will occult Mercury in the daytime sky – a tricky observation as Mercury will only be magnitude +0.3 at the time. Finally, as we approach the end of the month, keep an eye out for meteors as several showers will be active at this time.

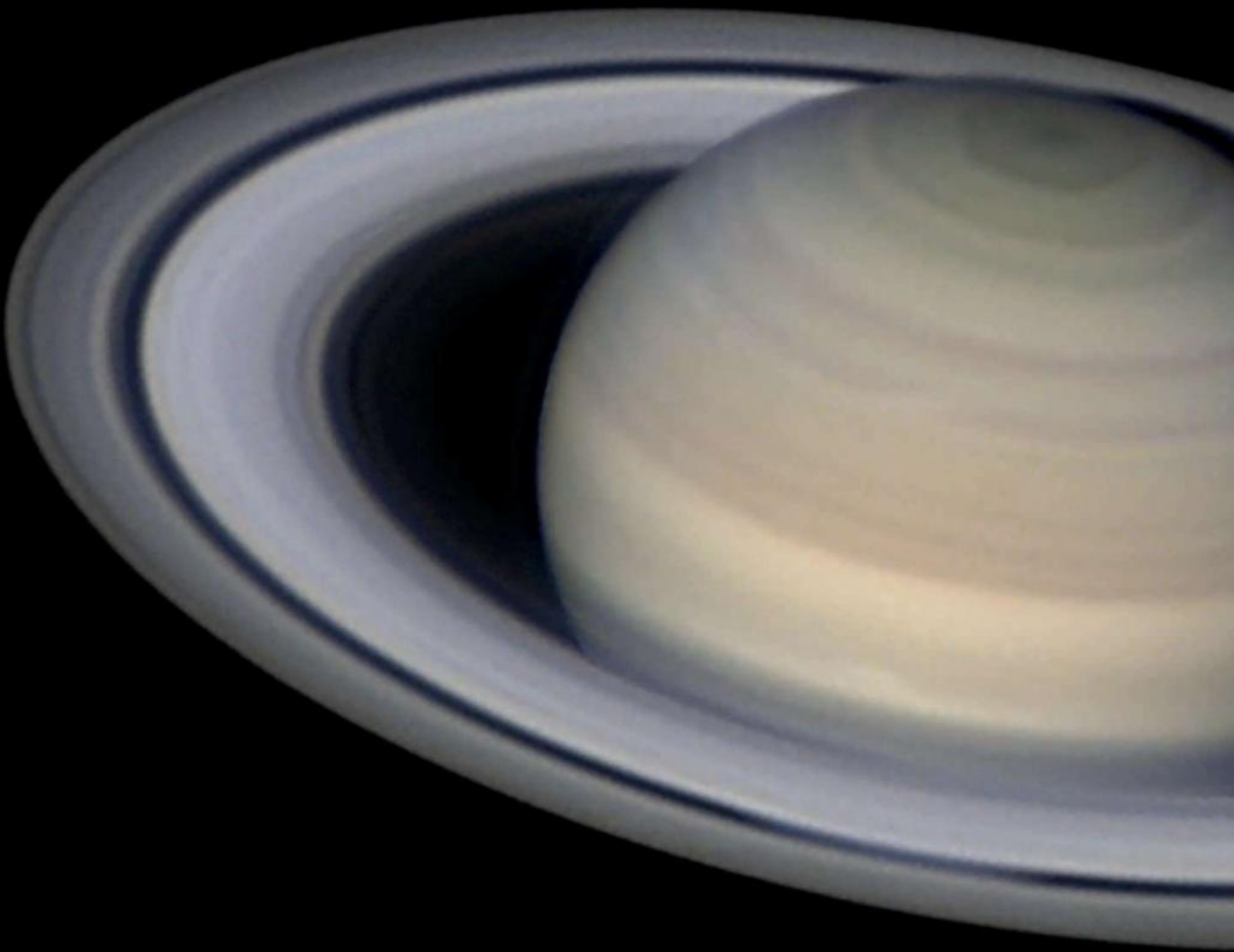


3 Juno's positions correct for 01:00 BST (00:00 UT) on dates shown

INSIGHT ASTRONOMY PHOTOGRAPHER OF THE YEAR

WINNER
PLANETS, COMETS & ASTEROIDS

Serene Saturn
Damian Peach, UK



AUGUST

August begins with the Moon moving in and out of Earth's shadow

KEY DATES

7 AUGUST
The rising full Moon will be partially eclipsed in the Earth's penumbral shadow

12/13 AUGUST
Peak of the annual Perseid meteor shower – a bright Moon will interfere this year

14 AUGUST
Lunar libration favours the Moon's northwest limb

16 AUGUST
From 01:00 BST (00:00 UT) the Moon passes in front of the southern part of the Hyades open cluster

21 AUGUST
A small partial solar eclipse is visible from the UK

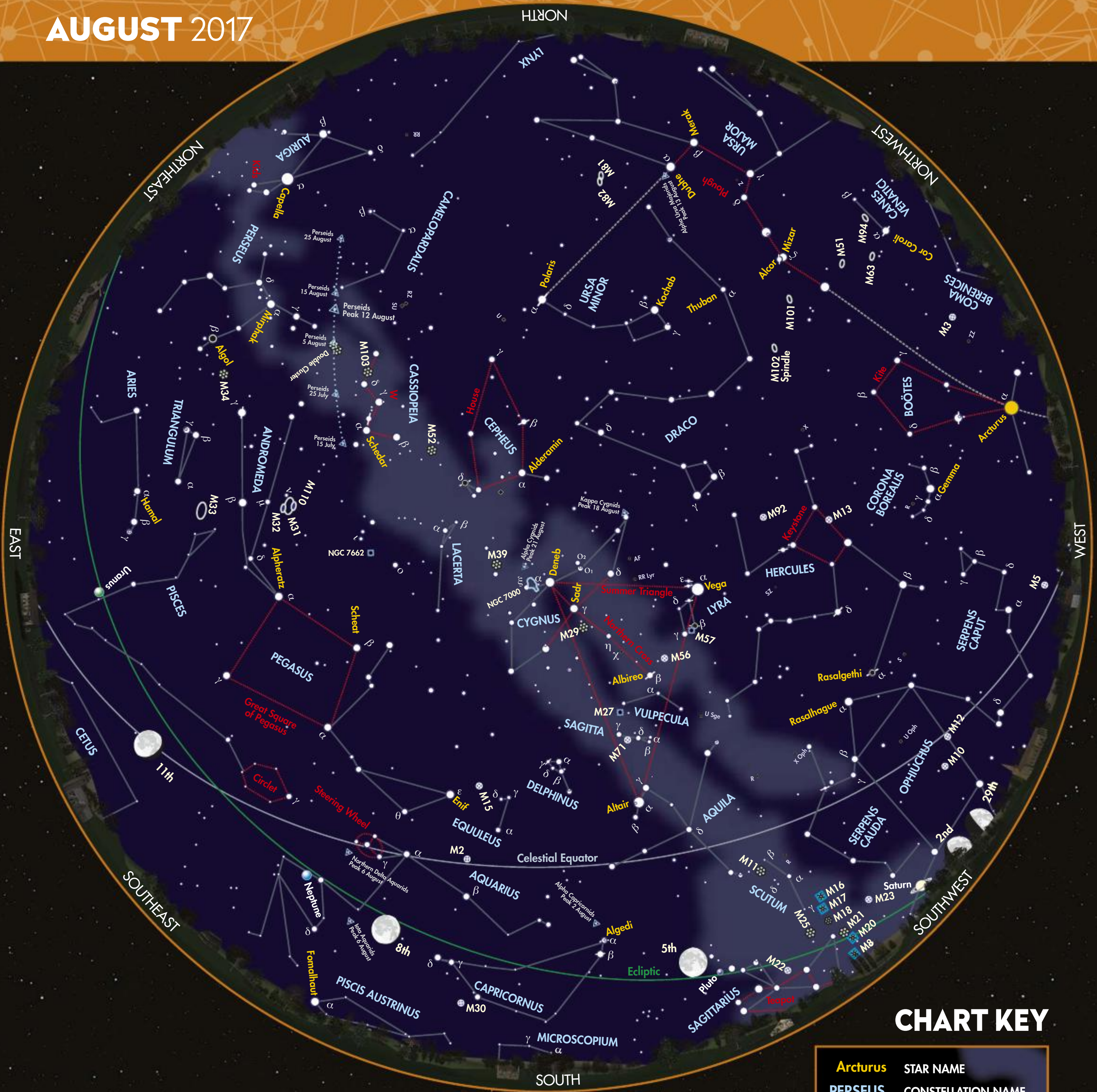


CHART KEY

MOON PHASES Key stages in the monthly cycle


FULL MOON 7 Aug


LAST QUARTER MOON 15 Aug


NEW MOON 21 Aug


FIRST QUARTER MOON 29 Aug

VISIBLE PLANETS Where to spot the planets this month

MERCURY
In conjunction with the Sun on 26 Aug and not well placed

VENUS
Morning planet, near a waning crescent Moon on 19 Aug and M44 on 31 Aug

MARS
Not particularly well positioned morning planet, emerging from last month's solar conjunction

JUPITER
Evening planet not that well positioned. A waxing crescent Moon is close on the 25th

SATURN
Evening planet due south as the sky darkens at the start of Aug

URANUS
Morning planet close to Omicron (ο) Piscium, rapidly improving in position during Aug

NEPTUNE
Well positioned close to Lambda (λ) Aquarii

PETE LAWRENCE X 3

AUGUST at a glance

Two eclipses make August a busy month for our Moon

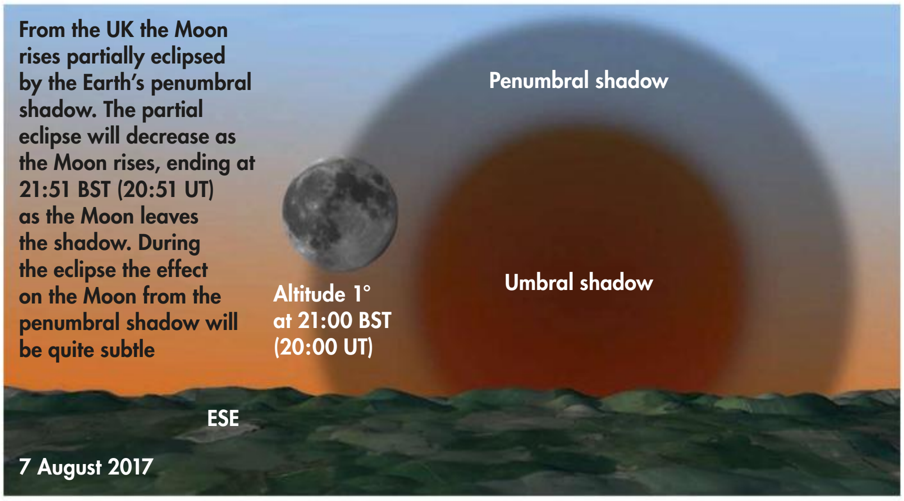
The Milky Way continues to be well placed during August as the skies get darker, while the Summer Triangle dominates the view. This is formed by the three bright stars Vega in Lyra, Altair in Aquila and Deneb in Cygnus. From the UK, the brightest part of the Milky Way is that which flows through Cygnus, where you should be able to see it split if you're in a dark-sky location. This split is caused by a dark dust lane blocking light from the Milky Way's more distant stars. It's prominent enough to earn its own name, being called the Cygnus Rift.

Alpha (α) Cygni, or Deneb, sits at the top of a large cruciform asterism called the Northern Cross. The star at the foot of the cross is Beta (β) Cygni, or Albireo. This binary star is a must see through a telescope because then you'll make out the beautiful golden yellow primary star with its dimmer azure-blue secondary nearby.

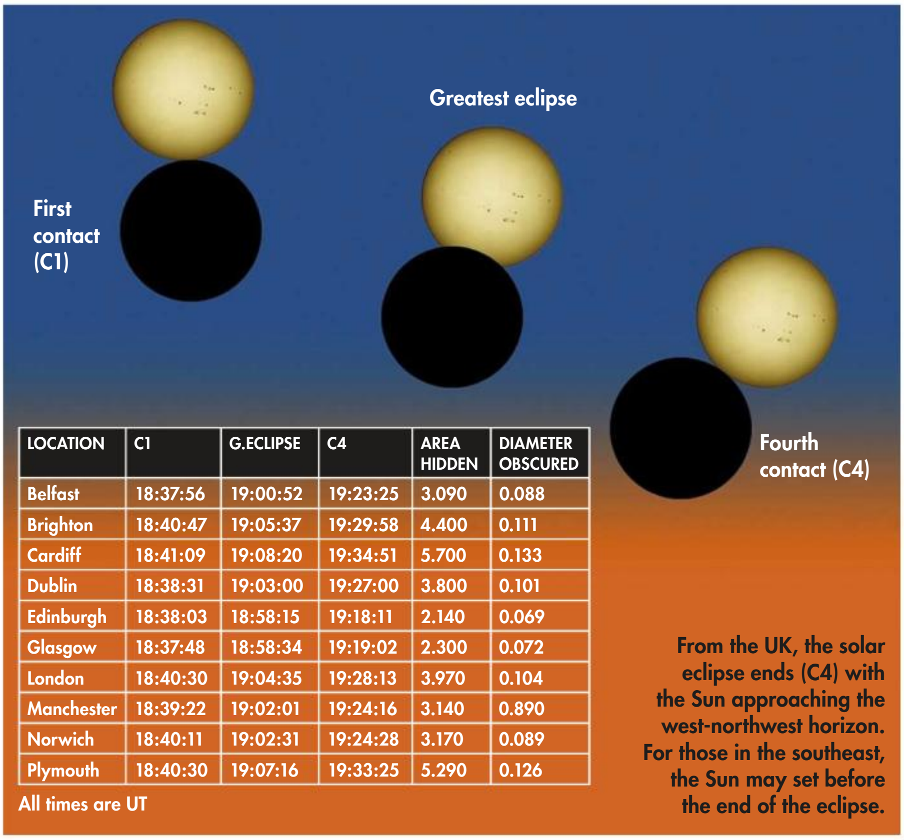
Vulpecula, the Fox, is a distinct constellation that appears to the southeast of Albireo, although in actuality it passes further north under the eastern wing of Cygnus. It's worth looking out for a small group of stars known as Brocchi's Cluster, or the Coathanger Cluster, after the pattern it forms in the southern part of Vulpecula. These stars aren't actually connected but rather a chance line-of-sight asterism. Binoculars or a telescope on low power will give you the best view of it.

Southeast of Vulpecula is Sagitta, the Arrow, a small constellation that looks like an arrow pointing east. Further southeast still is the constellation of Delphinus, the Dolphin, formed by a diamond pattern with a tail. This tight pattern is sometimes mistaken for the Seven Sisters open cluster, which is in Taurus.

Southeast of Dephinus is Equuleus, the Foal, a tiny, indistinct pattern. Below Equuleus is the larger, sprawling Aquarius, the Water Bearer. The most readily identifiable pattern here is the Water Jar asterism, which is said to resemble a three-spoke steering wheel. Southwest of Aquarius is the triangular form of Capricornus, the Sea Goat, made up of a downward-pointing triangle with two pairs of stars marking the east and west vertices.



From the UK the Moon rises partially eclipsed by the Earth's penumbral shadow. The partial eclipse will decrease as the Moon rises, ending at 21:51 BST (20:51 UT) as the Moon leaves the shadow. During the eclipse the effect on the Moon from the penumbral shadow will be quite subtle



LOCATION	C1	G.ECLIPSE	C4	AREA HIDDEN	DIAMETER OBSCURED
Belfast	18:37:56	19:00:52	19:23:25	3.090	0.088
Brighton	18:40:47	19:05:37	19:29:58	4.400	0.111
Cardiff	18:41:09	19:08:20	19:34:51	5.700	0.133
Dublin	18:38:31	19:03:00	19:27:00	3.800	0.101
Edinburgh	18:38:03	18:58:15	19:18:11	2.140	0.069
Glasgow	18:37:48	18:58:34	19:19:02	2.300	0.072
London	18:40:30	19:04:35	19:28:13	3.970	0.104
Manchester	18:39:22	19:02:01	19:24:16	3.140	0.890
Norwich	18:40:11	19:02:31	19:24:28	3.170	0.089
Plymouth	18:40:30	19:07:16	19:33:25	5.290	0.126

All times are UT

From the UK, the solar eclipse ends (C4) with the Sun approaching the west-northwest horizon. For those in the southeast, the Sun may set before the end of the eclipse.

Eclipses

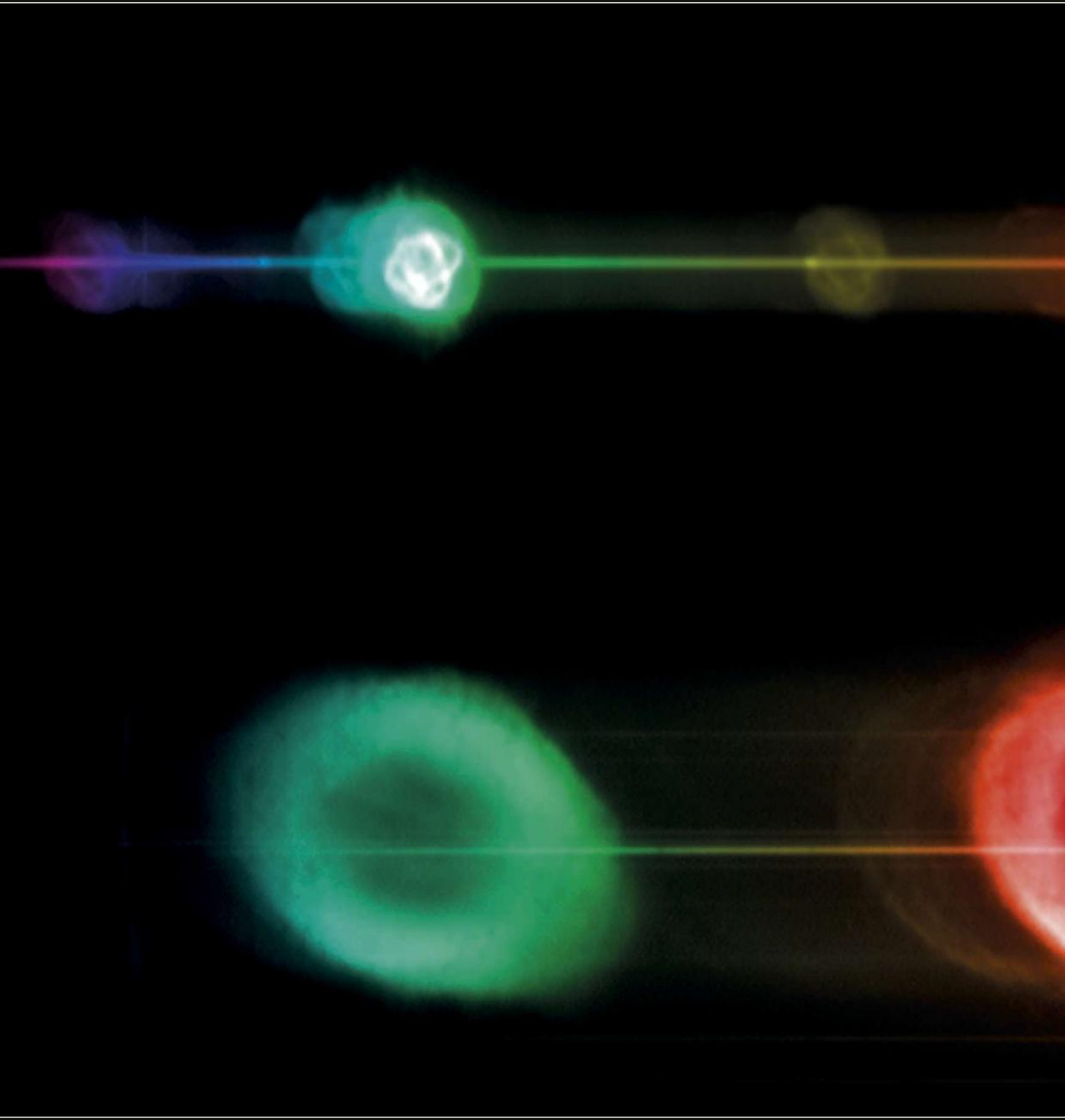
There are two eclipses during August. The first is a penumbral lunar eclipse that will be hard to see. This occurs when the Moon passes through the weak outer part of the Earth's penumbra shadow. The eclipse, which occurs as the Moon rises on 7 August, is actually the final stages of a true partial eclipse of the Moon, caused by the Moon clipping the darker umbral shadow of the Earth. Unfortunately for skywatchers in the UK, this occurs while the Moon is below the horizon. Moonrise from the centre of the UK is at 20:47 BST (19:47 UT) varying slightly with location.

The second eclipse takes place on 21 August when the Moon's disc clips the southern edge of the Sun. This will be all UK skywatchers get to see of a much anticipated total solar eclipse crossing continental North America. As ever with the Sun, only ever view it through a certified solar safety filter.

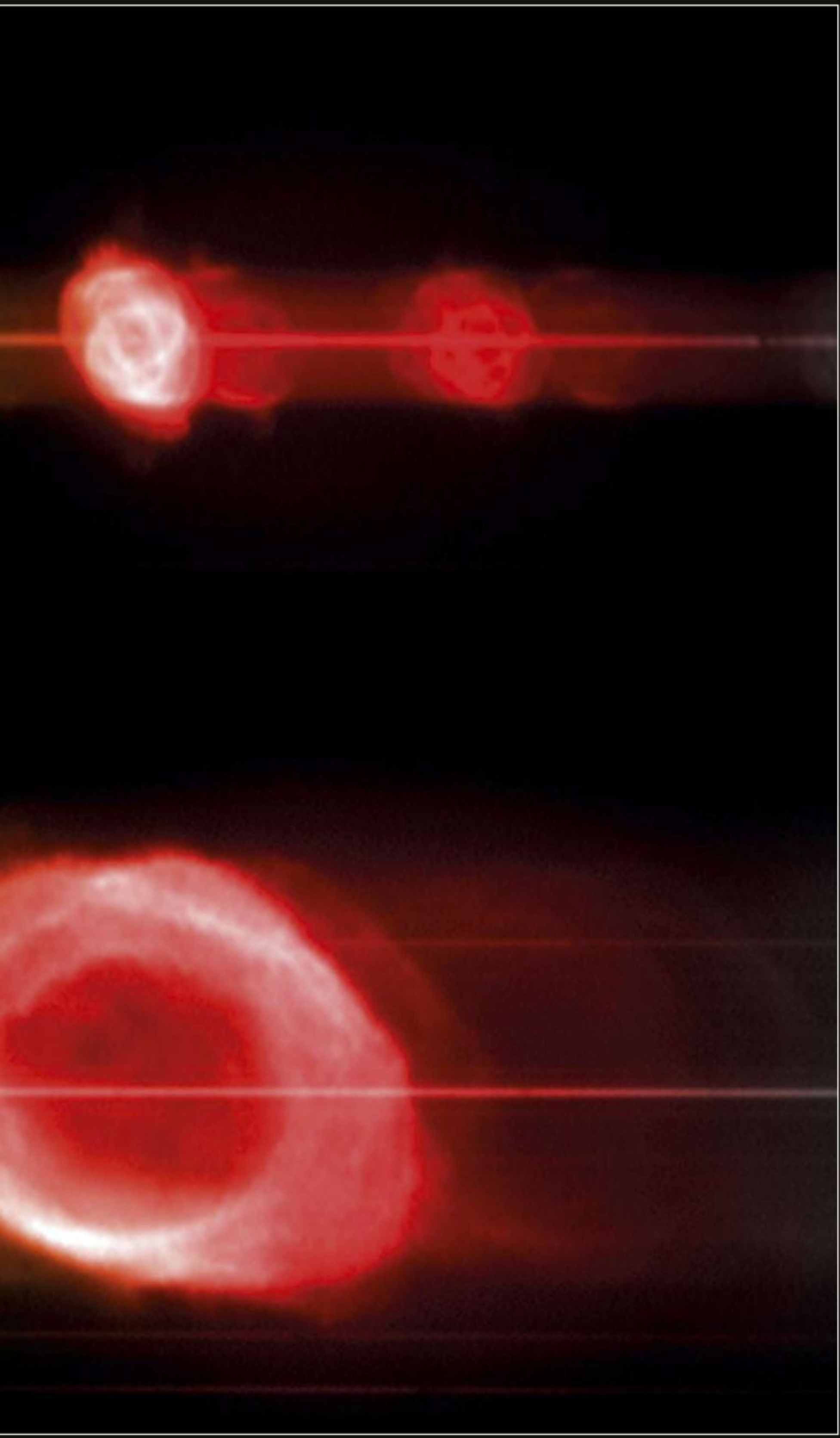
INSIGHT ASTRONOMY PHOTOGRAPHER OF THE YEAR

WINNER
ROBOTIC SCOPE

Iridis
Robert Smith, UK



SEPTEMBER



There's plenty of planetary activity in the month of the autumn equinox

KEY DATES

1-2 SEPTEMBER
Morning planet Venus passes south of the Beehive Cluster, M44

5 SEPTEMBER
Neptune reaches opposition

12 SEPTEMBER
Mercury is at greatest western elongation (18°)

16-17 SEPTEMBER
Mercury and Mars are close in the morning sky

18 SEPTEMBER
A lovely morning alignment of Mercury, Mars, a thin waning crescent Moon and Venus

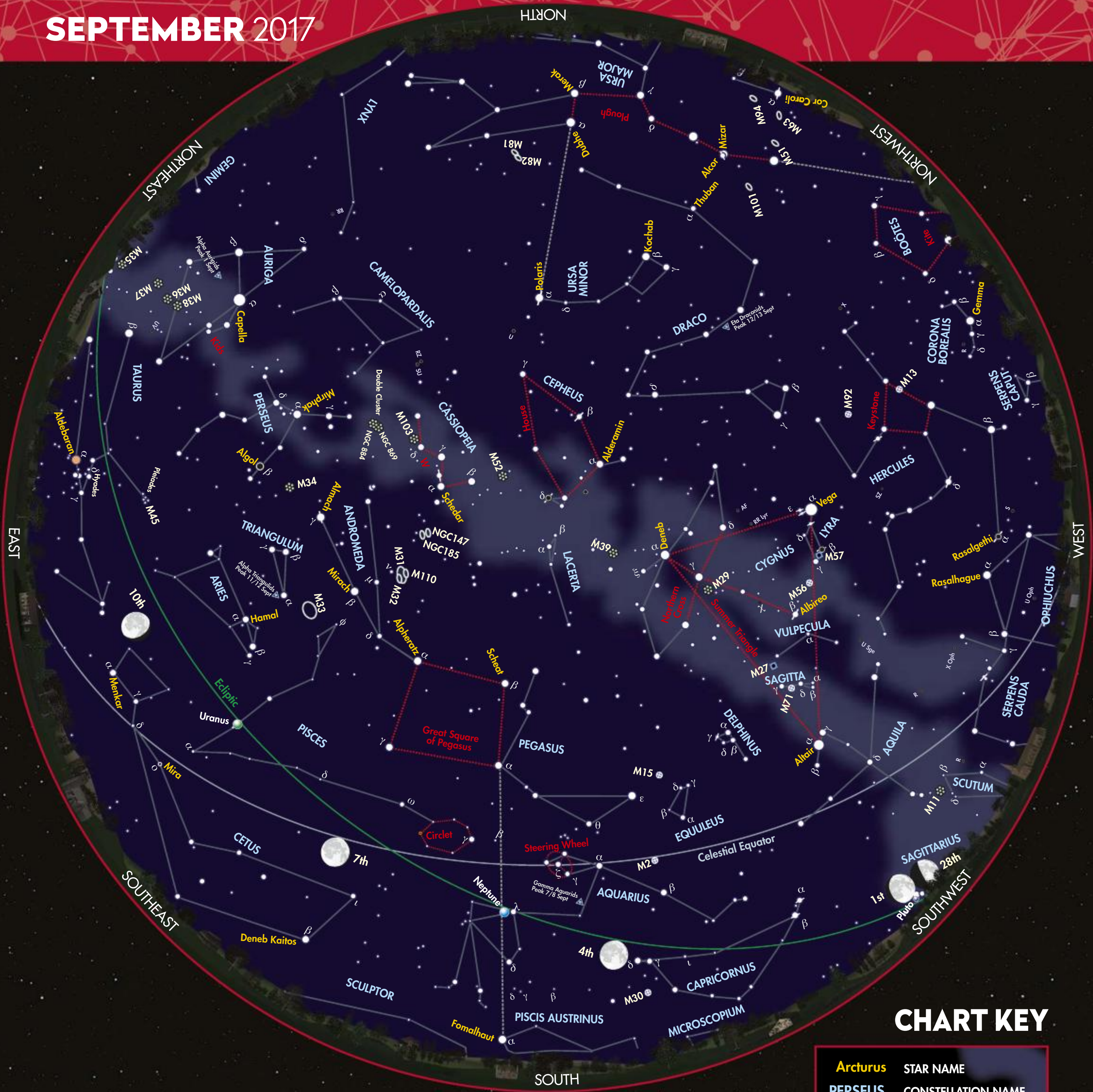


CHART KEY

Arcturus STAR NAME
PERSEUS CONSTELLATION NAME
GALAXY
OPEN CLUSTER
GLOBULAR CLUSTER
PLANETARY NEBULA
DIFFUSE NEBULOSITY
DOUBLE STAR
VARIABLE STAR
THE MOON (SHOWING PHASE)
COMET TRACK
ASTEROID TRACK
STAR-HOPPING PATH
METEOR RADIANT
Circlet ASTERISM
MILKY WAY
PLANET
STAR BRIGHTNESS:
MAG. 0 & BRIGHTER | MAG. +1 | MAG. +2 | MAG. +3 | MAG. +4 & FAINTER

MOON PHASES Key stages in the monthly cycle


FULL MOON 6 Sep


LAST QUARTER MOON 13 Sep


NEW MOON 20 Sep


FIRST QUARTER MOON 28 Sep

VISIBLE PLANETS Where to spot the planets this month

MERCURY Morning planet at greatest western elongation on 12 Sep

VENUS Morning planet passing the Beehive Cluster M44, at the start of the month

MARS Morning object slowly pulling out of the dawn twilight

JUPITER Evening planet too low for serious observation. Thin crescent Moon nearby on the 22nd

SATURN Visible in the evening sky and worth a look to see its wide open rings

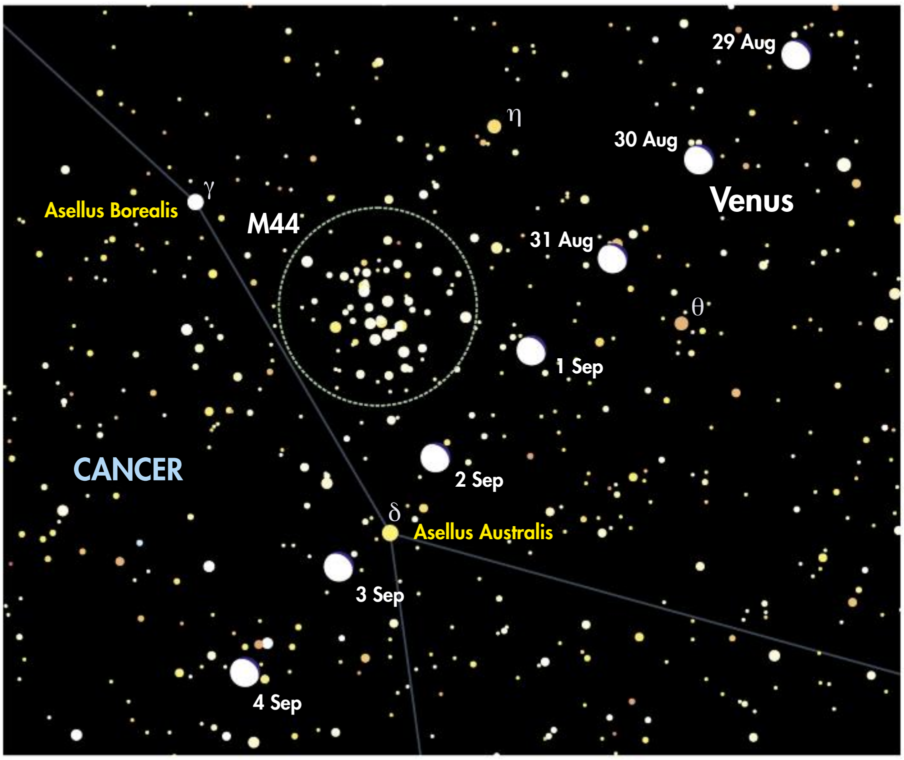
URANUS Morning planet reaching its highest point in the sky in darkness all month

NEPTUNE Reaches opposition on 5 Sep and is visible all night long throughout September

PETE LAWRENCE X 3

SEPTEMBER at a glance

The September skies play host to some lovely close approaches



▲ Location of Venus at 04:30 BST (03:30 UT) as it passes the Beehive Cluster, M44. The planet and the cluster will be low in the east-northeast at this time

The Northern Hemisphere's autumn equinox occurs on 22 September, a time when the nights are growing longer at their fastest rate. This allows us to see the bright part of the Milky Way flowing through the Summer Triangle. However, this region of sky is starting to drift westwards in the run up to midnight.

In its place is one of the more familiar patterns of the autumn sky: the Great Square of Pegasus. It's an odd formation, partly because it's not truly square but also because only three of its stars belong to Pegasus. Its northeast corner is Alpheratz, the alpha star of Andromeda.

Despite its shortcomings it's still useful for locating other celestial objects. For example, trace a line down the square's western side towards the horizon to find Fomalhaut, the alpha star of Piscis Austrinus, the Southern Fish. This is the most southerly first-magnitude star visible from the UK and is easily lost behind foreground objects above the horizon. Directly south of the Great Square is a faint circular pattern called the Circlet that represents the western fish of Pisces.

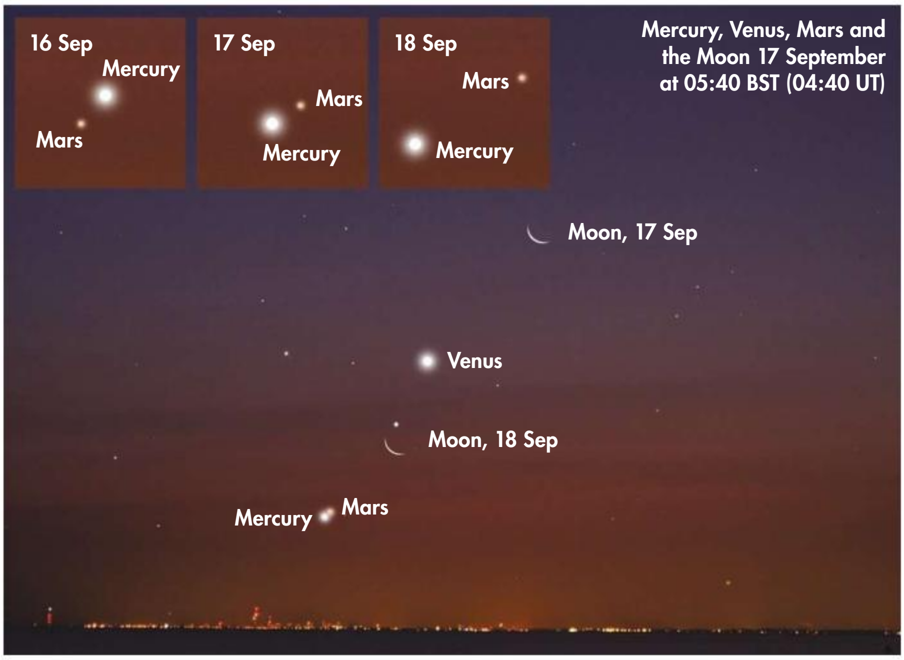
Following a diagonal path northeast across and out of the Great Square, bending slightly south as you go, brings you to Beta (β) Andromedae or Mirach. Slightly north of Mirach is dimmer Mu (μ) Andromedae and north of that, even dimmer Nu (ν) Andromedae. To the northwest of Nu is M31, the Andromeda Galaxy and despite being 2.5 million lightyears away, it can still be seen with the naked eye.

Extend the western side of the Great Square north and to the west of this line point you'll find a collection of stars representing Lacerta, the Lizard.

Morning glories

If you're an early riser then there's a treat in store at the start of September as Venus can be seen passing 1.5° to the south of the centre of the Beehive Cluster, M44. Both Venus and the cluster should fit in the field of view of a pair of binoculars. This also makes for a great photographic target. Spot them above the east-northeast horizon from 04:00 BST (03:00 UT).

Between 16 and 18 September the early morning sky will be something to behold. On 16 September Mercury and Mars will be 0.5° apart and visible around 05:20 BST (04:20 UT). At this time Mercury will be to the west of Mars. The following morning they swap sides with Mercury now 20 arcminutes to the east of Mars. On the 18th, take in the wider view as Mercury, Mars, a 4% lit waning crescent Moon and Venus all line up around 05:50 BST (04:50 UT). On the 19th the Moon will be the object closest to the Sun, showing a very slender 1% lit waning crescent phase.



Mercury, Venus, Mars and the Moon 17 September at 05:40 BST (04:40 UT)

> ***"What you're seeing is the integrated light from 70,000 stars all gravitationally bound within a sphere measuring 97 lightyears across"***

Stats

NAME AND CATALOGUE REFERENCE: **Messier 22**
CONSTELLATION: **Sagittarius**
OBJECT TYPE: **Globular cluster**
VISUAL BRIGHTNESS: **Mag. +5.1 (naked eye)**
DISTANCE: **10,400 lightyears**
APPARENT SIZE: **32 arcminutes**
PHYSICAL SIZE: **97 lightyears diameter**

Around 70,000 stars reside in M22 helping it to look spectacular despite its low UK altitude

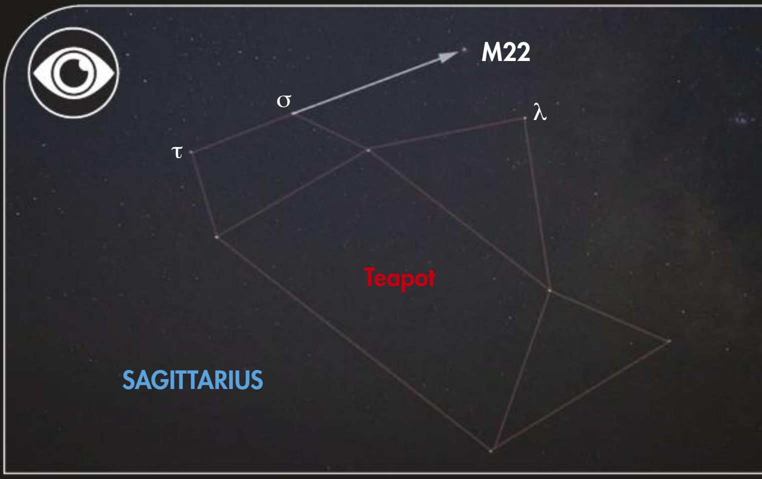
M22

Globular cluster in Sagittarius

Sitting low in the sky but densely packed with stars, M22 is one of the closest globular clusters to Earth

NAKED EYE The view from the ground

Messier 22 is a bright and impressive globular cluster in Sagittarius. It's somewhat muted from the UK due to its low declination but in clear skies provides hints of its true majesty. Under dark conditions it can just about be seen with the naked eye and its position in Sagittarius helps. Although we can't see the entire constellation from the UK, we do get a view of an asterism called the Teapot that sits at the heart of Sagittarius. M22 is 2.5° northeast of Lambda (λ) Sagittarii, the star at the top of the Teapot's lid. Another way to find it is to follow the two stars that mark the eastern side of the Teapot's handle, Sigma (σ) and Tau (τ) Sagittarii. Follow the line they make 1.6x further on to the northeast to arrive at M22.



BINOCULARS Getting a closer look

It's often said that the finest globular cluster visible from the UK is M13 in Hercules, although some argue that M5 in Serpens is preferable. M22, however, is brighter than either of them and despite being lower is easy to see in binoculars. To do so, use the Teapot asterism. Centre up on Lambda (λ) Sagittarii, or Kaus Borealis, at the top of the lid. When close to its highest position in the sky, due south, M22 will appear at the 10 o'clock position in the binocular view. The globular looks like a circular smudge of grey light. This may not sound that exciting, but bear in mind that what you're seeing is the integrated light from 70,000 stars all gravitationally bound within a sphere measuring 97 lightyears across.

TELESCOPE Seeing all the detail

A telescope shows the spectacular nature of M22. A 150mm instrument will show individual stars crossing the hazy core. Start off with a power around 50x and increase until you get a detailed view. A 250mm scope shows many outlying stars creating a halo around what looks like a slightly elongated core. A 300mm scope will resolve most of the cluster stars, presenting a magnificent view through the eyepiece. The apparent diameter will be around 20 arcminutes, but this can be affected by how much light pollution you have to look through. Reducing the power reveals a red, mag. +8.6 star to the northeast of the core. To the south are two notable strings of stars that almost resemble dangling legs.

JOHN CHUMACK/SCIENCE PHOTO LIBRARY, PETE LAWRENCE X 3

INSIGHT
ASTRONOMY
PHOTOGRAPHER
OF THE YEAR

WINNER
SIR PATRICK MOORE PRIZE FOR BEST NEWCOMER

Large Magellanic Cloud
Carlos Fairbairn, Brazil

OCTOBER

A packed month of planets, meteors and Moon craters

KEY DATES

5 OCTOBER
Venus, Mars and Sigma Leonis form a tight triangle in the morning sky

15 OCTOBER
A chance to spot Regulus just north of the Moon in daylight at 12:30 BST (11:30 UT)

19 OCTOBER
Uranus reaches opposition

21 OCTOBER
The Moon's libration gives a favourable view of giant crater Humboldt

21/22 OCTOBER
Peak of the annual Orionid meteor shower

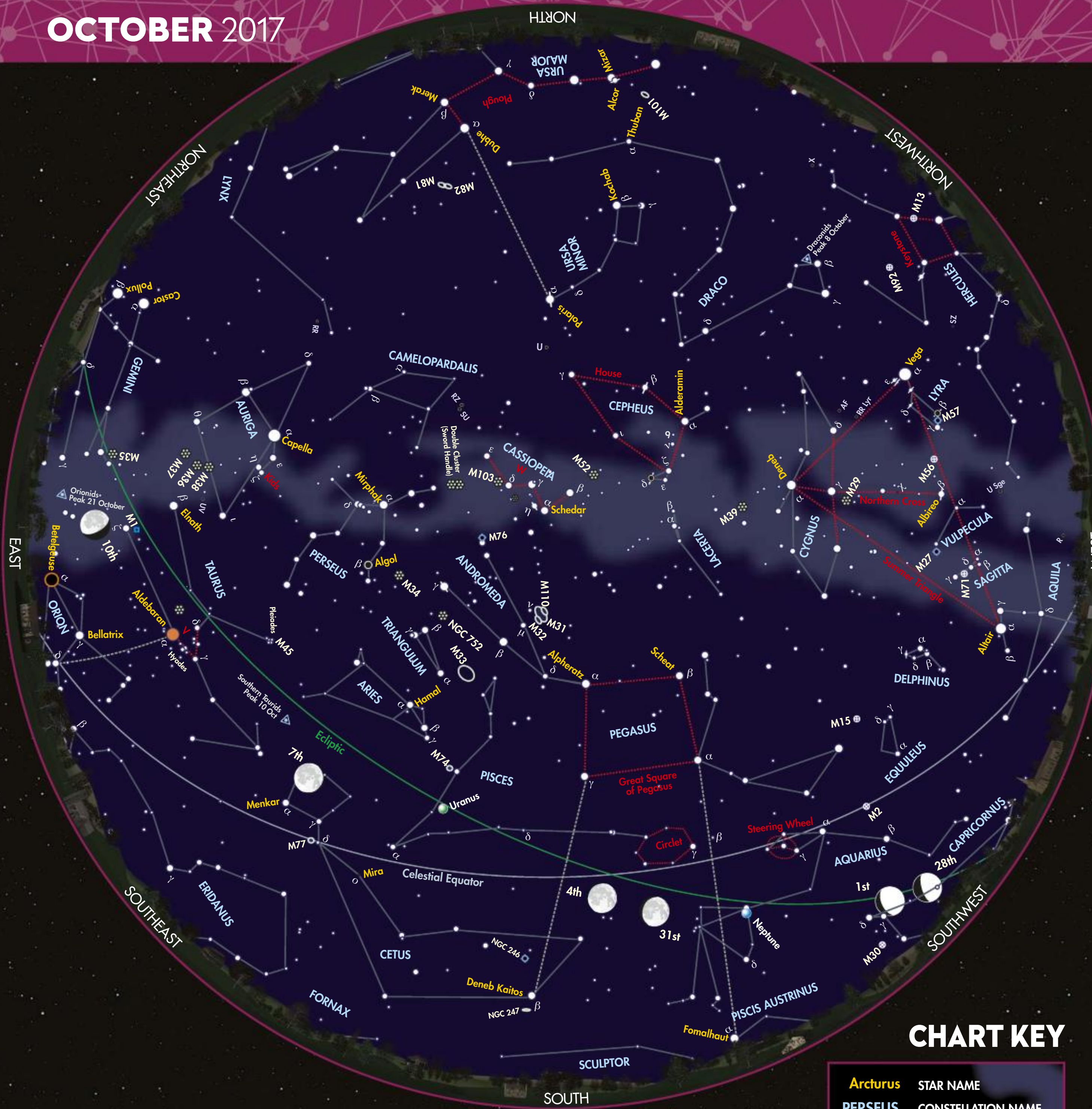


CHART KEY

MOON PHASES Key stages in the monthly cycle

FULL MOON 5 Oct

LAST QUARTER MOON 12 Oct

NEW MOON 19 Oct

FIRST QUARTER MOON 27 Oct

VISIBLE PLANETS Where to spot the planets this month

MERCURY
Poorly located this month and unlikely to be seen

VENUS
Bright morning planet very close to Mars on 5 Oct

MARS
Morning planet close to Venus at the start of the month

JUPITER
In solar conjunction on 26 Oct so not a viable target this month

SATURN
Evening planet, rather low in the south-southwest as the sky darkens

URANUS
Reaches opposition on 19 Oct and well placed all month

NEPTUNE
In Aquarius, reaching its highest point in the sky, due south. In darkness all month

PETE LAWRENCE X 3

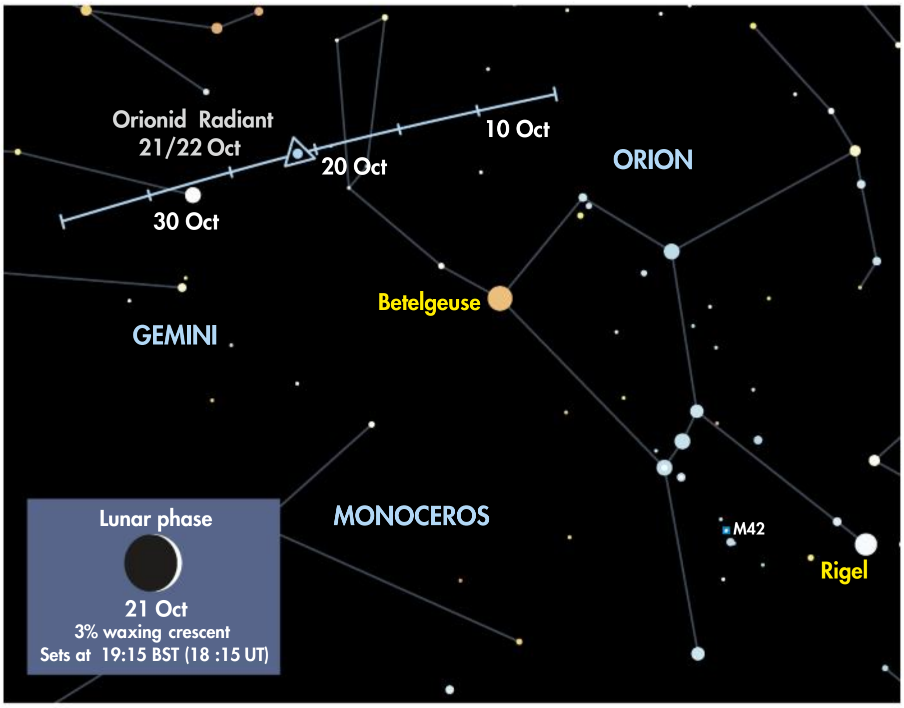
OCTOBER at a glance

The Orionid meteor shower lights up the late-October sky

October's sky is full of promise. Our main chart shows the constellations of autumn with Pegasus dominating the view high to the south. The main pattern here is the Great Square of Pegasus. Count how many faint stars you can see within the square boundary. If you get seven or more you have a good, dark sky.

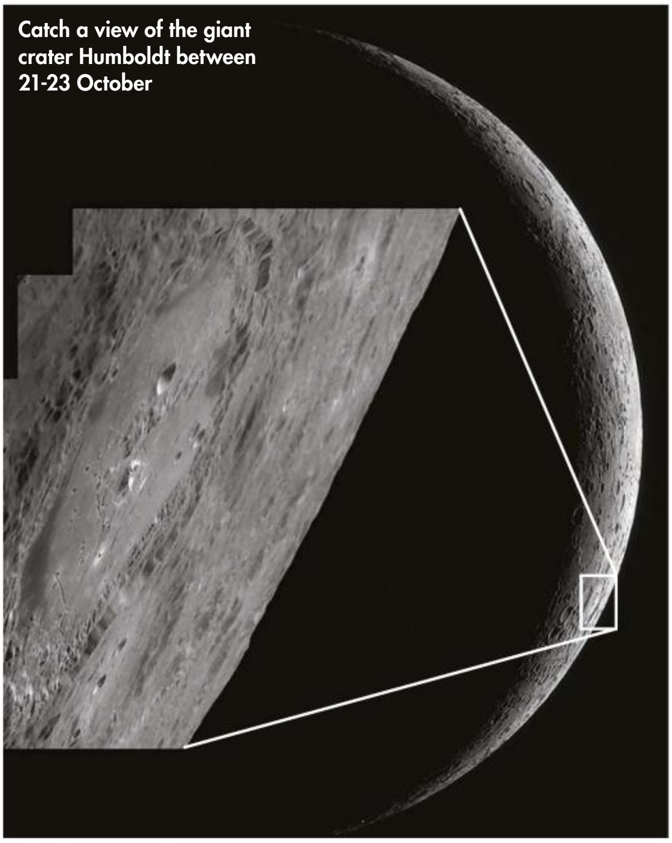
The Square's west side points down to Fomalhaut, the alpha star of Piscis Austrinus, the Southern Fish. The east side points down to Beta (β) Ceti or Deneb Kaitos, the 'whale's tail'. Cetus, the Whale, is an indistinct constellation occupying a large area northeast of Deneb Kaitos.

The constellation of Pisces has two faint lines of stars running east and south of the Great Square of Pegasus. The western fish is represented by the Circlet, a circle of dim stars south of the Great Square. Trace the line of stars going east of the circlet to Alpha (α) Piscium, or Alrescha. From there it turns sharply to head northwards to form the poorly defined second fish. Uranus is currently northwest of Alrescha.



▲ The Orionids' radiant lies between the constellations of Orion and Gemini

Return to the Great Square of Pegasus and look for the wedge of stars spreading from its northeast corner. This is the body of Andromeda, the Chained Princess. Located just to the north of the mid-point of the wedge is the Andromeda Galaxy, M31. At 2.5 million lightyears, this is the furthest object you can see with the naked eye, although strong light pollution will hide it.



Catch a view of the giant crater Humboldt between 21-23 October

North of Andromeda is W-shaped Cassiopeia, the Seated Queen. This pattern is circumpolar from the UK, meaning its close enough to the North Star, Polaris, to never set. Polaris is easy to find. First locate the Plough, which is shown on our chart low in the north at this time of year. Extend the line that runs through Merak and Dubhe up from the horizon until you arrive at Polaris.

Keep this line going to arrive at Gamma (γ) Cephei, or Er Rai. This is part of Cepheus, the King. Cepheus looks like the outline of a child's drawing of a house. There's a faint variable star, just below the mid-point of the bottom of the house, called Mu (μ) Cephei, or Herschel's Garnet Star. This is well worth hunting down with binoculars or a telescope as it appears deep orange in colour.

The Harvest Moon

The Moon will be full on 5 October and being the closest one to the Northern Hemisphere's autumn equinox it's technically the Harvest Moon. Between 21-23 October try and get a look at the waxing crescent Moon as the sky darkens. The Moon's libration and phase will present us with a good view of the giant 207km-diameter crater Humboldt. The 21 October Moon sets around 19:15 BST (18:15 UT) producing optimal conditions to enjoy this year's Orionid meteor shower, which happens to peak on that night. The shower has a ZHR of 20 meteors per hour, which will all appear to emanate from a location not far from the red supergiant star Betelgeuse in Orion.


INSIGHT
ASTRONOMY
PHOTOGRAPHER
OF THE YEAR
WINNER
SKYSCAPES
Binary Haze
Ainsley Bennett, UK

NOVEMBER

A packed month of astronomical activity promises amazing sights

KEY DATES

5 NOVEMBER
Lunar occultation of the Hyades begins early evening

6 NOVEMBER
Moon occults Aldebaran in the early hours

13 NOVEMBER
Morning planets Venus and Jupiter appear just 16 arcminutes apart at 07:00 UT

17 NOVEMBER
Lovely arrangement of Jupiter, Venus and a thin crescent Moon in the morning sky

17 NOVEMBER
Peak of the annual Leonid meteor shower, which has a ZHR of 10 meteors per hour

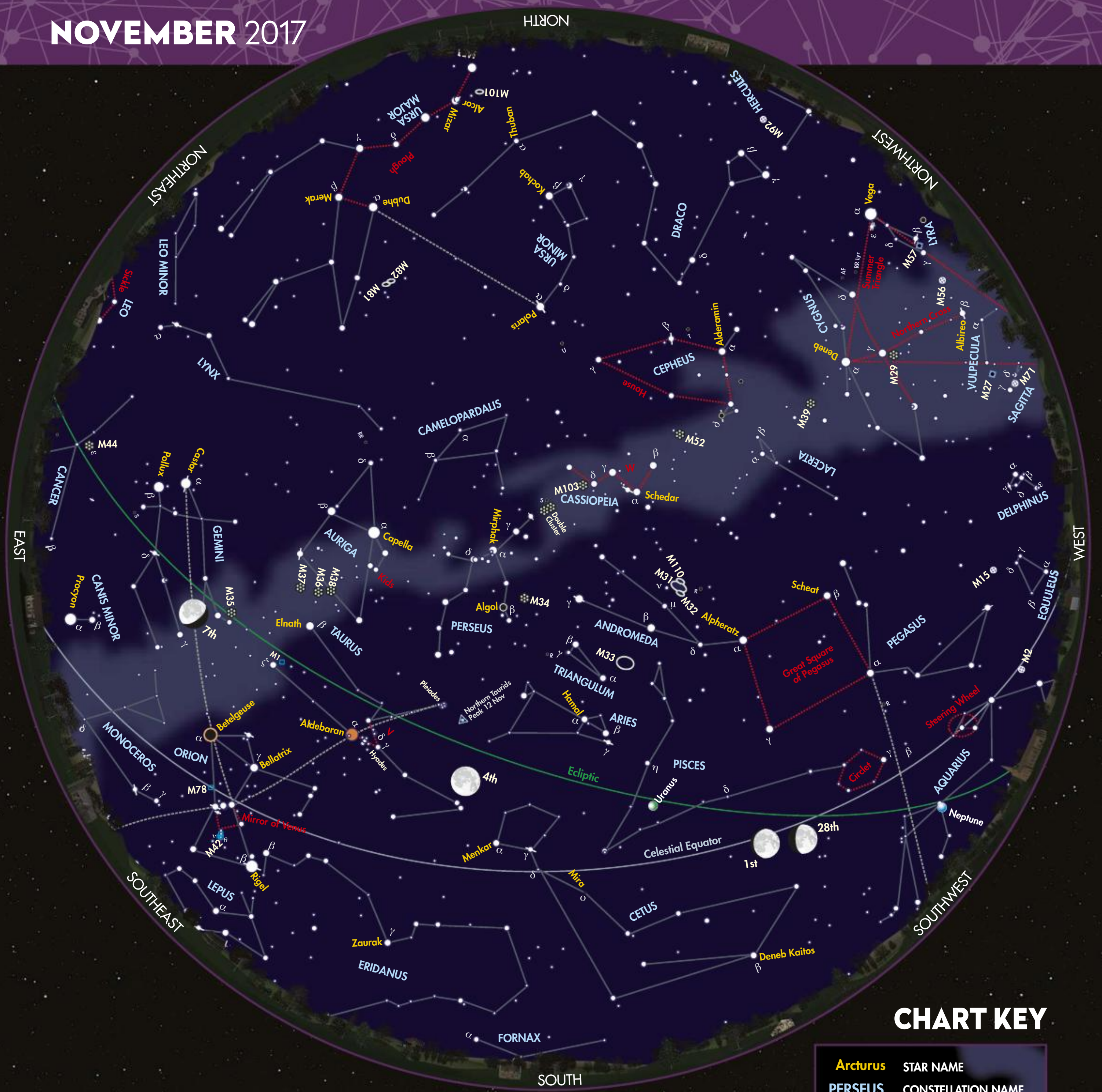


CHART KEY

- Arcturus — STAR NAME
- PERSEUS — CONSTELLATION NAME
- GALAXY
- OPEN CLUSTER
- GLOBULAR CLUSTER
- PLANETARY NEBULA
- DIFFUSE NEBULOSITY
- DOUBLE STAR
- VARIABLE STAR
- THE MOON (SHOWING PHASE)
- COMET TRACK
- ASTEROID TRACK
- STAR-HOPPING PATH
- METEOR RADIANT
- Circlet — ASTERISM
- MILKY WAY
- PLANET

STAR BRIGHTNESS:

MAG. 0 & BRIGHTER · MAG. +1 · MAG. +2 · MAG. +3 · MAG. +4 & FAINTER

MOON PHASES Key stages in the monthly cycle


FULL MOON 4 Nov

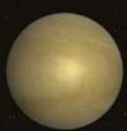

LAST QUARTER MOON 10 Nov


NEW MOON 18 Nov


FIRST QUARTER MOON 26 Nov

VISIBLE PLANETS Where to spot the planets this month


MERCURY Evening planet, reaching its greatest eastern elongation on 24 Nov but not well placed


VENUS Morning planet, having a close encounter with Jupiter on 13 Nov


MARS Poorly positioned morning planet


JUPITER Morning planet, close to Venus on 13 Nov and forms a triangle with Venus and the Moon on 17 Nov


SATURN Difficult evening planet, potentially visible for a short time after sunset

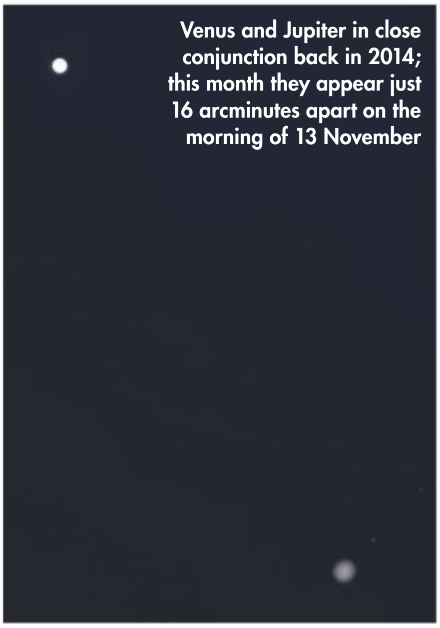

URANUS An evening planet well positioned in Pisces


NEPTUNE Evening planet in Aquarius, well placed all month

PETE LAWRENCE X 3

NOVEMBER at a glance

There's a nice close conjunction and a grand lunar occultation



Venus and Jupiter in close conjunction back in 2014; this month they appear just 16 arcminutes apart on the morning of 13 November

The stars of winter begin encroaching from the east during November, but before they arrive, there's still plenty to see in the autumn sky. Wedge-shaped Andromeda, the Chained Princess, rides high in the sky on our chart, the wedge appearing to emanate from the northeast corner of the Great Square of Pegasus.

Just above the mid-point of the wedge lies the Andromeda Galaxy, M31. Sitting 2.5 million lightyears away from Earth, it's the furthest object you can see with the naked eye under normal sky conditions.

The faint constellation of Pisces runs close to the eastern and southern edges of the Great Square of Pegasus. The faint stars appear to converge at a sharp point, which indicates the direction to follow to reach Cetus, the Whale or Sea Monster. This is a large, sprawling constellation that lacks any real form.

Follow the east side of the Great Square of Pegasus south to locate Deneb Kaitos, the bright star marking the whale's tail. There's a fairly easy to identify quadrilateral of fainter stars northeast of Deneb Kaitos. The southernmost star in this pattern is Tau Ceti, a Sun-like star 'only' 11.9 lightyears away. It's believed to be orbited by five planets, one of which excitingly lies in the star's habitable zone.

The head of Cetus is represented by a pattern that looks like a misshapen 50p piece. Alpha (α) Ceti, or Menkar, marks the eastern extent of this pattern. North of the head lies the constellation of Aries, the Ram. The three brightest stars of Aries form what's best described as a 'bent line', the brightest star being Alpha (α) Arietis, or Hamal. The rest of Aries spreads off towards the east.

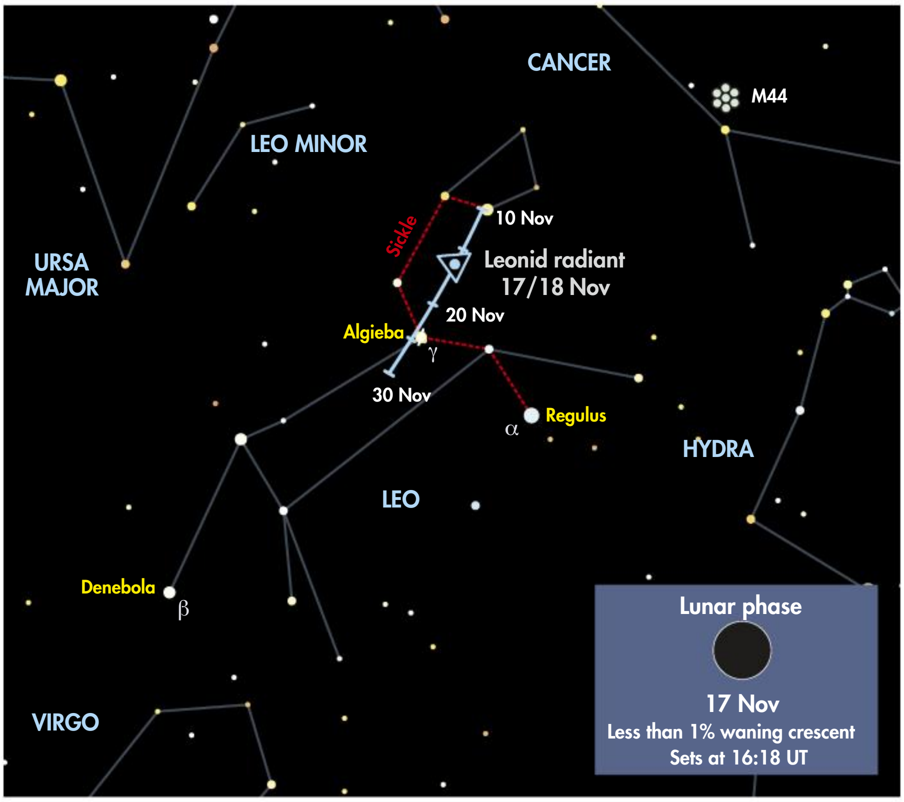
North of Aries lies the curiously named Triangulum, the Triangle, unsurprisingly formed from three principal stars. It's curious because any three stars form a triangle unless they're in a straight line. In mythology Triangulum represents the triangular-shaped island of Sicily. Triangulum contains the beautiful face-on spiral galaxy M33, the Triangulum Galaxy. This lies northwest of Alpha (α) Trianguli, or Rasalmothallah, and despite a relatively bright catalogue listing can be challenging to see because of its low surface brightness.

To the northeast of Triangulum you'll find Perseus, the Greek Hero, resembling a distorted lower-case Greek letter Pi (π). At the bottom of the western leg lies Beta (β) Persei, or Algol. This is an eclipsing binary dimming in brightness for around 10 hours every two days, 20 hours and 49 minutes. In mythology, Perseus rescues Andromeda from Cetus by cutting off the head of the Gorgon Medusa, then showing the severed head to Cetus, which subsequently turns to stone. The star Algol represents the winking eye of the Gorgon.

Clusters and conjunctions

November starts with a well placed lunar occultation of the Hyades open cluster. Start watching from 18:40 UT on 5 November as the Moon approaches Gamma (γ) Tauri, which marks the pointed end of the V-shaped cluster. The climax occurs around 02:30 UT on 6 November as the 94% lit waning gibbous Moon hides bright Aldebaran from view.

Later in the month, don't miss the close conjunction between the bright planets Venus and Jupiter, visible in the morning sky on 13 November. Four days later on 17 November, Venus, Jupiter and a 1% lit waning crescent Moon form a beautiful right-angled arrangement also in the morning sky. Later that evening don't forget to keep a look out for Leonid meteors. This shower peaks on 17/18 November when the Moon is virtually new and conveniently out of the way.



▲ A nearly new Moon means views of the Leonids should be good during their peak

INSIGHT ASTRONOMY PHOTOGRAPHER OF THE YEAR

RUNNER UP
PEOPLE AND SPACE

Man on the Moon

Dani Caxete, Spain

DECEMBER

The constellation of Orion holds many treasures this month

KEY DATES

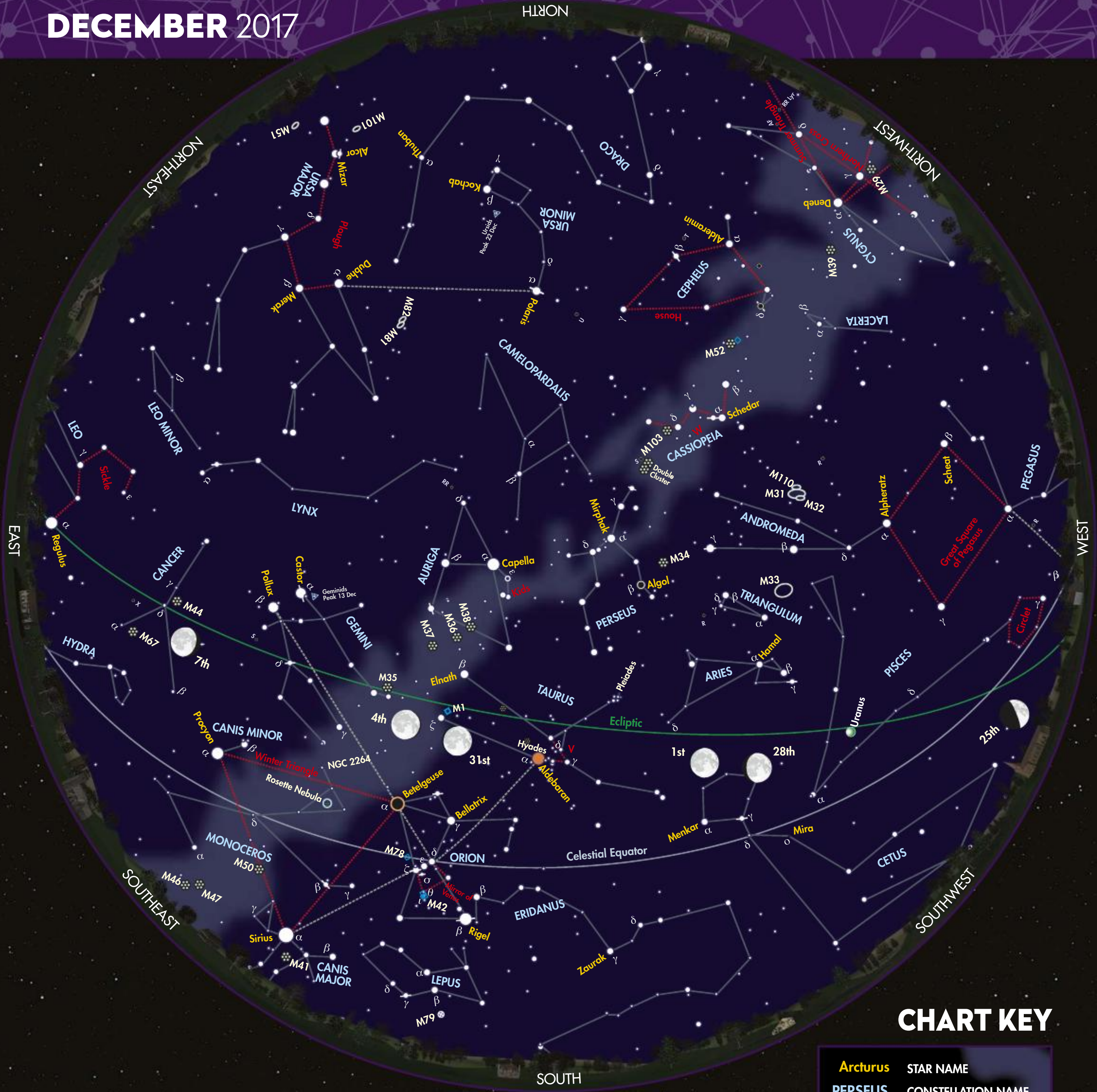
8 DECEMBER
Regulus reappears from behind the rising Moon this evening

13/14 DECEMBER
Peak of the annual Geminid meteor shower

14-17 DECEMBER
An opportunity to see asteroid 3200 Phaethon – the parent body of the Geminids

22 DECEMBER
Peak of the Ursid meteor shower

30 DECEMBER
Lunar occultation of the Hyades with Aldebaran occulted early on 31st



MOON PHASES Key stages in the monthly cycle


FULL MOON
3 Dec

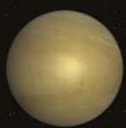

LAST QUARTER MOON
10 Dec


NEW MOON
18 Dec


FIRST QUARTER MOON
26 Dec

VISIBLE PLANETS Where to spot the planets this month


MERCURY
Solar conjunction on 12 Dec after which it rapidly improves in the morning sky


VENUS
Morning planet visible during the first week of Dec but lost soon after that


MARS
Morning planet closing on Jupiter. Meets with a waning cresent Moon and Juptier on 13 Dec


JUPITER
Morning planet improving in position throughout the month


SATURN
Reaches solar conjunction on 21 Dec and not visible

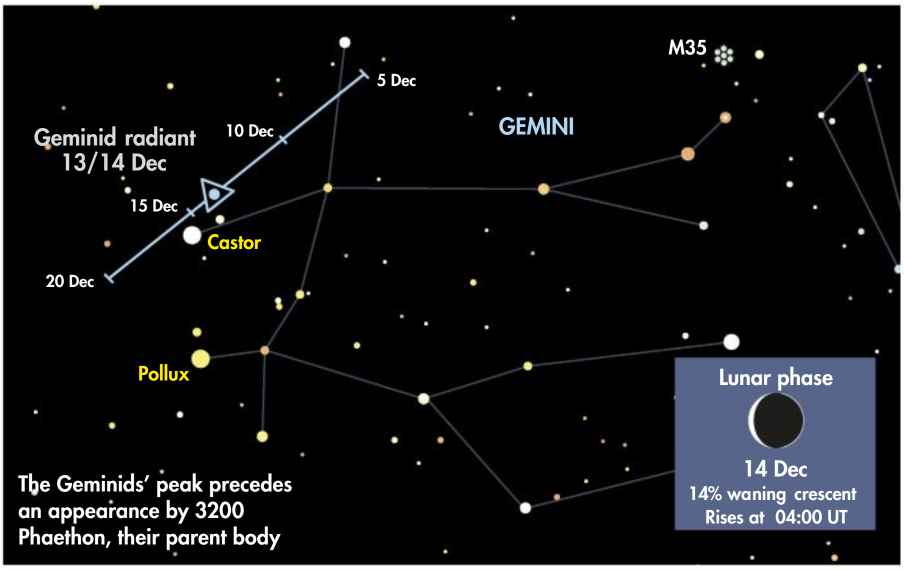

URANUS
Evening planet in Pisces that remains well placed throughout the month


NEPTUNE
Well placed at the start of Dec but declines in altitude towards the end

PETE LAWRENCE X 3

DECEMBER at a glance

The Moon moves aside for the Geminid meteor shower this month



The Geminids' peak precedes an appearance by 3200 Phaethon, their parent body

The December nights are very long and full of spectacular constellations, giving you plenty of time to enjoy them. The only down side is that they're often cold! The most striking pattern is Orion. His body is formed by seven stars, three of which lie in a straight line to make his belt. Hanging from his belt is his sword and in here lies the Orion Nebula, M42. Viewed with the naked eye, the sword has a faint allure, but with a pair of binoculars you'll be able to see the misty form of the nebula. Through a telescope it's an absolute delight with loads of delicate detail.

The bright star in Orion's southwest corner is blue supergiant Rigel. The opposite corner is marked by red supergiant Betelgeuse, an old star with a massive diameter estimated to be nearly 900 times greater than the Sun.

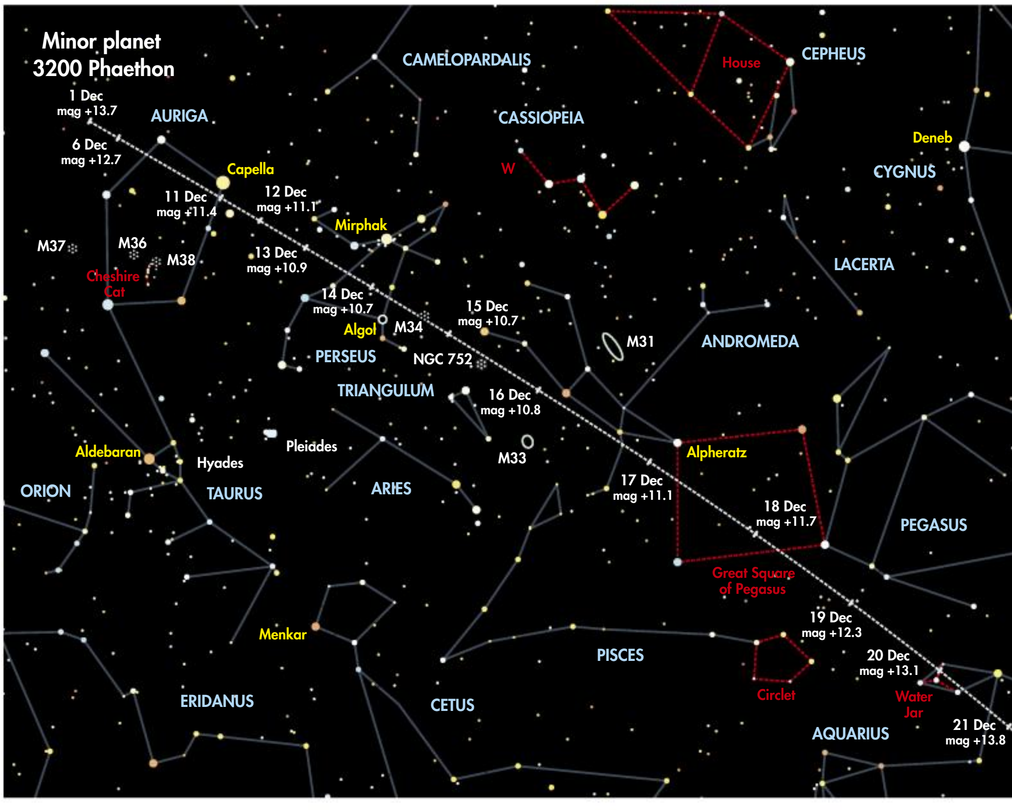
Take me to the river

Below Orion is Lepus, the Hare, which resembles an infinity symbol with ears. To the west of Rigel and Lepus is the northern portion of Eridanus, the River. From the northern hemisphere its lacks any really bright stars. However, viewed in the southern hemisphere, Eridanus ends with the bright star Achernar, which means 'end of the river'.

Extend Orion's Belt northwest to arrive at orange Aldebaran, the brightest star in Taurus. Its name means 'follower', possibly a reference to it following the spectacular Pleiades cluster, or Seven Sisters, across the sky. Aldebaran sits at the end of the southern arm of the V-shaped Hyades open cluster. Despite its visual connection, Aldebaran is much closer than the cluster, being 65 lightyears away compared to the Hyades at 153 lightyears. Extend the line from Orion's Belt through Aldebaran and you get to the Pleiades open cluster. This is about three times further away than the Hyades, at a distance of 444 lightyears. Northeast of Taurus lies the misshapen pentagon of Auriga, the Charioteer, topped with the bright yellow star Capella. This is a rich constellation containing the open clusters M36, M37 and M38. They can be seen with binoculars but a telescope gives the best view. Northernmost M38 sits at the end of a curved line of stars forming the 'smile' of the Cheshire Cat asterism.

The new Moon on 18 December is perfectly timed for the return of the Geminids. Emanating from a region near the star Castor in Gemini, the Geminid meteor shower has a ZHR of 120 at its peak during the early morning of 14 December.

Meteor showers are normally associated with the dust debris strewn around the orbit of comets. But the Geminids' parent body is an asteroid called 3200 Phaethon. This is unusual as it has an orbit more akin to a comet, taking it closer to the Sun than any other named asteroid. There's a rare opportunity to spot 3200 Phaethon this month as it makes a relatively close approach to the Earth on 16 December. At 10.25 million km away it should be visible through a small telescope.



▲ 3200 Phaeton traces a path across our skies this month and should be visible on 16 Dec

"It's the remains of a star that went supernova in 1054 AD, an event so bright that it remained visible in daylight for 23 days"

Our most powerful telescopes are able to reveal the colourful patterns entwined around the Crab Nebula

Stats

NAME AND CATALOGUE REFERENCE: **M1**
CONSTELLATION: **Taurus**
OBJECT TYPE: **Supernova remnant**
VISUAL BRIGHTNESS: **Mag. +8.4 (binoculars)**
DISTANCE: **6,300 lightyears**
APPARENT SIZE: **6x4 arcminutes**
PHYSICAL SIZE: **11x8 lightyears**

M1

The Crab Nebula

The fallout from a massive stellar explosion that occurred almost 1,000 years ago can still be seen in today's sky

BINOCULARS Getting a closer look

M1 is the Crab Nebula in Taurus. It's the remains of a star that was seen to go supernova in the year 1054 AD, an event so bright that it remained visible in daylight for 23 days and visible to the naked eye for nearly two years. If you look at the area today you'll see the remaining layers of star that have been blasted off into space. You can just about see M1 with binoculars but a good, dark sky is required. It looks like a faint glowing patch. The key to locating it is to first identify mag. +3.0 Zeta (ζ) Tauri. There's an irregular quadrilateral formed with Zeta and three fainter stars to the north. Once you've identified this, M1 sits half a degree west of the mag. +6.9 star marking the quadrilateral's northern corner.

SMALL TELESCOPE Get more detail

A small telescope shows M1 as a compact glow. Start with a low power then slowly increase the magnification to get the best view. It appears 3x5 arcminutes in size through a 150mm scope. It may seem this is all you're going to see, but let your eye adjust to the view. Use averted vision, looking slightly off to the side, to put the nebula's light onto a more sensitive part of your retina. With time, the elongated glow becomes a rough S shape. The darkness of your sky makes a big difference here as any brightening will cause the nebula to shrink or disappear. The Messier catalogue was created to record deep-sky objects that could be mistaken for comets and the visual behaviour of the Crab fulfils this remit perfectly.

LARGE TELESCOPE See it all

The larger the aperture the more detail you'll see. The S-shape described above becomes more pronounced, the core more elongated and brighter than the other regions. Choose a magnification that gives a good scale while retaining enough contrast and brightness to allow detail to be seen. Imaging helps bring out further details including the filamentary structures that produce the mottling you'll see. A camera also shows what remains of the supernova star's insides: an exotic mag. +16.5 pulsar. This was the first pulsar to be linked to a supernova and is just 20km across despite containing 1.4x the Sun's mass. It emits a beam of radiation that we see every time the pulsar spins, at a rate of 30 times every second.

WOLFGANG PROMPER/CCDGUIDE.COM, PETE LAWRENCE X 3

INSIGHT
ASTRONOMY
PHOTOGRAPHER
OF THE YEAR

You've seen the winners of 2016's premiere astrophotography competition on the opening pages of our monthly guides and our favourite runner-up in December. Now see the rest of the runners-up and the highly commended entries

RUNNERS-UP

A runner-up prize was awarded for each main category except Robotic Scope and the Sir Patrick Moore prize for Best Newcomer

▲ OUR SUN

Sun Flower Corona

Catalin Beldea and Alson Wong, Romania and USA

Equipment: CFF Telescopes 80mm f/6 oil-spaced triplet apochromatic refractor telescope, Astrotrac mount, Nikon D7200 camera

◀ **AURORAE**

Black and White Aurora

Kolbein Svensson, Norway

Equipment: Nikon D750 camera, 14mm f/2.8 lens

▼ **GALAXIES**

Towards the Small Magellanic Cloud

Ignacio Diaz Bobillo, Argentina

Equipment: Astro-Physics 130 f/5 Gran Turismo telescope, Losmandy G11 mount, Canon EOS 6D camera

▶ **PLANETS, COMETS & ASTEROIDS**

Comet Catalina

Gerald Rhemann, Austria

Equipment: ASA Astrograph 8-inch f/2.9 telescope, ASA DDM-60 mount, FLI PL 16803 camera

▼ **SKYSCAPES**

Silent Waves of the Sky: Noctilucent Clouds

Mikko Silvola, Finland

Equipment: Canon EOS 6D camera, 300mm f/3.5 lens

▲ STARS & NEBULAE

Perseus Molecular Cloud

Pavel Pech, Czech Republic

Equipment: ASA 10-inch Newtonian telescope, Gemini 53F mount, Moravian Instruments G3-11000 CCD camera, f/3.6 reducer

▼ INSIGHT ASTRONOMY PHOTOGRAPHER OF THE YEAR – YOUNG

What the City Does Not Show You

Jasmin Villalobos, USA (aged 15)

Equipment: Canon EOS 1200D camera, 20mm f/3.5 lens, ISO 3200

◀ OUR MOON

Rise Lunation

Katherine Young, Sweden

Equipment: Canon PowerShot SX50 HS camera, 215mm f/6.5 lens, ISO 400

HIGHLY COMMENDED

Highly commended prizes were awarded for each main category, with three prizes awarded in the Insight Astronomy Photographer of the Year – Young category

▲ **SKYSCAPES**

Geminids over the LAMOST Telescope

Yu Jun, China

Equipment: Canon EOS 6D camera, EF 24mm f/1.4L II USM lens

▲ OUR MOON

Moonrise at the Pier

Sergio Garcia, Mexico

Equipment: Nikon D750 camera, 600mm f/6.3 lens

◀ PLANETS, COMETS & ASTEROIDS

King of the Planets

Damian Peach, UK

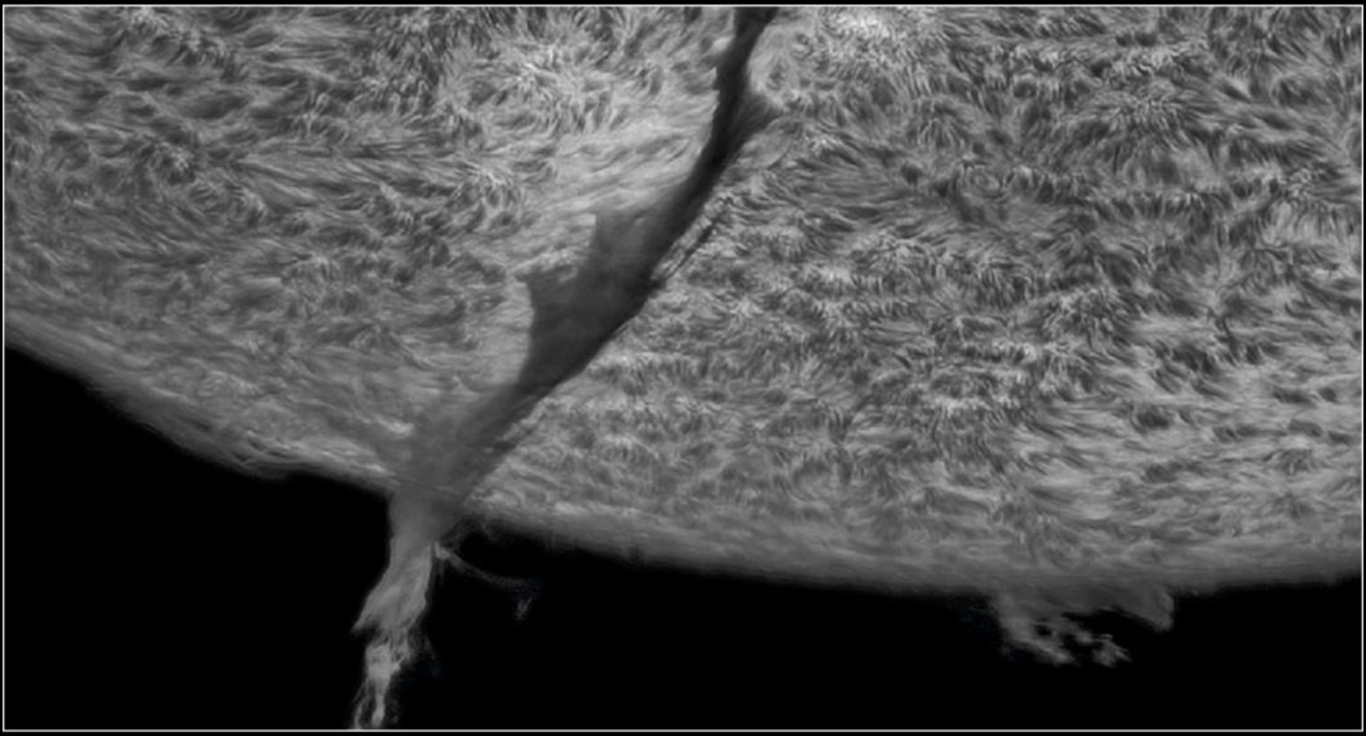
Equipment: Celestron C14 telescope, Celestron CI-700 mount, ZWO Optical ASI 174mm camera

▼ OUR SUN

Huge Filaprom

Gabriel Octavian Corban, Romania

Equipment: Sky-Watcher Equinox ED120 Doublet refractor telescope, Sky-Watcher NEQ6 Pro mount, Pt Grey Grasshopper GS3-U3-23S6M-C camera, 3780mm f/31.5 lens, Daystar Quark H-alpha filter



INSIGHT ASTRONOMY PHOTOGRAPHER OF THE YEAR – YOUNG ▶

Just Missed the Bullseye

Scott Carnie-Bronca, Australia (aged 14)
Equipment: Canon 70D camera, 17mm f/5.6 lens

▲ INSIGHT ASTRONOMY PHOTOGRAPHER OF THE YEAR – YOUNG

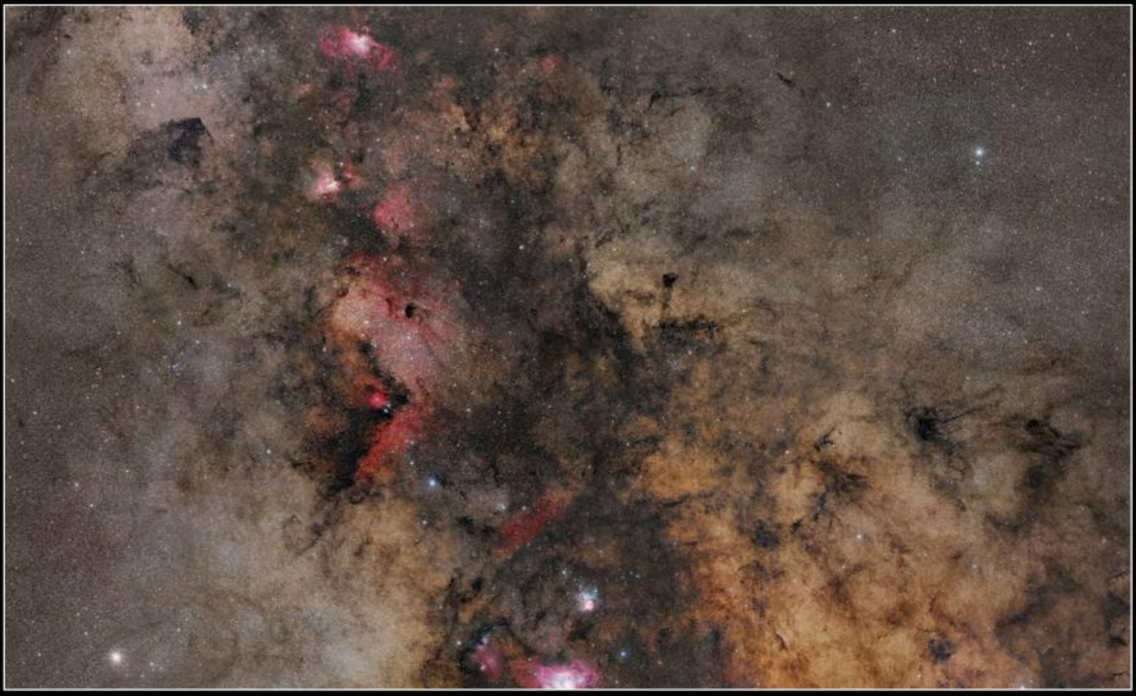
Jupiter

Olivia Williamson, UK (aged 12)
Equipment: Celestron C11 Schmidt Cassegrain telescope at f/25, Sky-Watcher AZ-EQ6 GT mount, Imaging Source DMK 21AU618 camera

INSIGHT ASTRONOMY PHOTOGRAPHER OF THE YEAR – YOUNG ▶

Northumbrian Aurora

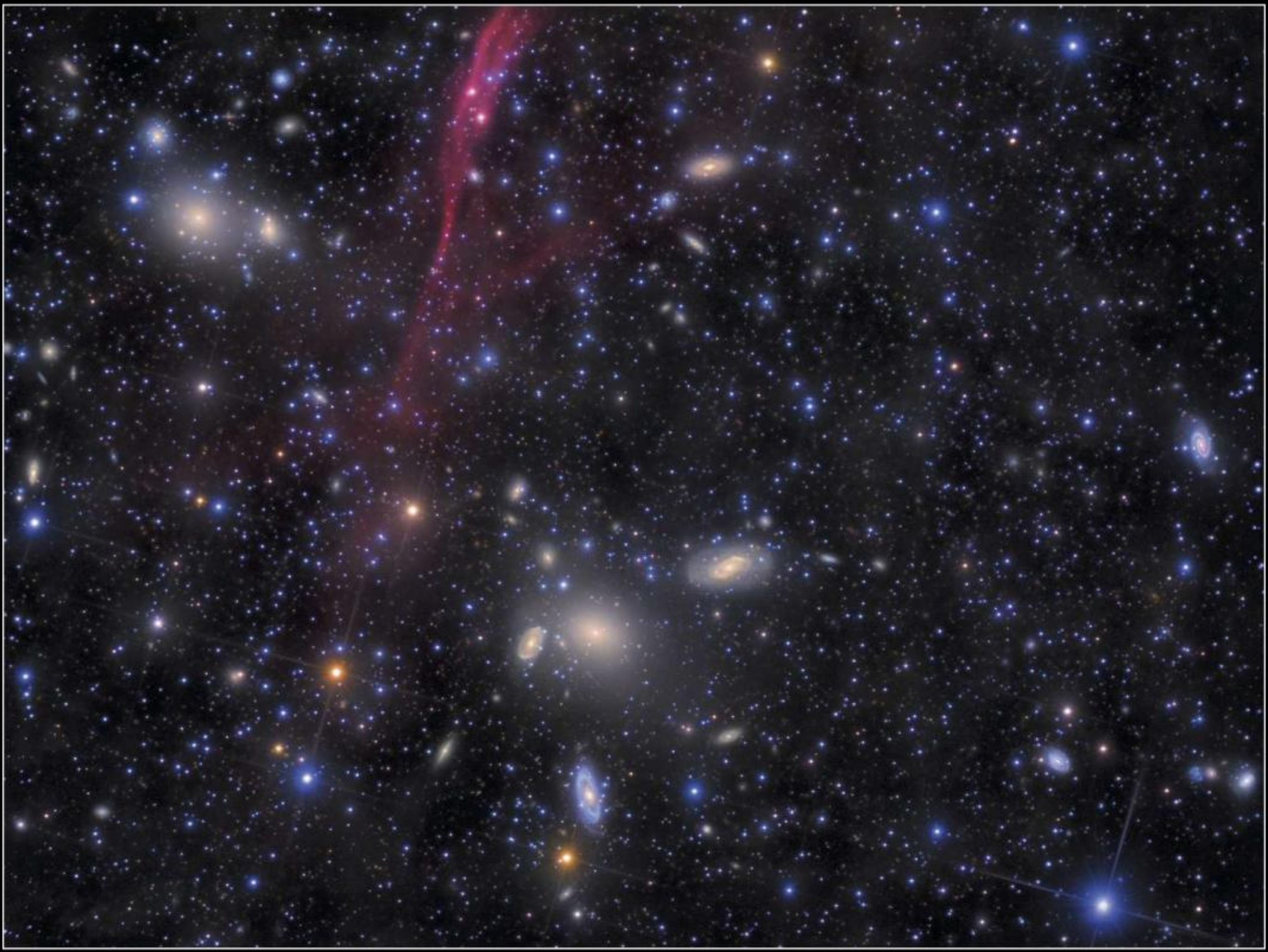
Jonathan Farooqi, UK (aged 15)
Equipment: Canon EOS 550D camera, 18mm f/3.5 lens



◀ STARS & NEBULAE

Starlight and Silhouettes

Tom O'Donoghue, Ireland
Equipment: Takahashi FSQ-106N f/5 refractor telescope, Takahashi EM-200 mount, Atik 11000 CCD camera



▲ GALAXIES

Antlia Galaxy Cluster: Extreme Deep Field, 152 Hours

Rolf Wahl Olsen, Denmark

Equipment: Home-made 12.5-inch f/4 Serrurier Truss Newtonian telescope, Losmandy G11 mount, QSI 683wsg-8 camera

▲ AURORAE

Corona

Bernt Olsen, Norway

Equipment: Nikon D800 camera, Nikkor 14–24mm f/2.8 lens

▲ PEOPLE & SPACE

A Wise Son Makes a Glad Father

Robin Stuart, Kenya

Equipment: Canon EOS 5D Mark III camera, 14mm f/2.8 lens

▲ The oval Mare Crisium in the upper right changes position relative to the Moon's eastern limb due to libration

SHOWING LUNAR LIBRATION

Pete Lawrence shows you how the rocking and rolling of the Moon allows you to see around its sides

The Moon is the Earth's nearest neighbour in space and both orbit a common centre of gravity, or barycentre, which lies 1,700km below the Earth's surface. Over time the Moon's rotation period has synchronised with this orbit causing it to present the same, battered face to us throughout the lunar month. Well nearly…

The orbit is elliptical so the Moon's distance from us is constantly changing along with its speed. This is slowest when the Moon is at its furthest distance from us and fastest when it's closest.

The plane of the Moon's orbit is also inclined by approximately 5° to that of the Earth's orbit around the Sun.

Taken together, these effects allow us to see a bit more of the Moon than we should. The speed variation allows us to peek around the eastern and western edges of the Moon while the inclination allows us to glimpse around the northern and southern edges. This rocking and rolling is known as libration and its effects, when combined, allow us to see a total of 59% of the Moon's surface.

RECOMMENDED EQUIPMENT

Any setup that's capable of capturing the entire disc of the Moon and showing the main features of the lunar surface, such as the dark seas and larger craters.

Features really close to the edge of the Moon are described as being within the libration zone. When libration is favourable for them, they can be seen with reasonable clarity. When libration is unfavourable, they won't be visible at all. Catching a good look at a feature in the libration zones is harder than you might think. Obviously the libration needs to be favourable, moving the feature closer to the centre of the Moon's disc. Then the phase has to be right. It's no good having favourable libration for a feature if the phase means it can't be seen. On top of this, the weather also has to play ball to allow you to see the favourable phase-libration window.

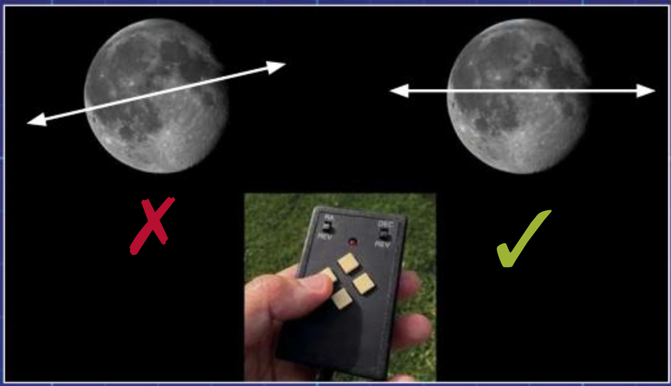
There are various ways to see what libration will be evident on a particular date. For example, the excellent Virtual Moon Atlas (**www.ap-i.net/avl/en/start**), has this capability.

You can see and illustrate the effects of libration by imaging the Moon's disc over as many consecutive nights as possible, then creating an animation from the results. The vagaries of the UK's weather mean that many sequences will be interrupted, but it's surprising how short a window in cloud you need to actually catch the Moon – so it's worth being tenacious! Try to capture as many sequences as you can throughout the course of the year and then use the longest for your animation.

PETE LAWRENCE X 7

STEP-BY-STEP GUIDE

Create an animation to see more of the Moon

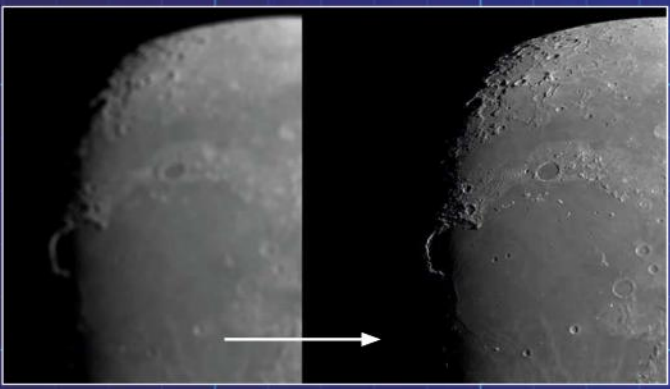


STEP 1

This project is suitable for a setup that can record a full lunar disc while also showing a reasonable amount of detail; Mare Crisium and crater Grimaldi are the bare minimum. A focal length of 400mm or longer is recommended. Full-disc shots make life easier but mosaicing higher-magnification images to cover a full disc will work too.

STEP 2

It's important to keep the same orientation between shots. If you're using an equatorial mount, place the Moon in the field and slew back and forth in RA. Carefully rotate your camera so the Moon moves parallel to the upper and lower edges of your image frame. Once done, your camera will be aligned to the RA-Dec coordinate system.



STEP 3

Choose the terminator region as the focus target and focus as accurately as possible. Here the stark shadows and highlights really help. If your camera allows, zoom in to make sure your focus is really sharp. Even when the Moon is full, there should still be a very thin terminator visible right on the edge.

STEP 4

Adjust the camera's sensitivity and exposure to give you a correctly exposed image of the Moon. Avoid white-outs (over-exposure) or black regions on the disc (under-exposure). For DSLRs, keep the ISO relatively low, 100-200 for example. For non-tracking setups, use a higher ISO and shorter exposure to avoid motion blur.

STEP 5

Load a completed sequence into a layer-based editor, one image per layer and in date order. Make all layers invisible except the bottom one. Make the next layer up visible and align with the bottom layer so the disc centres correspond exactly. Repeat this process for all the layers, aligning each one to the layer immediately below.

STEP 6

There are various ways to create the animation. Photoshop, for example, has a 'timeline' feature that lets you create animation frames with each layer. Alternatively, save each one in a lossless format such as TIF and load them into the freeware PIPP application (sites.google.com/site/astropipp) from where the animation can be created.

VARIABLE STARS LIGHT CURVES

Pete Lawrence guides you through the process of how to chart the changing brightness of stars

Many of the stars visible in the night sky vary in brightness over time. Most vary by such a small amount that you'd need specialist equipment to be able to detect it. Others, such as Omicron (ο) Ceti, or Mira, have such large swings that they can change the appearance of their host constellation.

Some vary periodically while others are erratic. Examples include Beta (β) Perseii, or Algol, which varies predictably over a period of two days 20 hours and 49 minutes, and R Corona Borealis, which appears to have a mind of its own!

RECOMMENDED EQUIPMENT

Any setup that can record stars down to the limit of the comparison charts, including DSLR's fitted to small telescopes or standard lenses.

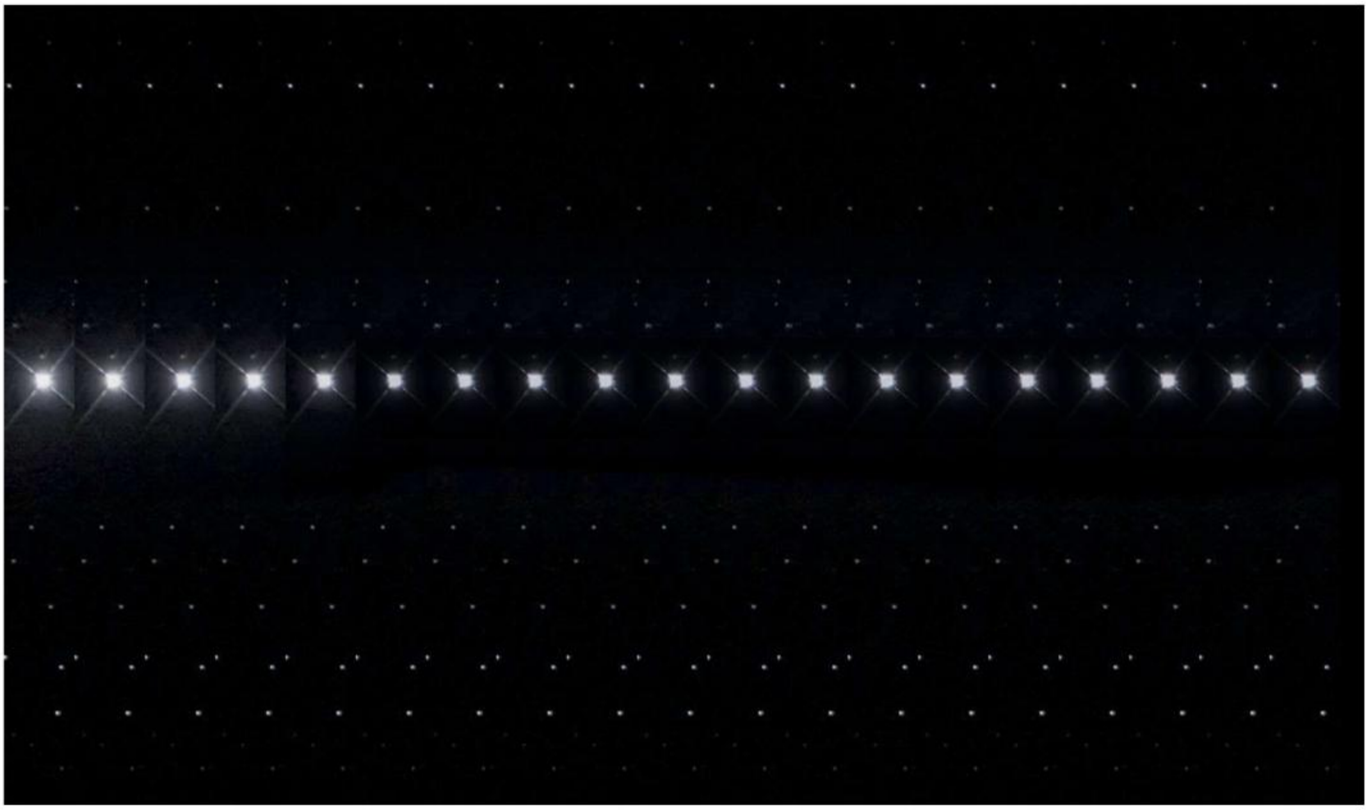
Methodically recording the brightness of a variable star is a valuable way to keep an eye on what it's doing and provide scientific information that can be used to deduce what makes it tick. Collecting this information allows you to produce a light curve: a graph that shows brightness variations over time. There are many fine organisations out there to help you observe variable stars, and these often have excellent resources to help you find and select comparison stars. It's important to get these right otherwise you may end up comparing one variable star with another, leading to a very confusing mix of light curves.

Photographically, it's possible to produce a strip diagram showing how a star's brightness varies over time. Here, the difficulty is getting the exposure right so that it emulates the results from a previous session. Keeping the exposure settings the same from one night to the next is the first step, but difference between the transparency of the atmosphere from one night to the next can still cause issues.

Certain software, for example Maxim DL, has routines that allow you to work out how bright an object is by comparing it to comparison stars of known brightness in the image. Such routines allow for the automatic generation of light curves from numerous images (**www.cyanogen.com/help/maximdl/Photometry.htm**).

To get you started, this project gives you a basic method for showing how a star varies photographically over time. The results will be approximate but should be accurate enough to allow you to produce an interesting strip diagram, or animation, to show how these objects vary.

We've picked three stars to get you started, but if you want more, visit **www.britastro.org** or **www.aavso.org**. Our three selections are Algol, R Coronae and Mira. Algol's variability is predictable and relatively fast. R Coronae is unpredictable and requires constant monitoring while Mira is semi-predictable, taking 332 days to complete one cycle.

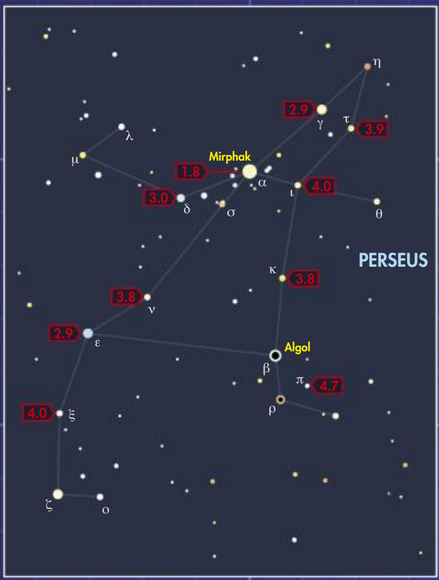


PETE LAWRENCE X 7

▲ **A time-strip image can be used to show how a variable star's brightness changes over time**

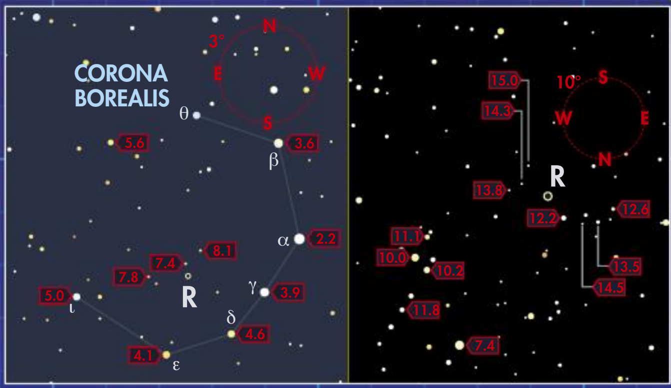
STEP-BY-STEP GUIDE

Produce light curve charts for three stars



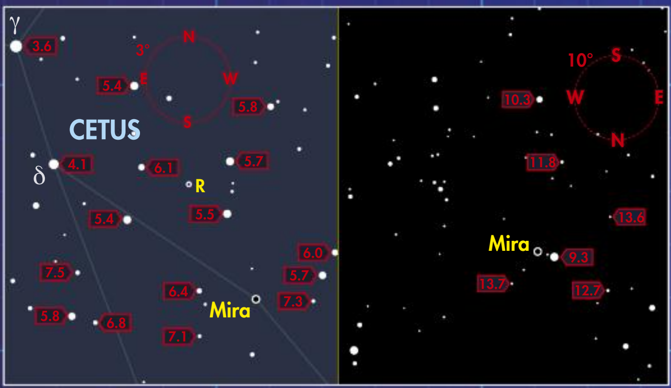
STEP 1

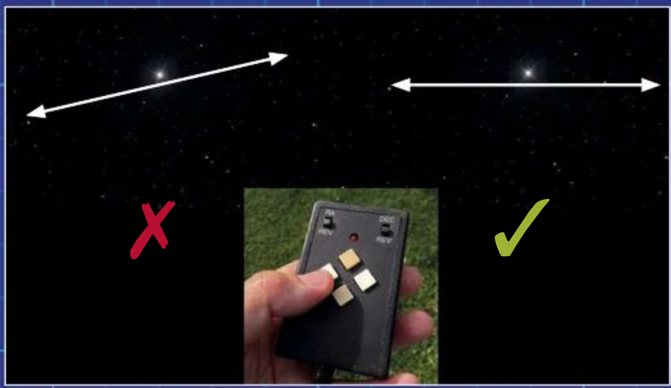
Algol is located towards the bottom of the western leg of the Pi (π) shaped constellation of Perseus. Visible all year round it's not so well positioned between April-July. It exhibits 10 hour-long eclipses every two days 20 hours and 49 minutes meaning it's not possible to catch a complete cycle during a single UK night.



STEP 2

R Coronae is conveniently located within the semi-circular pattern of Corona Borealis. It's visible all year round with November offering the worst circumstances when it's relatively low in the northern part of the sky. This is a more challenging star to record as it swings approximately between 6th and 14th magnitude with an erratic timescale.



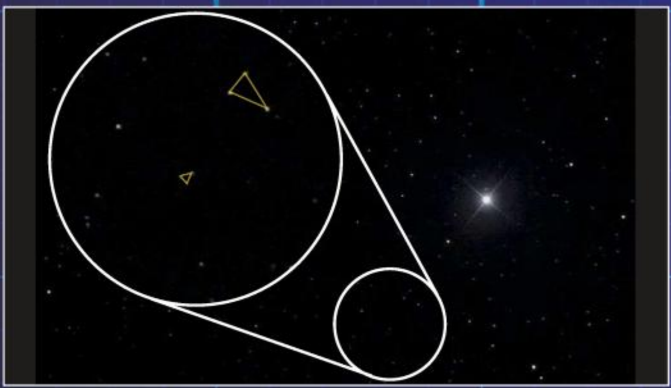


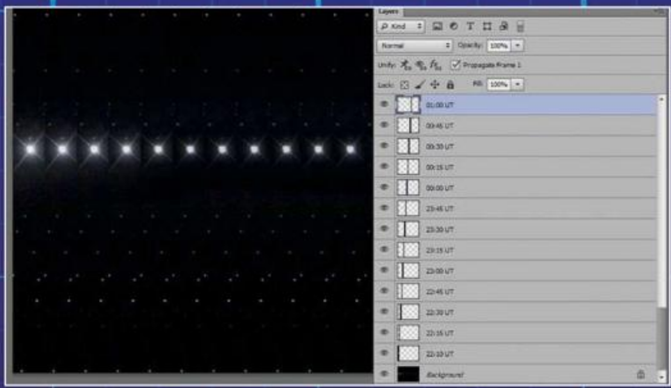
STEP 3

Omicron (o) Ceti, or Mira, is the brightest periodic variable star that can't be seen with the naked eye for part of its cycle. At its brightest, it competes with the brighter stars of Cetus, while at its dimmest you may struggle to locate it with binoculars. The V-shaped pattern of Pisces points directly at it.

STEP 4

Using the same configuration each time, centre on the target star. While not essential, keeping the field orientation the same each time can help when checking the comparison stars. If you're using an equatorial mount, slew back and forth in RA, rotating the camera until the stars move parallel to the bottom edge of the frame. Focus accurately.



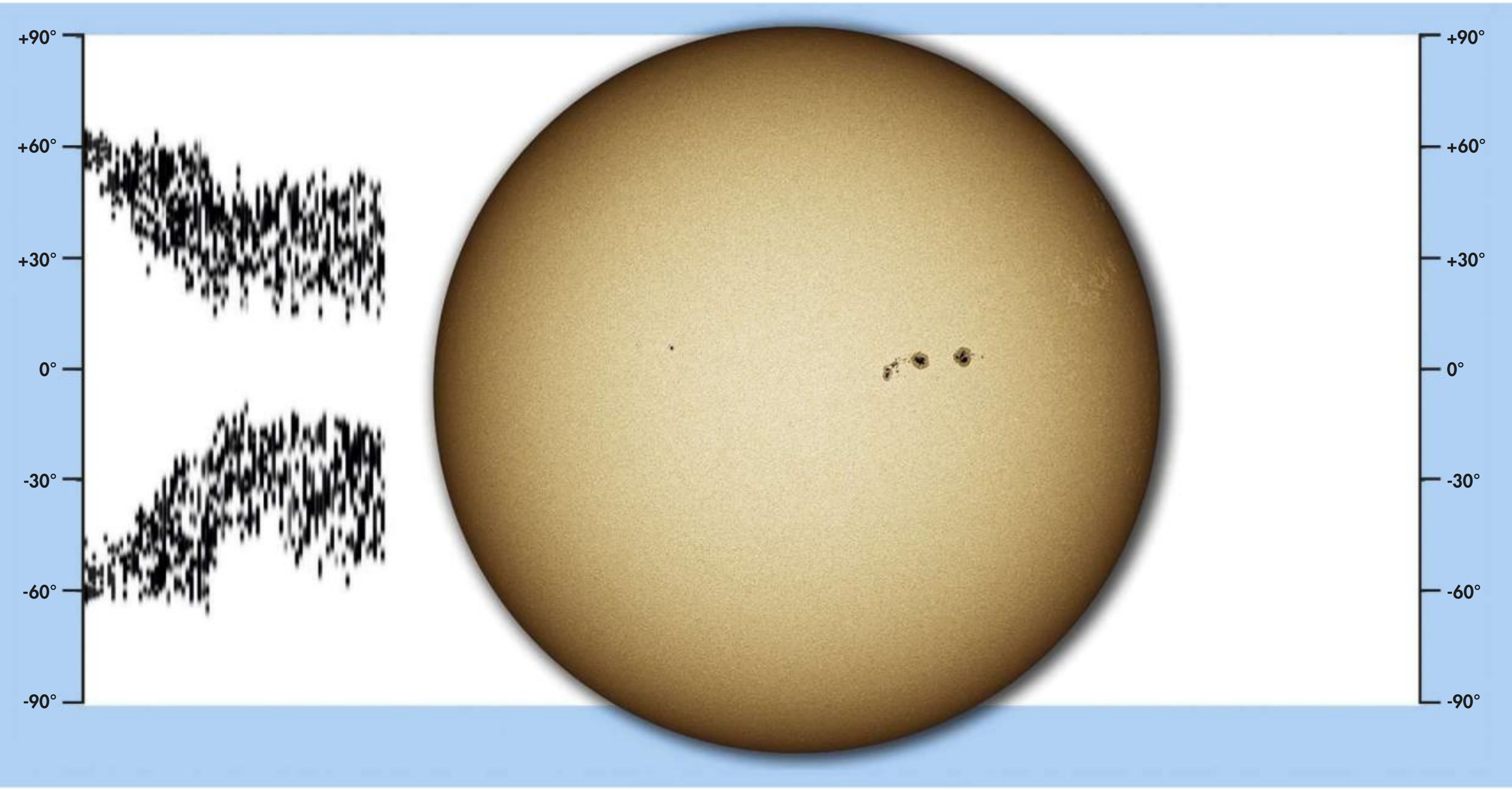


STEP 5

Choose camera settings that record stars slightly below the brightness of the comparison stars described in the charts. Record these settings and take note of a faint 'calibration' star pattern of your choice in the first image. For subsequent images, repeat the settings, adjusting if necessary to get the star pattern looking similar between shots.

STEP 6

Cut narrow vertical strips of the same width from each image and assemble them along a timeline. For example, for R Coronae and Mira, each strip represents a day. Leave missed days blank. For Algol, choose a timeline to reflect a sequence over one night, possibly merging results when you have enough to show a complete recognisable curve.



▲ The more solar activity you plot, the more the pattern formed in your diagram will resemble a butterfly. Be patient – it'll take a long time

PLOTTING A BUTTERFLY DIAGRAM

Chart solar activity on the Sun's surface to gradually build up a butterfly diagram. **Pete Lawrence** shows you how

The Sun is an amazing object to observe. Its appearance changes from one day to the next, delivering a different experience each time you view it. In white light the features of interest are sunspots, slightly cooler regions of the Sun's disc that look dark in comparison to the surrounding photosphere. Although there are typically some spots visible each day, it's not unknown for the Sun to appear completely blank.

Sunspots come and go according to the solar-cycle, which has a visual period of around 11 years. Over the course of this cycle sunspot numbers increase to a peak at solar maximum, and reduce to a low point at solar minimum.

A short-term variability in the number of sunspots visible from one day to the next is accompanied by a longer term variation in where they occur on the disc: at the start of a cycle, spots appear at higher heliocentric latitudes than at the end. Plotting where spots appear throughout a cycle on a graph of heliocentric latitude and time produces what's known as a butterfly diagram due to its symmetry. This shows how spots start closer to the Sun's poles and gradually migrate towards the equator.

A true butterfly diagram plots sunspot area over time, but it's possible to show the latitude migration fairly simply too. You don't have to image the Sun every day but you will have to keep an eye on solar activity (via **www.spaceweather.com**, for example) and image the Sun whenever a new sunspot group, or active region, becomes visible. Organise the results into monthly summary strips and then join them to form the diagram.

The fun thing about this project is that if you regularly image the Sun in white light, there's little more you need to do until you're ready to create the next strip, which can be done during those cloudy periods when you're unable to observe.

Capturing the entire solar disc in white light is something that can be done with a relatively simple setup but your telescope must be fitted with an appropriate white-light solar filter before you point it at the Sun. Also remember to cap or remove the finder. Once you're set up, a full-disc solar image can normally be done in just a few minutes and with the result, you have the ability to create something of real scientific interest. Just be aware that this is a very long-term project – it typically takes years for serious patterns to emerge.

RECOMMENDED EQUIPMENT

Any setup which can produce a full solar disc using a certified white light filter. A driven equatorial mount is highly recommended.

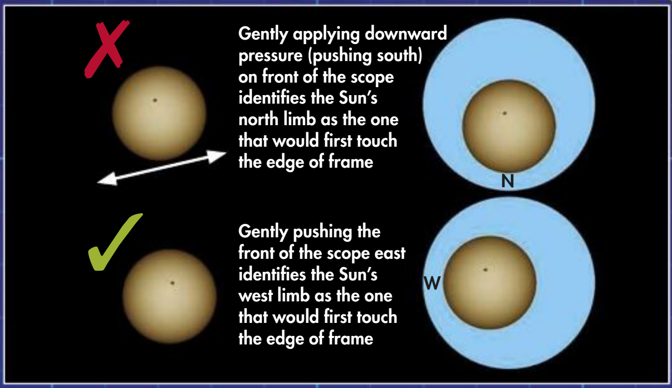
PETE LAWRENCE X 7

STEP-BY-STEP GUIDE

Observe the sun safely to create a butterfly diagram

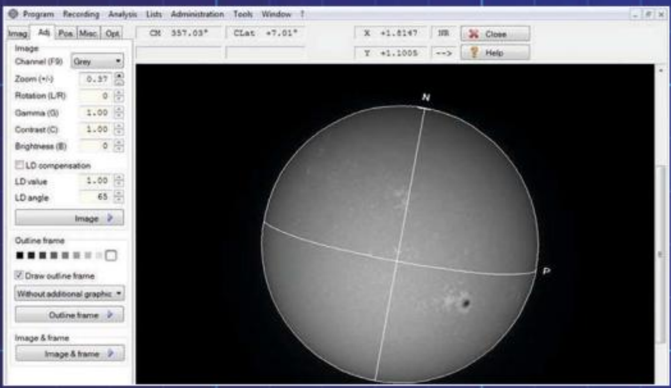
STEP 1

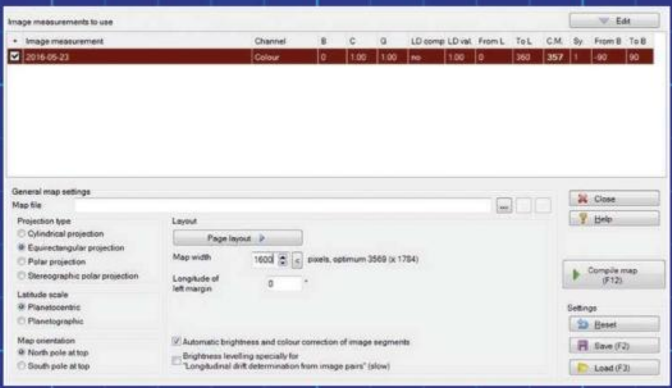
A white light filter can be made from solar film (typically £25 for an A4 sheet), card and tape. Cut it so it entirely covers your scope's front aperture and remove or cap any finders. Use a camera set up for whole disc imaging or to cover areas that may then be mosaiced to produce the full-disc image.



STEP 2

Using an equatorial mount slew back-and-forth in RA. Rotate your camera until the Sun's movement is parallel to the bottom frame edge. Pushing down gently on the scope (southwards) identifies the Sun's north edge as that which touches the frame edge first. A gentle push east similarly identifies the Sun's western limb.



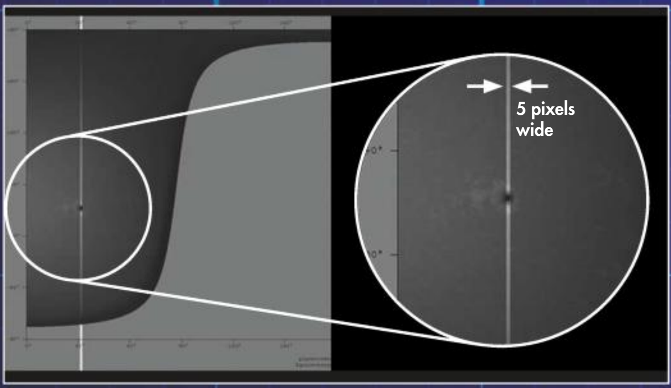


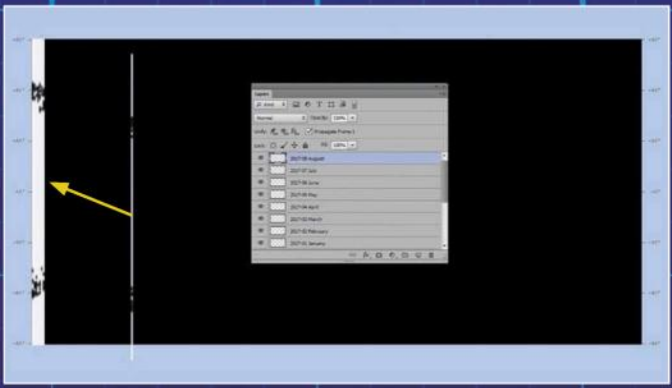
STEP 3

Install WinJupos (jupos.org). Select Program>Celestial body>Sun, then Tools>Ephemerides. Enter image's date and time. Tick 'C.M. + equator'. Select Recording>Image measurement and open the image. Imag. tab: enter image date and time. Adj. tab: press F11 and adjust frame using N/P to match ephemerides graphic orientation.

STEP 4

Reselect the Image tab and save the file (F2). Select Analysis>Map computation. Click on Edit then Add and select the IMS file just saved. Choose Equirectangular projection, Planetocentric and North pole at top. Set the map width to 1,600 and click on Compile map (F12). Then save the result.





STEP 5

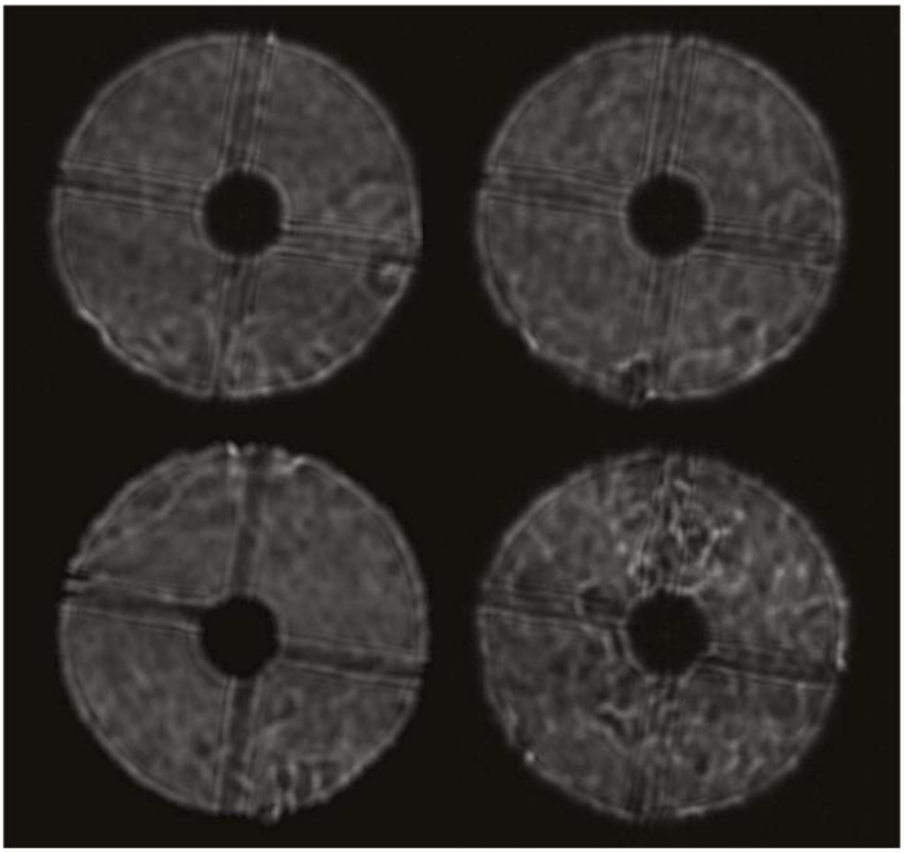
Create a new image five pixels wide and the height of the map you made in step four. Copy step four's map into the five-pixel wide strip as a new layer. Move it horizontally and centralise on the largest spot. If other spots are visible, duplicate the layer and move that horizontally so that appears in the strip too. Set blend mode to darken to merge.

STEP 6

Add results for other days over the month period. Save the final strip referencing the month and year in the filename. If necessary clean the strip by painting out the dark edge extremities with the brightest surface colour. Repeat the process for each month. Add the strips side-by-side to your master butterfly diagram. Add a black strip for missed months.

How to... THERMALLY OPTIMISE YOUR TELESCOPE

Martin Lewis shows you how to combat the irritating effects of tube currents



▲ **Image-disturbing tube currents can be seen silhouetted against the greatly defocused image of a bright star; the currents appear as slow swirls trapped within the disc**

TOOLS AND MATERIALS

FANS AND BATTERIES
For Newtonian mirror cooling choose a low-vibration ball-bearing or Hydro Wave-bearing electric computer fan. Power the fan from an external power supply or an on-board battery pack.

RADIATOR FOIL
The aluminium-coated insulation material sold to fit behind radiators or line lofts can also be used on the outside of a telescope tube.

SPACE BLANKET
A Mylar space blanket is an alternative to radiator foil and can be bought from camping and outdoor shops. Ideally, use both products.

TOOLS
Scissors and insulating tape will be needed to cut and hold the radiator foil or space blanket in place.

Thermal dynamics can have a big influence on the views you get through your telescope, blurring planetary detail, distorting star images and degrading contrast in detailed objects such as globular clusters. If you want the best performance – whether you're imaging or observing visually – it's worth getting to grips with these issues so you can minimise their impact.

Inside a cooling telescope, the warmer (less dense) air rises from hotter parts of the instrument as they lose heat by convection. These 'tube currents' are trapped inside the body of the telescope and, because the warmer air has a different refractive power than the cooler air, they introduce differing delays to light passing through it. This upsets the ability of your telescope's optics to bring the light into a sharp focus.

The longer the optical path inside your telescope and the more unequal the air temperatures, the greater the problems the tube currents cause. For a scope with a 1m focal length, even a 0.1°C temperature difference over its length is enough to degrade images.

Larger telescopes are more affected than smaller ones due to their longer light path, but also because they have a smaller ratio of area to mass, meaning they take longer to cool down. Reflectors also tend to suffer more than refractors because light has to make one passage of the tube before being collected by the mirror and bent inwards away from the tube walls, where the worst convection currents often lurk.

To eliminate the problematic convection currents you just need to allow every part of your telescope to cool to the ambient temperature. Thermal effects subside when the optics and other parts inside your telescope have a less than 1°C difference to the ambient temperature. When that temperature differential is less than 0.5°C, the tube currents diminish and the layer of warmer unstable air that's otherwise stuck to the front of the mirror or primary lens

ALL PICTURES: MARTIN LEWIS

▲ Insulating material, such as a space blanket, can stop your scope cooling too much

almost completely melts away – allowing maximum optical performance.

Unfortunately, getting the scope to cool down sufficiently isn't always easy. If it's been stored indoors, then taking it out into the cold night air and expecting it to perform at its best straight away is misguided. It's much better to store it outside before you begin observing and allow it to cool down properly.

A small or medium telescope might cool down fully in 30 minutes, but a large one can take hours to acclimatise. Because air temperatures continue to fall through the night, the scope may remain a few degrees above ambient. Big telescopes also have big mirrors, and the large mass and the poor conductivity of glass mean they don't give up their heat readily. Fans blowing gently on the back of the mirror can help here.

Insulate against the cold

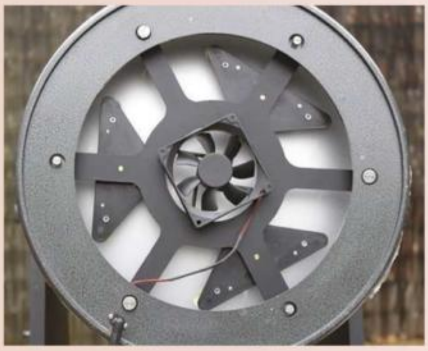
Even if the scope has lost all of its heat to the air, you can still get convection issues of a different kind. Parts of the telescope that face the cold night sky, particularly the top face of the telescope's tube, can drop several degrees below ambient temperature, inducing convection currents of cold air that cascade down inside the tube. Unlike normal tube currents, which tend to die down with time, such 'inverse' tube current processes can plague you all night. The good news is you can combat these effects by wrapping parts of your scope in a poorly radiating material, such as shiny aluminium, or by adding a layer of insulation.

The best way to check for any residual thermal issues before starting your observations is to perform a star test where you rack an eyepiece well inside focus. This allows you to clearly see any thermal currents in the tube silhouetted against the bright expanded disc of the defocused star.

By following the steps to the right, you will see how badly thermal issues affect your telescope and will hopefully be able to reduce their severity to give you sharper views of the night sky.

STEP-BY-STEP GUIDE

Ways to keep your scope at the right temperature



STEP 1

You can speed up the cooling of a Newtonian mirror by fitting an electric fan to the rear cell so that it blows onto the rear face of the mirror. If possible, mount the fan on soft rubber washers or string it between elastic bands to isolate its vibrations.

STEP 2

A low-tech alternative to installing an internal fan on your telescope is to place a desk fan nearby so that it blows on the mirror end. This will help to get the scope closer to the ambient temperature so you can start your observing session.

STEP 3

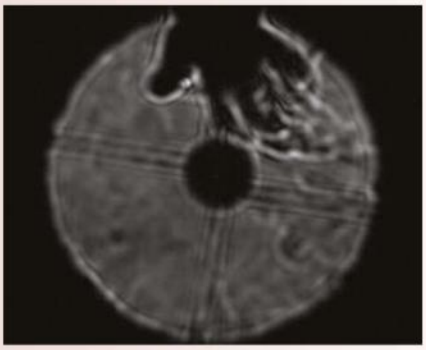
Allow plenty of time for the scope to acclimatise to the outside temperature before you use it. To help speed things up, store your telescope in an unheated place, such as a shed or garage, when not in use. If it's stored in a warm place, it'll need longer to cool.

STEP 4

Fit the scope with a layer of aluminium-coated radiator insulation to reduce inverse tube currents caused by the cold night air, especially during still and transparent nights. This will ensure the exposed parts of the tube stay closer to ambient temperature.

STEP 5

Another method of reducing inverse tube currents is to wrap a Mylar space blanket around the body of your telescope. Like the more permanent insulated foil, this reduces the radiative chilling of the telescope by the cold night air.



STEP 6

Rack the eyepiece far inside focus to expand the image of a bright star to one-third of the field diameter. Tube currents will be seen as swirling patterns of bright and dark, trapped within the circular disc. Experiment using your hand at the front end to see the currents.

How to... MAKE A SIMPLE SOLAR FINDER

WARNING
Do not look directly at the Sun with the naked eye or any unfiltered optical instruments

Stephen Tonkin shows you how to align your scope with the Sun in seconds with this home-made add-on

▲ The completed finder is a great complement to any white-light solar observing setup

TOOLS AND MATERIALS

MATERIALS
12cm of 22mm-diameter copper or white plastic plumbing pipe, 22mm stop-end, 22mm brass compression straight coupler, two compression fitting inserts (if using plastic pipe), translucent plastic milk bottle, 6x30mm finder bracket.

SUNDRIES
Self-amalgamating or electrical tape, safety glasses.

TOOLS
Awl, drill (5mm), pipe-cutter or hacksaw, masking tape, small half-round file, vice with soft jaws, two adjustable spanners or fixed-jaw spanners to fit 22mm cap nuts (32mm across the flats), scissors, fine-tip permanent marker, craft knife.

Non-solar telescopes fitted with white-light filters can be difficult to align to the Sun. One option is to make another white-light filter for your finderscope, but it's difficult to securely fit a filter to a reflex (red-dot or projected reticle) finder; those that display a projected reticle can be permanently damaged by being exposed to the unfiltered Sun. What you need is a bespoke solar finder and we're going to show you how to make one here.

A word of caution. You must ensure that the full aperture of any instrument that you use to observe the Sun is covered with a proper solar filter or filter-mask combination, which you must check before each use. If you don't check it, you risk causing instant and permanent damage to your equipment and, more importantly, your eyes.

It's essential that any solar finder is easy and safe to use, and that it should be robust enough to prevent it from being easily damaged. The safety factor is paramount – there must be no way that you can inadvertently use it to look directly at the Sun. You'll find a solar finder easy to use if its bracket replaces that of the conventional or reflex finder in the telescope's finder shoe. For this reason, we've used a Sky-Watcher finder bracket, which will also fit the finder shoe of several other brands of telescope.

This solar finder is essentially a short pinhole camera with a recessed screen – the screen is recessed so that it can't be easily damaged. The screen is held in place by the retaining ring in a brass compression fitting so it can't accidentally fall out, even with vigorous shaking. Also, the finder can't be removed from the bracket without using tools as the release collar of the stop-end fitting at the front of the finder is inaccessible, so there's no danger of it being accidentally dismantled.

The components required to make the solar finder are easily available, require minimal adaptation and are easy to assemble. They meet the robustness requirements in that they're tried and tested for a purpose that is significantly more demanding than use in a solar finder.

ALL PICTURES: STEPHEN TONKIN

▲ After you've centred the Sun once, the finder should remain perfectly aligned

The stop-end we're using is the SpeedFit; it's a very near fit to the front end of a Sky-Watcher 6x30 finder bracket, with three or four turns of electrical tape to secure it. The circular collar on the cap-nut of the brass compression fitting is an ideal diameter for the bracket's adjustment screws.

Practical considerations

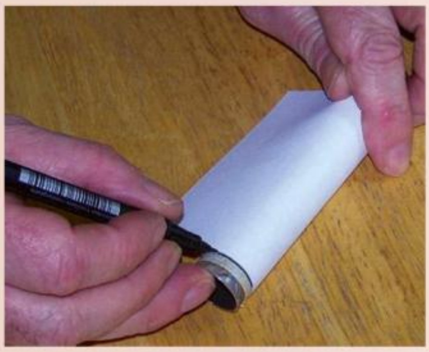
Resourceful readers can freely adapt the design so that it'll fit a different finder bracket or can be made from alternative materials that are already to hand. For example, our prototype used the lid of a 35mm-film canister and the eye cup from a broken pair of binoculars, both of which luckily fitted a piece of focuser drawtube from our junk box. Although we had to modify the base of the finder-bracket with a hacksaw and file for it to fit the finder shoe on the telescope.

The first time you use your solar finder, you'll need to align it to the main telescope. Attach the finder and fix the telescope's solar filter in place. Using a low-magnification eyepiece, centre the image of the Sun in the main telescope. Adjust the finder bracket's alignment screws so that the projected image of the Sun is central on the finder screen and check the main telescope again. It usually takes only two or three attempts before the finder is properly aligned, after which it will remain permanently oriented in that position unless you adjust the alignment screws in the bracket.

From then on, all you need to do is fix the telescope's solar filter in place, attach the solar finder to the telescope and move the telescope so that the projected image of the Sun falls onto the centre of the reticle on the finder's screen. Finding and centring the Sun now takes only a matter of seconds. This ease and speed of acquiring the target is especially valuable when you are trying to observe the Sun through gaps in the cloud on overcast days.

STEP-BY-STEP GUIDE

Build your own solar finder with everyday items

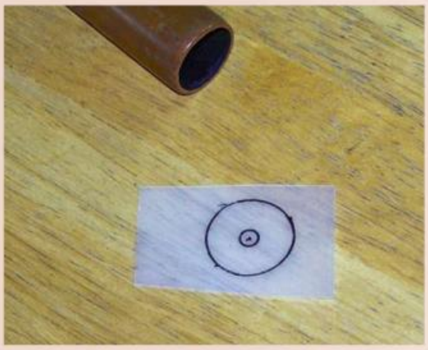


STEP 1

Cut two lengths of pipe: one that's 8.5cm long for the finder body and another that's 1.5cm long for the retaining ring that holds the screen in place. If you don't have a pipe-cutter, wrap the pipe in paper and masking tape, and mark a 'square-cut' ring.

STEP 2

Use an awl or a similar tool to remove the tiny dimple in the recess in the middle of the face of the stop-end. Use the recess as a guide to drill a 5mm hole in the centre of the face. Wear safety glasses when you're drilling.



STEP 3

Cut a flat section of plastic from the milk bottle, approximately 25mm square. Use a fine-point permanent marker to draw around the end of the pipe, then draw a reticle inside the resulting circle. Carefully cut out the screen on the inside of the circle line.

STEP 4

Insert the screen, ink-side down, into the pipe-stop in one side of the straight coupler. Slip the compression olive over the retaining ring and push it into place. Screw on the cap-nut and use the long pipe to push the retaining ring fully home.

STEP 5

Put the collar of the open end of the stop-end into the finder bracket and try to determine how many turns of electrical tape you'll need to make it fit snugly. Wrap the tape onto the collar and trim it so that it won't interfere with the release collar.

STEP 6

Put the long length of pipe into the compression fitting and tighten both cap-nuts half a turn. Attach the finder to the bracket, ensuring that the alignment screws bear onto the circular cap-nut collar. Push on the stop-end to secure the finder firmly in place.

▲ The sensor of a DSLR camera is tucked behind the reflex mirror, hence the camera has to be switched on while you clean it

How to... CLEAN YOUR DSLR SENSOR

Blow and brush the dust from your DLSR's sensor with **Ian Evenden**'s cleaning tips

Dust build-up on a camera sensor can lead to dark blobs on your DSLR images. When it comes to astronomical photos those blobs can obscure detail and darken the brightest parts of a planet or nebula – a particularly galling scenario when you've gone to so much trouble to capture that light in the first place. While these blobs can often be removed in image-editing software with cloning or healing tools, it's best to treat the problem at its source. That means taking the plunge and cleaning the camera's sensor.

The sensor of a DSLR camera hides behind a reflex mirror, which deflects the light coming from the lens up into the prism that forms the viewfinder. It flips out of the way when an exposure is made or the camera is used in live view mode, and thus provides a certain degree of dust-proofing, but the tiny motes can, and will, still get in. The air displacement caused by zoom lenses moving their elements around, for example, can suck dust in.

Dust-reducing systems are built into many modern DSLRs (look for the 'sensor cleaning' message on the screen as you turn the camera on and off) and these do a decent job of shaking light dust particles from the sensor by vibrating it at ultrasonic speeds.

Before and after

Before you clean your sensor, take a test shot. Pop on a lens, stop it down to f/22, and take a photo of the sky during the day

ALL PICTURES: IAN EVENDEN

TOOLS AND MATERIALS

Cleaning kit, air blower and brush, positionable light or a head torch, clean cloth, clean working environment.

WARNING
We do not recommend you use the cans of compressed air commonly used to blast dust out of keyboards, as these can introduce moisture into the electronics of your camera.

(taking care not to aim at the Sun, of course) or a plain white wall, then increase the contrast in an editing app. The resulting image won't be the finest you've ever taken – it'll probably be a noisy mess – but it will highlight the condition of your camera's sensor. The dust becomes more noticeable the more you close down the lens aperture and sticks out most on a plain light background.

With a magnifying glass or loupe, you'll be able to identify individual specks of dust on the sensor using the image you just took as a guide – note that specks at the bottom of the sensor will be at the top of the picture. But taking the photo is really more useful to determine the state of the sensor. If dust is visible on the f/22 image, but not on images taken at f/2.8 or f/8, then you should consider leaving it alone until the specks become a problem. And once you've cleaned your sensor, you can take another f/22 photo to see the difference you've made.

The right tools

For large or stubborn dust particles, cleaning kits are available from most photographic retailers or online, and generally consist of a small bottle of cleaning solution and some brushes or swabs. Alternatively, a dry electrostatic brush can be used that the dust will stick to. Using the right sort of cleaning material is important, as a DSLR sensor is delicate and a scratch to its surface will do more damage than any amount of dust. Don't be tempted to dive in with a paintbrush, a lens cleaning brush, or anything that could damage the sensitive chip.

It's possible to clean a sensor without touching it at all. Lightly attached particles of dust can be removed using a blast of air. Special blowers are available for this, some shaped pleasingly like a rocket. Hold the camera with the lens mount pointing down, then blow air up into the camera. Dislodged dust will then drift down under the force of gravity.

Before you begin, clean the outside of your camera and the area you're going to work in. This is important to prevent you adding more dust to the sensor than you remove. If you're using a blower, keep it in a sealed plastic bag so it doesn't collect dust and blow it into your camera's innards. You'll also want to make sure your camera battery is charged, as it will be on and holding its mirror open throughout the cleaning process.

STEP-BY-STEP GUIDE

Cleanse your camera's sensor

STEP 1

You need to get at the sensor if you're going to clean it so the first thing to do is expose it. Most DSLRs have a cleaning option in their menus, though all models and manufacturers are different, so check the manual. Once you've activated it, the mirror will flip back.

STEP 2

Use a blower to dislodge any lightly attached particles. Then lightly drag an electrostatic brush across the sensor – don't scrub or dab as if you're applying paint – then remove it without catching it on the lens mount and knocking the dust off. Never touch the bristles.

STEP 3

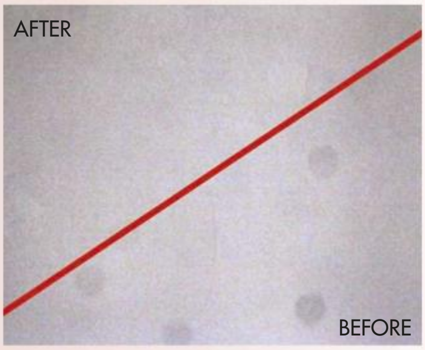
Squeeze a few drops of cleaning solution onto a swab, not onto the sensor. You only need enough to make it damp, not so much that the solution drips off the swab when it's held upside down. The fluid will evaporate quickly, so don't hang about.

STEP 4

Place the swab gently on the sensor and move it from side to side. The kits are tailored to the kind of sensor you have (usually APS-C or full frame) so the swab should be the right size and you won't have to wiggle it about to get the necessary coverage.

STEP 5

When you've completed a wipe in one direction, flip the swab over so you're using the clean side, and use that to wipe in the other direction. Once this is done, remove the swab and dispose of it. Don't be tempted to reuse them.



STEP 6

You're done. Turn the camera off and the mirror should flip back into position. Attach a lens, switch it back on again, and take another reference photo to admire your work. The image above shows the same area of a sensor before and after cleaning.

Glossary

Essential astronomical terms defined and explained

ALTAZIMUTH MOUNT
A type of telescope mount that's simpler to set up than an equatorial mount, but requires simultaneous movement about the vertical (altitude) and horizontal (azimuth) axes to track a celestial object.

AVERTED VISION
A technique for observing faint objects through a telescope. It involves viewing slightly to the side of the object, allowing its light to fall on an area of the eye more sensitive to light.

BARLOW LENS
A Barlow lens sits between a telescope's focuser and an eyepiece, and is used to increase the magnification of an eyepiece.

CATADIOPTRIC TELESCOPE
This is an optical system that uses both reflective and refractive elements. The Schmidt- and Maksutov-Cassegrain telescopes are both catadioptric designs, with a lens at the front and a mirror at the back of the scope.

CELESTIAL EQUATOR
A projection of the Earth's equator on to the night sky.

CELESTIAL SPHERE
This is the name given to the projection of the night sky on to an imaginary sphere around the Earth. The astronomical co-ordinates of right ascension and declination are also mapped on to this sphere.

COLLIMATION
The process of aligning the optical elements of a telescope.

DECLINATION
The celestial equivalent of latitude, this is the distance of a body north or south of the celestial equator, measured in degrees, minutes and seconds (°, ′ and ″). Objects north of the celestial equator have a positive declination, while those south of the celestial equator have a negative declination.

ECLIPTIC
The apparent annual path of the Sun against the background stars.

ELONGATION
The angle in the sky between a planet and the Sun, as seen from Earth. When a planet is at greatest elongation (east or west), it is – from our perspective – at its farthest apparent distance from the Sun.

EQUATORIAL MOUNT
A telescope mount with an axis that's aligned parallel with the Earth's axis of rotation. This enables stars to be tracked as they drift across the sky by moving just one axis.

EYE RELIEF
The distance your eye has to be from an eyepiece for you to see the full field of view. People who wear glasses have to put their eye further away from the eyepiece and so need a longer eye relief.

FINDERSCOPE
The small, low-magnification telescope that is attached parallel to a main telescope tube. It's used to first locate celestial objects as it has a wider field of view than the main tube.

FOCAL LENGTH
The distance between a telescope's main lens or mirror and the point at which an image is brought into focus. You can work out magnification with this number, which is calculated by dividing the focal length of a telescope by that of an eyepiece.

MAGNITUDE
The brightness of an astronomical body. The lower the number, the brighter the object is. Magnitudes brighter than zero are represented with a negative number.

MERIDIAN
An imaginary line circling the Earth from north to south that marks the point at which the Sun is at its highest in the sky. Ante- and post-meridiem (am and pm) respectively mark the times before and after the Sun crosses the Meridian at midday.

NEWTONIAN TELESCOPE
A telescope that uses mirrors to collect and focus incoming light. A primary mirror collects the light, which is then intercepted by a smaller secondary mirror at an angle and reflected out of the side of the telescope to give a convenient viewing angle.

OPPOSITION
The position of a superior planet when it's opposite the Sun in the sky, as viewed from the Earth.

PLÖSSL EYEPIECE
A type of telescope eyepiece that provides a wide field of view and good eye relief, as typically there's a large distance between the lens and the exit pupil.

POLARSCOPE
A small scope that fits into equatorial mounts to help achieve an accurate polar alignment for your telescope. Accurate polar alignment is essential to take good quality, long-exposure images, where the star field needs to be tracked.

REFLECTING TELESCOPE
A telescope that collects and focuses light using one or more mirrors.

RGB
A digital image records any colour as a combination of different intensities of red, green and blue.

RIGHT ASCENSION
The celestial equivalent of longitude, right ascension is measured in hours, minutes and seconds (h, m and s). The 0h line is measured from the point where the Sun crosses the celestial equator on its apparent path through the sky each year, a point called the vernal equinox.

SEEING
A measure of how steady Earth's atmosphere is. When the atmosphere is turbulent, views through a telescope tend to be blurrier; this is also the reason that stars appear to twinkle.

UNIVERSAL TIME (UT)
A timescale based on the rotation of the Earth on its axis, UT is measured from midnight at the Greenwich Meridian. In astronomical use UT replaced Greenwich Mean Time (GMT), which was measured from the Greenwich Meridian at midday, on 1 January 1925.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