The “Bucket List” for Backyard Stargazers

by

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About the “Bucket List”

Stroll through most bookstores and you see them on the shelves… thick books full of a thousand fascinating places to see before you die. Or pieces of great music to listen to. Or exotic things to eat, or exhilarating things to do.

All worthy activities, no doubt.

But we want to think bigger.

So *One-Minute Astronomer* has put together a totally subjective list of ten celestial sights to see before you die, or “kick the bucket”, as they say. We call it the *“Bucket List for Backyard Stargazers”*.

Yes, there are many more than ten things to see up there… millions, in fact. But we choose quality over quantity. Our list is targeted at the casual stargazer, with no special expertise or training or ambition other than to see some of the most beautiful, and in some cases, transient sights in nature.

For some of these objects, you’ll need access to a pair of binoculars or a small telescope. Others require travel and good timing and luck. And for others, you need to simply look up. But all these sights are not that hard to see, once you know how and when and where to look for them. You’ll learn that here.

But that doesn’t mean these are all easy to see. I’d venture a guess that not one person in ten thousand has seen all the objects on this list. (I haven’t, despite more than 30 years of stargazing).

Once you see these 10 sights, then whatever else happens in your life, you can be assured you’ve seen some truly remarkable things that few people– even the most celebrated professional astronomers– ever get to see.

Clear Skies,

Brian Ventrudo, Ph.D.
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#10: The Omega Centauri Star Cluster

We begin the list with the dazzling star cluster Omega (ω) Centauri. Found in the deep southern sky, this globular cluster is an easy target for southern-hemisphere observers from March through October. But in May and early June, some northern stargazers get their best chance to spot the cluster as it peeks just above the southern horizon.

And it's well worth a look. So breathtaking is this swirling mass of stars in a small telescope that astronomy writer Stephen James O'Meara says "observing Omega Centauri is like peering into the working mind of the Creator."

Hubble Space Telescope image of the core of Omega Centauri (credit: NASA)

Omega Centauri is the 800-pound gorilla of our galaxy's globular clusters.

Like other "globs", Omega Centauri is a gravitationally-stable sphere of 12-billion-year-old stars that formed not long after the universe itself.

And like other globs, it orbits the center of our galaxy in a halo of some 180 similar ancient star clusters.

But Omega Centauri is far bigger than the rest. It packs 5-10 million stars into a diameter of 150 light years, a density some 10,000 times greater than we see in our

own night sky. By some estimates, it's at least 5-10x more massive than any other globular cluster in the Milky Way.

Omega Centauri is exceptional in another way. It seems to have formed more slowly than other globs, with two episodes of star formation over two billion years. This suggests it formed by a different mechanism than other globular clusters. Some astronomers speculate it may be the remains of a separate dwarf galaxy absorbed by the Milky Way billions of years ago.

The cluster is one of the few of its kind visible to the unaided eye. Which brings us to its name. Renaissance astronomers cataloged the cluster as a star, and at the time, stars were labeled roughly in order of brightness with Greek letters Alpha to Omega. Since the massive cluster looked like a dim star, it was listed as the star Omega Centauri. Not until John Herschel turned a large telescope on the "star" was its true appearance revealed.

The star cluster Omega (ω) Centauri, upper left, about 13 degrees northeast of the star Gacrux at the top of the Southern Cross (click to enlarge)

And what an appearance! Even in binoculars, the cluster is magnificent. Its misty glow spans a nearly a full degree of sky, twice the span of the full Moon.

Turn a 3 or 4-inch telescope on this cluster and it becomes a shimmering ball of stars, glowing like a frosted light bulb against a rich background of closer-by stars. Even in a small scope, individual stars are visible around the edge; a slightly larger scope resolves the 12-billion-year-old stars right to the core. When you have this object in your sights, look carefully and don't rush. Examine the color and pattern of the stars, and enjoy watching for shapes and streams and gaps in the rich stellar tapestry of this magnificent cluster. Use low magnification to make sure the cluster fits in your field of view.

To see Omega Centauri at all, you need to be south of 43ºN latitude, roughly. It's easy to see south of 30ºN latitude. Ideally, you can venture south of the equator, where the cluster is high in the sky and well placed for viewing from March to October. But a diligent few have seen it from as far north as Point Pelee, the southernmost point in Canada. From there, the cluster appears to skim the surface of Lake Erie for a few clear spring nights.

In southern latitudes, you can find Omega Centauri about 13 degrees– a little more than the width of your fist held at arms length– northeast of gamma Crucis, the top star of Crux, the Southern Cross. The cluster lies some 16,000 light years from Earth.

Find it, enjoy it, and tick one object off your celestial “bucket list”.

The star cluster Omega (ω) Centauri, upper left, about 13 degrees northeast of the star Gacrux at the top of the Southern Cross

#9: Sunrise on the Moon

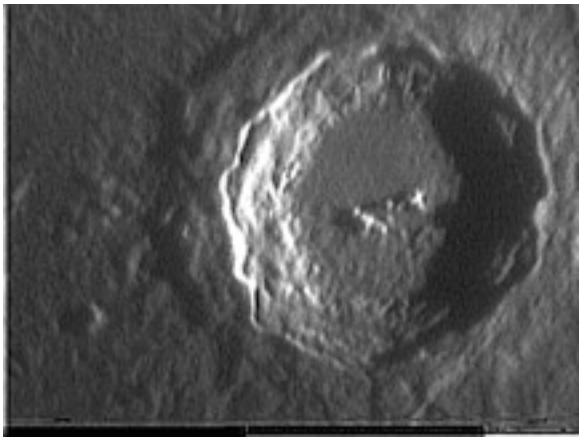
We move on to sight #9, one of the most moving and dynamic scenes you'll ever see in a small telescope: the sun slowly rising over one of the Moon's most spectacular craters.

And you can see it from anywhere on Earth once you know how, when, and where to look.

First, a little orientation…

Look at the Moon any night during the two weeks between its new and full phase. You'll see a bright area and a dark area. An astronaut standing on the bright part of the Moon would enjoy lunar daytime. On the dark area, he would experience night. And along the boundary between the two, which is called the *terminator*, he would see the sun just rising over the lunar horizon.

Because of the sun's low angle at lunar sunrise, our astronaut would see even the lowliest stump of a hillock casts a long, exaggerated shadow across the Moon's surface. And we get the same view from Earth. Which is why the terminator almost always offers the most vivid viewing of the Moon's mountains and ridges and craters. Even a small ridge a few hundred meters high, which would be invisible from Earth with most telescopes, casts a shadow many kilometers long… big enough to glimpse in a small scope. And the bigger the hill, the bigger the shadow.

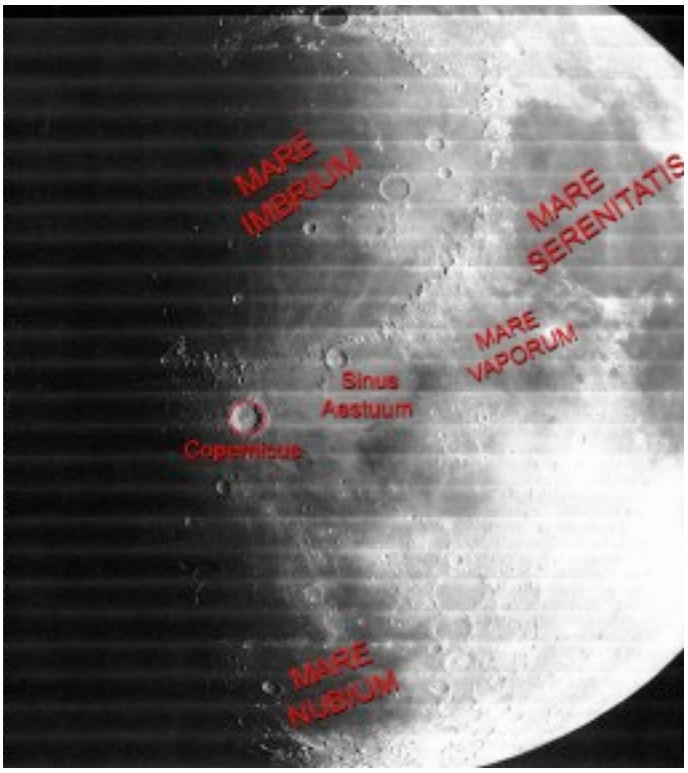


Sunrise over Copernicus crater

Of course, some lunar surface features cast more dramatic shadows than others.

Where the terminator crosses the dark, flat lunar seas (or maria), you see no shadows at all… just a bright side and a dark side. Not particularly exciting.

But when the sun rises over a lunar mountain range or walled crater, it casts an immense shadow. And it often illuminates higher elevations first, setting them apart from unlit lower-lying regions. You might, for example, see an illuminated mountain peak standing out like a candle flame from the lower-lying regions along the terminator. Very striking.



The Moon as it looks nine days after "new" phase and five days before full, showing the crater Copernicus near the terminator.

Perhaps no other lunar feature comes close to capturing the drama of a lunar sunrise than the immense crater Copernicus. A fairly young crater at just 800 million years old, Copernicus spans some 100 km just north of the lunar equator and south of the Mare Imbrium (see image below). The crater has tall, terraced side walls and a cluster of peaks near its center. So there are many hilly features which cast long shadows when the crater lies along the terminator.

Copernicus graces the terminator about nine days after new moon each month, and about five days before full moon. So it's well placed for viewing in the evening… you don't need to stay up late. And if the timing's right, you can watch sunlight fan out over Copernicus during the course of an evening. It's a stirring sight to see the crater's walls and central peaks catch the sun's first rays, followed by the low-lying crater floor.

And while you can certainly see the crater in binoculars, a telescope gives you a much better view. Since the Moon is bright, you can use high magnification if you have steady air. Try different eyepieces and magnifications to see what gives you the best view. The image at the top of the page gives you an idea of what you can see at 200-300x.

Your next chance to see the sun rise over Copernicus is coming up on June 20-21, roughly. And like all lunar features, if you miss this sight one month, just wait 29 days to see it again.

Only 24 humans– all Apollo astronauts– have witnessed sunrise on the Moon close up. It will be a long time before anyone returns to the Moon. But with a small scope, from your backyard or balcony, you too can see a magnificent sunrise over the craters and mountains of the Earth's nearest neighbor.

A grand sight for all of us to see, surely, before we "kick the bucket."

#8: A Total Solar Eclipse

Today, we present #8 of our celestial sights for all of us to see before we kick the bucket: a total eclipse of the sun.

Solar eclipses have struck wonder and fear into mankind since prehistoric times. The classical Greek poet Archilochus wrote of an eclipse:

"Zeus, the father of the Olympic Gods, turned mid-day into night, hiding the light of the dazzling Sun; and sore fear came upon men."

And Mark Twain's fictional Connecticut Yankee leveraged a solar eclipse to escape a tight spot in King Arthur's court:

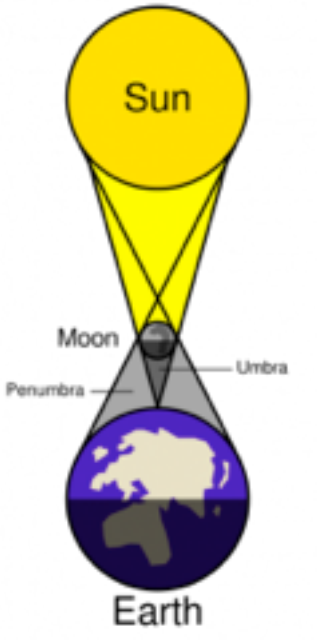
"It got to be pitch dark, at last, and the multitude groaned with horror to feel the cold uncanny night breezes fan through the place and see the stars come out and twinkle in the sky."

The sudden disappearance of the Sun is, understandably, an unsettling sight. But Zeus has nothing to do with it. A solar eclipse results from the clockwork mechanics of the solar system, as the Moon passes between the Earth and the Sun and casts a shadow across a narrow band of the Earth's surface, the so-called "band of totality".

Eclipse are more spectacular because our Moon, which has a diameter 400 times smaller than our Sun, lies almost exactly 400 times closer. This means the disk of the Sun and Moon sometimes overlap exactly, which presents an amazing view of the glowing outer reaches of the solar atmosphere called the chromosphere and corona.

Just outside the narrow "band of totality", an observer sees the Moon cover only a part of the solar disk; this is a partial solar eclipse. And for some eclipses, the Moon is a little too far from Earth to cover the Sun's disk exactly, so it leaves a ring of light around the solar circumference. This is an annular solar eclipse… quite different from a total solar eclipse.

But a total eclipse presents, by far, the most memorable experience for any stargazer. As the event unfolds, the Moon's limb first crosses the Sun's disk a few hours before totality: without a telescope, the effect is unnoticeable. Then, a few minutes before the peak of the eclipse, the sky and Earth darken, the temperature drops, and animals and insects are startled into their nighttime routine. In the final moments before totality, bright beads of light appear along the limb of the merged disks– these are the so-called Bailey's Beads caused by the edge of the Sun shining through lunar valleys. As the sun shines through a single valley just before and after totality, a "diamond ring" effect may be visible.



The alignment of the Sun, Moon, and Earth during a solar eclipse

Though it lasts just a few minutes, a total eclipse presents one of the most impressive and shocking sights in nature. Science writer Timothy Ferris, in his book *Seeing in the Dark*, describes his view of the total solar eclipse of March 2, 1970 in North Carolina:

"Suddenly the sky collapsed into darkness and a dozen bright stars appeared. In their midst hung an awful, black ball, rimmed in ruby red and surrounded by the doomsday glow of the grey corona. No photograph can do justice to this appalling sight: The dynamic range from bright to dark is too great, and the colors are literally unearthly."

During the brief minutes of totality, you can look towards the sun without eye protection. But keep your wits about you. As the Sun emerges and the diamond ring appears,

make sure you look away and watch the rest of the show through the proper solar filters.

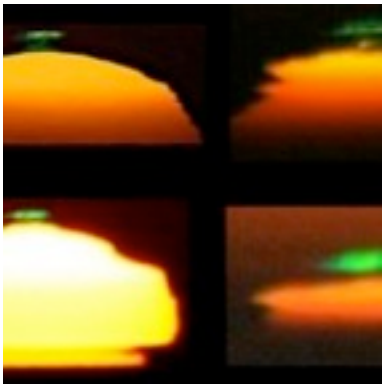
The next solar eclipse occurs this week, on July 11, though it's only visible across the South Pacific Ocean, between Chile and New Zealand. But solar eclipses occur almost yearly over a narrow band of the Earth's surface. It may take centuries for an eclipse to grace an particular point on Earth, so if you want to see one, you need to pack your bags and travel.

Here's a link to help you find the next solar eclipse near you.

And if you can't wait that long, here's a wonderful video from the BBC of a total eclipse over India…

http://www.youtube.com/watch?v=eOvWioz4PoQ

#7: The Green Flash



Visit the quaint but noisy tourist town of Key West, Florida, and you'll have no shortage of things to see. Harry Truman's "Little White House". Jimmy Buffet's Shrimp Boat recording studio. And Ernest Hemingway's old home, now a museum, conveniently situated near the tall lighthouse that guided the great writer home as he stumbled in a drunken haze from Sloppy Joe's or the Green Parrot.

As night falls on Key West, a large crowd gathers in Mallory Square at the foot of Whitehead Street. Most are there to browse the tourist shops and see the buskers. But some have come to see the dramatic sunset over the Gulf of Mexico, and a few hope to see a rare and beautiful sight… the fleeting "green flash" of light that appears on the sun's limb as it vanishes over the horizon… and which comes in at #7 on our Bucket List of celestial sights to see before you die.

Like a rainbow, the green flash is an effect of our atmosphere. When the sun sinks low on the horizon, its light passes through a thick layer of atmosphere which scatters blue and green light out of the line of sight, making the sun appear red-orange. As the red-orange disk sinks out of sight, our atmosphere bends (or refracts) the sun's light from below the horizon. So when we see the sun's disk just above the horizon at sunset, the sun has already set. We're just seeing an image of the sun refracted from below the horizon.

As the sun's image continues to sink, we eventually see only a sliver of light above the horizon. Since the air bends green, blue, and violet light more than red, the red light from this sliver sets first, followed by orange, yellow, green, blue, then violet, which sets last. This is the essence of the green flash.

But wait! Since blue and violet light are refracted more than green light, why don't we see a blue or violet flash instead? Sometimes we do. But unless the air is very clear, blue and violet light are scattered out of the line of sight by the air molecules of our atmosphere… the same effect that makes the sky blue. So green is the most common color that makes it all the way to an observers eye.

The image at the top of the page gives you a hint of what the green flash looks like.

You can only see the green flash if you have a clear view of a cloudless horizon over a great expanse of atmosphere. Looking at the sunset over an ocean is a good bet, and Key West is one of the most famous places to see the green flash. A flat prairie, or desert, or mountain range can work as just well. Even a sunset seen from an airplane. But the flash is only visible for a couple of seconds, as you can see in the video below (it's more impressive when you see it live):

http://www.youtube.com/watch?v=GEoKFZ4GS_Y

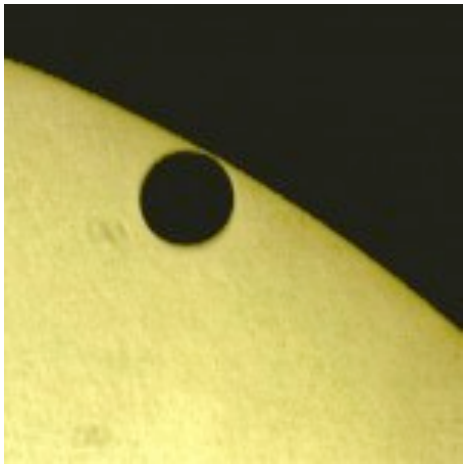
Another tip: the green flash lasts longer at far northern or southern latitudes where the sun takes longer to set. The flash, like sunsets, is most short-lived in the tropics.

And yes, you can see the green flash at sunrise as well.

But please be careful when you try to see this lovely sight. Don't stare at the setting sun or you will surely suffer eye damage. Instead, wait until the sun is almost down. Glance towards the sun briefly with your peripheral vision. And when you sense the sun has nearly set, take a careful look for this rare and beautiful sight.

Not many people know of the green flash, and far fewer ever get to see it. If you have a clear view of the horizon, as over an ocean or mountain range, try to see this sublime and fleeting sight. And check one more off your celestial bucket list.

#6: The Transit of Venus



Now to #6… the passage of Venus across the solar disk as seen from the Earth, also called the transit of Venus.

While not as striking as a solar eclipse, a transit of Venus is far more rare. It's happened just seven times since the invention of the telescope more than 400 years ago. The next transit in June 2012 will be our last chance to see this remarkable event. There won't be another until December 2117.

Here's what you need to know to cross the transit of Venus off your celestial bucket list…

Like a solar eclipse, a transit occurs when Venus passes between Earth and the Sun. And like an eclipse, the transit requires careful alignment of the Sun, Earth, and Venus.

As seen from Earth, Venus usually passed over or under the Sun every 584 days, on average.

But the geometry of the orbits of Earth and Venus, and the period of the planets' orbits cause Venus to pass in front of the Sun at well-defined intervals of 121.5 and 101.5 years, in either June or December. And the transits occur in pairs separated by eight years. Right now, we're between transits. The last occurred on June 8, 2004. The next is on June 6, 2012. The last transits came on December of 1874 and December 1882.

A transit of Venus was once a huge deal for astronomers. In the early 18th century, Edmond Halley determined a way to measure the distance from the Earth to the Sun by timing the transit of Venus from widely separated parts of the Earth. Once this distance was known, the distances to other planets could be determined through Kepler's Laws (which you'll learn in an upcoming article). The transits were so important that most advanced nations sent astronomers around to world to measure the events of 1761 and 1769.

(The persistent and unlucky Guillaume le Gentil, who you met in this article, was one of hundreds of scientists dispatched to observe the transit of 1761).

The transit of Venus in 1761 yielded few conclusive results from hundreds of attempted measurements. So the pressure was on for 1769. And it all worked out… the transit of 1769 was measured precisely by, among others, the team led by one Lieutenant James Cook, RN, who witnessed the event from Tahiti before sailing on to claim Australia for England. Astronomers used Cook's measurements to calculate a distance to the Earth of 150 million kilometers, close to the now-accepted value of 149,597,870.7 kilometers.

It's the history, and the rarity of the event, that makes the transit of Venus such a compelling sight.

And it's a beautiful sight, too, even for the casual stargazer.

The transit unfolds in four stages. First, the leading edge of the planet contacts the Sun. Then the trailing edge, which is hard to time exactly because of the "black drop effect" which bleeds darkness from the limb of the planet as it moves onto the solar disk. The same two stages reverse themselves as the planet leaves the solar disk. The whole event takes 3-6 hours, compared to the scant few minutes of a solar eclipse.

During the transit, the black disk of Venus, just 33x smaller than the solar disk, blocks enough light to measurably decrease the Sun's brightness. NASA's Kepler observatory, in fact, uses this same idea… a transiting planet blocking light from its home star… to look for Earth-like planets around nearby stars. Astronomers will use the 2012 transit of Venus to test new measurement techniques to find extra-solar planets such as those used by Kepler.

The 2012 transit begins at 22:09 UT (GMT) on June 5, and ends at 04:50 UT on June 6. The western Pacific, including most of Australia and New Zealand can see the entire transit. Western Africa, Spain and Portugal, and eastern South America will not see the transit because it occurs when the sun is set. And the rest of the world can see some of the transit after the Sun rises or before it sets.

The maps below shows where the 2012 transit of Venus is visible.

To see the transit, you'll need a safe solar filter. It's visible without a telescope, but you'll get a better view if you watch the event with a scope and a solar filter.

So start planning. After June 6, 2012, you won't get another chance to see this rare and beautiful event…

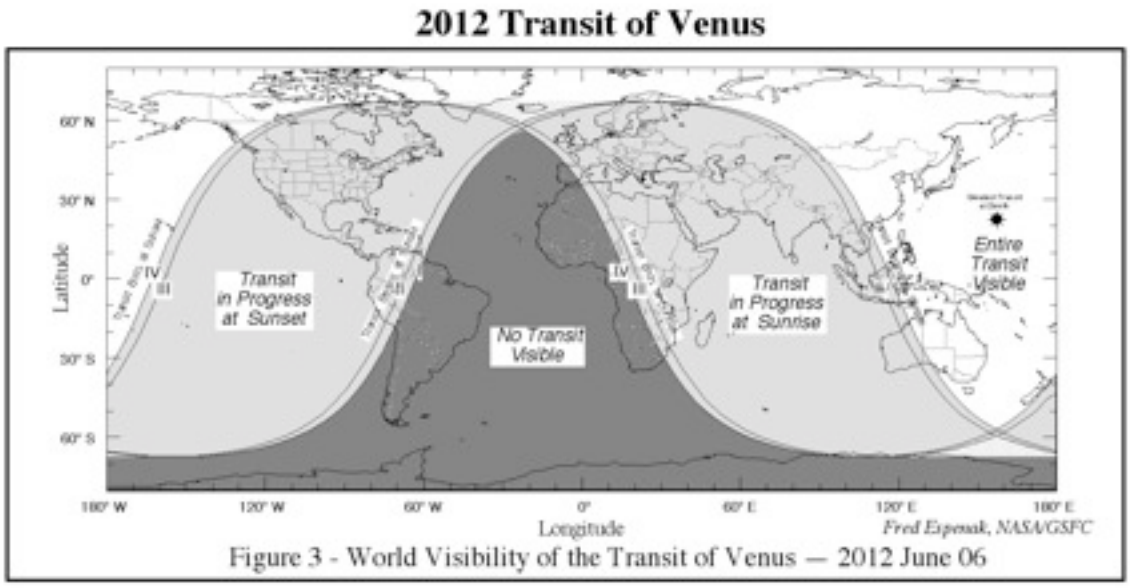


Figure 3 - World Visibility of the Transit of Venus — 2012 June 06

As a preview, here's a video of the 2004 transit of Venus...

http://www.youtube.com/watch?v=VgvwjQVCqYc

Postscript: Mercury also transits the Sun. But because it's closer to the Sun than Venus, Mercury transits much more frequently, about 13-14 times every hundred years. The planet is also smaller and farther, which makes the transit far harder and less impressive to observe.

#5: A Meteor Storm

A meteor storm! The very term makes an honest stargazer's heart beat faster. While a good meteor shower, like the Perseids, may show 50-60 meteors every hour, a meteor storm sprays shooting stars at a rate of hundreds or thousands an hour. During a spectacular storm in 1833, the sky seemed to "fill with falling fire" for nearly half the night.

While spectacular, a meteor storm, which comes in at #5 on our "Bucket List for Backyard Stargazers", may be the most difficult to see because they are extremely brief and rare.

But take heart. NASA is already preparing to deal with a possible outburst next year from a usually lacklustre shower in Draco. And since such events are hard to predict, there may be more opportunities in the coming years. One thing for sure… if you do see a meteor storm, you'll never forget it.

The Leonid meteor shower, which peaks this week in the early morning of November 17, has offered stargazers the most reliable opportunity to see a meteor storm. The shower flares up every 33 years to present a deluge of meteors for a few hours on the early morning on or around November 17. Experts predict this year's Leonids will be quite tame, alas. So meteor storm this year.

But there have been some remarkable Leonids in the past. The great Leonid meteor storm of 1833 was perhaps the most spectacular in recorded history. Visible from eastern North America, the storm produced as many as 200,000 meteors per hour, startling 19th-century observers into a glazed stupor or near-catatonic terror. Nearly everyone awakened to see the bright meteors and attending commotion on the morning of November 12. The storm lasted nearly four hours. According to astronomer Agnes Clerke, "the frequency of meteors was estimated to be about half that of flakes of snow in an average snowstorm".

The meteors came so quickly during this 1833 storm, it was clear the radiant, or apparent source, of the meteors lay towards the Sickle of the constellation Leo. And the radiant moved with the stars during the evening, which finally made it clear that meteors

came from outside the Earth's atmosphere. Until then, some believed meteors were an atmospheric phenomenon, the belief of which lended the term "meteorology" to the study of the weather.

An engraving showing the 1833 Leonid meteor storm; a second image, showing the storm over Niagara Falls, is shown at the top of the previous page.

Astronomers looked at historical records to determine the Leonids peaked at multiples of 33 years… in 1799, 1533, 1366, 1202, and 1037, for example. We now know the peaks correspond to brief periods during which Earth passes through a concentration of debris left in the path of Comet Tempel-Tuttle. The Leonids last peaked in 1999, with bonus peaks in 2001 and 2002 (though they did not approach the dramatic peak of 1833).

Sadly, the Leonids will likely remain quiet this year, and for many years to come. Perturbations of the comet by Jupiter mean the Earth may miss the usual rendezvous with this stream of concentrated comet dust for many decades, perhaps.

So chances are, none of us may ever see anything like the outburst of 1833, or even 1999. But there are still opportunities to see a respectable meteor storm, though it likely won't be the Leonids.

Your best near-term bet for a meteor storm lies with the Draconid meteor shower next year. The Draconids, so-named because the meteors streak across the sky from a point in the constellation Draco, will peak on October 8, 2011. Experts believe it may put on a good show, with perhaps 750 meteors per hour… we'll have more information as the date approaches. With a little luck, you'll see a rich and remarkable spray of meteors. And you can check this event off your celestial bucket list.

#4: The Southern Sky

“When you see the Southern Cross for the first time
You understand now why you came this way”
- Stephen Stills

When 15th-century European navigators first embarked on long voyages to southern seas, they watched nervously as they crossed the equator as Polaris, the North Star, sank below the horizon. These navigators knew well the northern stars, and relied on them for safe passage. What wonders and omens, they asked, would the southern skies hold?

They need not have worried. For the southern skies held many delights.

Even hardened explorers like Magellan and Vespucci were dazzled by what they saw.

The bright Southern Cross soothed their fears and suggested divine sanction for their voyages.

The mysterious celestial clouds of Magellan had no counterpart in the northern skies.

And the vast symmetrical arc of the Milky Way overhead shone so brightly as to seemingly cast shadows during dark nights on the southern seas.

It’s the same for stargazers today…

That’s because the south side of our planet gives a better view into the most star-rich portion of the spiral arm of our galaxy next-nearest to the center. As a result, there are more bright stars, star clusters, and nebula along the band of southern constellations from Sagittarius through Crux and Carina than in any other part of the sky.

And purely by chance, the southern skies also hold many bright objects including globular clusters and peculiar galaxies that lie outside the plane of the Milky Way,

Here's just a partial list of southern-hemisphere celestial sights unmatched in northern skies…

• The three brightest stars Sirius, Canopus, and Rigil Kent (also known as Alpha Centauri, the nearest star system to Earth)

• The Magellanic Clouds, two irregular dwarf galaxies gravitationally interacting with our own, and easily visible to the unaided eye

• Omega Centauri and 47 Tucanae, the two brightest globular clusters in the sky

• NGC 5128… a giant elliptical galaxy caught in the act of devouring an entire spiral galaxy like our Milky Way

• The Coalsack, the largest and most conspicuous dark nebula in the sky, which stands out from the glittering star field in Crux, the Southern Cross

• The Eta Carinae Nebula, the largest and brightest emission nebula in the sky, even more spectacular than the Orion Nebula.

Towards the center of the Milky Way, as seen from Australia.

But for the casual stargazer, perhaps the most magnificent sight from the southern hemisphere is the thick star clouds towards the center of the Milky Way in the constellation Sagittarius. In the north, these star clouds are dimmed by the murky air near the horizon. In the south, in June through August, they are directly overhead. Lie back under the Milky Way south of the equator, and you'll easily grasp our true place at the edge of a vast disk of stars.

And there are more oddities for northerners to see in the southern sky. The sun is on the north side of the sky, and moves from right to left during the day (opposite from the northern hemisphere); there is no corresponding "southern star" near the southern pole; and of course, Orion is upside down, caught in a celestial cartwheel across the northern sky.

So how and where can you see the southern stars?

Anytime, anywhere south of the equator. If you go, bring as much optics as you can carry… binoculars, telescope, or both. The southern hemisphere is less light-polluted than the north, so it's hard to find a bad place. Though downtown Johannesburg, Sydney, or Auckland are not ideal places for stargazing.

Your best bets, of course, are dry, dark locations. The dryest parts of Australia are wonderful (Alice Springs is a favorite for many stargazers). The coal-black night skies of the nature reserves of South Africa come highly recommended from many readers of this website. And of course, the bone-dry Atacama desert in northern Chile has excellent sky, and even dedicated destinations for astro-tourists (such as in San Pedro de Atacama, and in the Elqui Valley east of La Serena).

For northern dwellers, a view of the stars of the southern hemisphere require time and money and travel. But what stargazer has lived fully without peering over the limb of the Earth to see the other half of the universe? Surely, something worth checking off your celestial Bucket List?

P.S. And what about our southern hemisphere readers? Is it worth a trip north? I think yes… the northern skies have more interesting constellations. The Big and Little Dippers are a magnificent sight, as are the star clusters of Cassiopeia and Perseus. The galaxy duo M81 and M82, near the Big Dipper, along with the Double Cluster in Perseus, are unequalled. And you will not see a prettier galaxy anywhere in the sky than NGC 4565 in Coma Berenices.

#3: A Bright Comet

While a half-dozen comets come and go each year, most are too faint to see without optical aid. But a bright comet, with a swollen head brighter than Venus and a tail streaking a third of the way across the sky is a stunning and unnerving sight, one that should be seen by even the most casual stargazer. It's a sight you'll never forget, and it comes in at #3 on our Bucket List.

By cosmic standards, a comet doesn't amount to much. It's a tiny remnant of the formation of the solar system, a dusty ice ball a few kilometers across that floats unseen in the outer reaches of the solar system.

But from time to time, a passing star or giant molecular cloud gives an anonymous comet a little nudge, and it starts a long journey towards the inner solar system. If the timing and mechanics are right, such a comet may put on a spectacular show in the night sky.

On average, a bright and truly spectacular comet comes about once a decade. The last was Comet McNaught in 2007 (see image above), a dazzling sight for southern-hemisphere observers that (so far) is considered the "comet of the century". Before that, there were the back-to-back appearances of Comet Hale-Bopp and Comet Hyukutake in 1997 and 1996. And before that, Comet West put on a lovely show in the pre-dawn skies in 1976.

There have been other dazzlers, too, including three comets in the 19th century bright enough to see in the daytime sky, and a fourth that appeared early in 1910.

The return of Comet Halley was a dud in 1986. The comet gave its dimmest performance in recorded history, though it's been reliably bright over the past millennia. This most famous of comets has a rich historical background that makes it rewarding to observe. Known since antiquity, the comet served as an omen over the centuries, and marked many historical events, including the Battle of Hastings in 1066 (a good omen for the Normans), and the invasion of Europe by Genghis Khan in 1222 (a very bad omen for most Europeans).

The comet also gave Edmund Halley a chance to test Newton's newly discovered laws of gravitation, and determine that several historical comets were actually the same comet that returned every 76 years. Halley predicted this comet's return in 1758, and he was correct. While he didn't live long enough to see it himself, his name remains associated with this periodic visitor.

Halley's Comet is the brightest of the short-period comets that return to the inner solar system every few years or decades. But most bright comets have orbital periods measured in thousands of years. And some bright comets visit just once, never to return.

Comet McNaught in 2007

Most bright comets arrive unpredictably from the distant Oort Cloud. They're often discovered accidentally by amateur and professional astronomers with large telescopes and complex imaging equipment. One such discovery, made last December, yielded what's now called Comet Elenin, which may put on a good show in August and September of this year, though it's hard to predict just how bright a comet will become. The brilliance of Comet McNaught caught astronomers by surprise in 2007, so Comet Elenin may yet turn out to be spectacular, or at least respectably bright for most

observers even without optical aid. Or it could be another dud… we'll know soon enough.

Comet West in 1976

No photograph or experience can prepare you for the magnificent and ghastly sight of a bright comet in the night sky. When you see one, you understand why they caused such fear in more superstitious times. The apparent size of the coma, or head, of the comet can be larger than any other sight save the Moon or Sun. And the tail can display lovely fine structure and filaments that can change over the course of minutes and hours. No other celestial object matches its appearance.

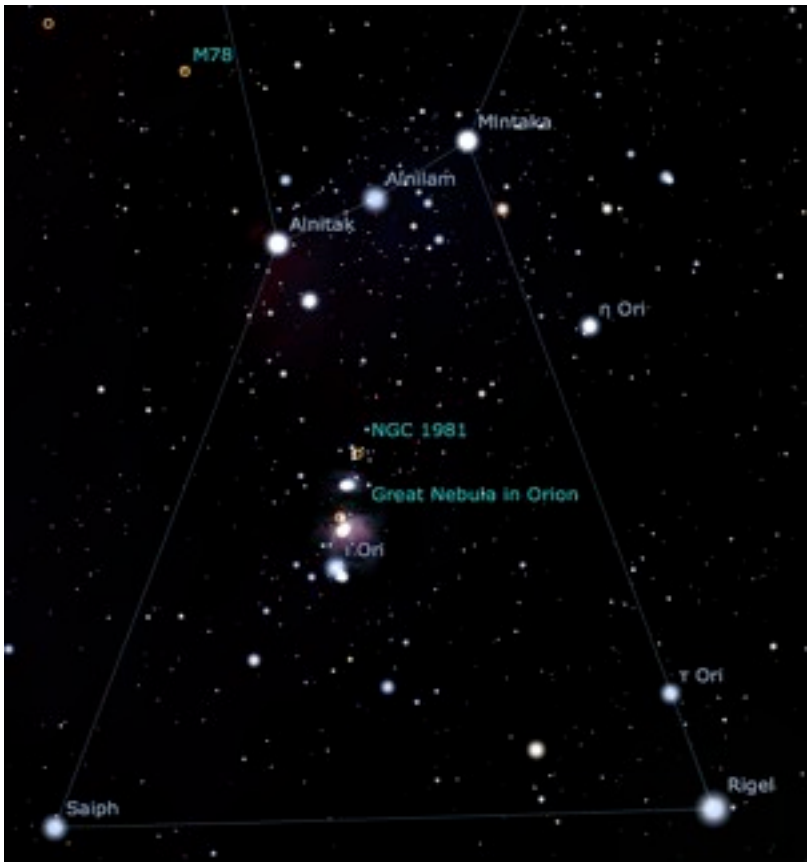
The great Mark Twain was born during the return of Halley's Comet in 1835. In 1909, he predicted his life would end with the comet's return. "The Almighty has said, no doubt", wrote Twain, "'Now here are these two unaccountable freaks; they came in together, they must go out together'". Twain died in April, 1910, a day after Comet Halley made its closet approach to the Sun.

It's hard to arrange your life around a comet (as did Mark Twain), but a careful and leisurely examination of a bright comet is a delightful event in the life of any stargazer. When one comes along, make sure you see it, savour it, and cross it off your celestial bucket list.

#2: The Great Orion Nebula

At #2 on our *Bucket List for Backyard Stargazers* is the Orion Nebula, a blister of glowing gas set alight by blazing newborn stars. As beautiful an object as you will ever see in the night sky, this nebula is just a small part of the vast star-making machinery in our own Orion Arm of the Milky Way that offers many wondrous sights for backyard observers. The Orion Nebula is one of the grandest sights in all of nature: the birth of a cluster of new stars out of a dark cloud of interstellar gas and dust. And you can wander outside any night from December through March and see it for yourself…

You'' find it in the "sword" of stars that appears to hang off Orion's Belt. The nebula is the middle "star" in the sword, which to the naked eye appears slightly fuzzy. It's visible to stargazers in both hemispheres.



A map showing the position of the Orion Nebula in the "sword" off Orion's Belt

Turn a telescope toward M42 and you will see a greyish bat-shaped mist lit up by dozens of blue-white stars. Try looking at the nebula with a range of magnifications. Start low, say at 40-50x, and work your way up. The nebulosity extends much farther than you may first think: use averted vision to glimpse its full expanse. At high magnification you'll lose the overall shape, but you can see the fine detail in the nebula's mottled structure and the beautiful diamond-like stars near the center that sparkle like a jar full of fireflies.

The Great Orion Nebula, M42

Because of its size and brightness, the Orion Nebula looks almost as good from city skies as it does from country skies, and is a fine sight in small and large telescopes.

In a small scope, the nebula appears greyish because its light is not bright enough to stimulate the color-sensing cone cells in your retina. In a larger telescope, you might see traces of green and red. I have never seen the color firsthand, but it must surely accentuate the beauty of this wonderful object.

The Orion Nebula is so complex and sublime that you see new detail every time you look at it. Try not to rush when you observe this wonder. Savor it. And if you can, try to make sketches to train your eye to see more detail. This nebula is an object that, in my opinion, looks better visually than photographically.

The particulars: M42 lies some 1,500 light years from Earth and spans about 20 light-years. Radio telescopes show the unlit gas and dust span more than 100 light-years beyond the visible nebula and contain the mass of 10,000 Suns.

At the heart of the nebula is the multiple star system theta Orionis, also called the Trapezium, so-named because it looks like a tiny trapezoid (see image at top). There are actually six stars here, though you need good seeing, a 4 inch or larger telescope, and magnification of 100x or more to resolve them all. The stars of the Trapezium, which are just 100,000 years old, have blown a bubble in the surrounding gas that gives us a view of the nebula's inner core.

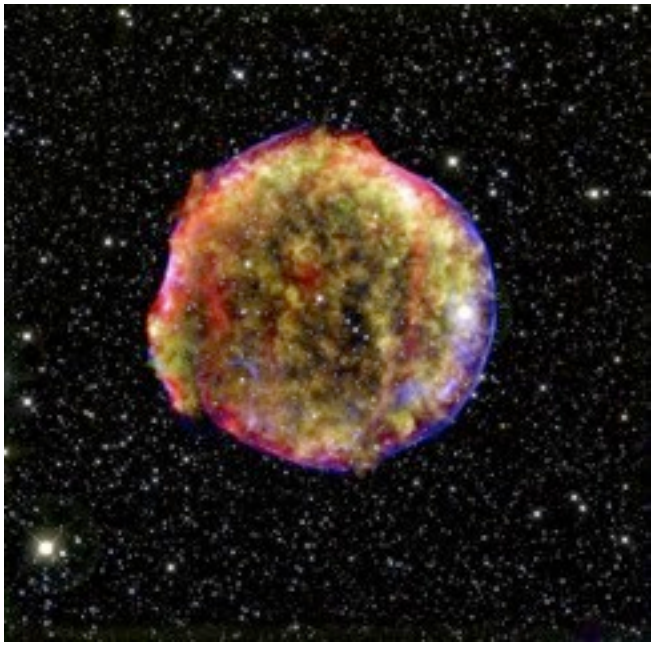
The energy that lights up the gas and dust of the Orion nebula comes from dozens of hot new stars that have recently coalesced out of the nebula itself. Hydrogen and traces of oxygen gas absorb the blue and ultraviolet light from the stars and re-radiate red and green light at characteristic wavelengths. A UHC or OIII filter may improve the contrast in some parts of the nebula, especially for urban observers.

Astronomy writer Walter Scott Houston said of the Orion nebula, *"No amount of intensive gazing ever encompasses all its vivid splendor". It's truly one of the most beautiful things you will ever see.*

#1: A Supernova

During an after-dinner stroll on a cool autumn evening in 1572, the great Danish astronomer Tycho Brahe was stopped in his tracks by the sight of a blazing new star in the constellation Cassiopeia. Tycho knew every star in the sky since his youth, and he lived in a time when many thought the heavens never changed. So when he saw this new star, he was, as he later wrote, *"so astonished at this sight that I was not ashamed to doubt the trustworthiness of my own eye."*

Tycho was amazed by what's now called a supernova, a massive exploding star which for a few weeks can outshine an entire galaxy. It's a sight you should see for yourself, as luck allows, which is why it tops our celestial Bucket List.



A multi-wavelength image of the remnants of Tycho's 1572 supernova.

Tycho had no way of knowing the nature of this new star. It would take more than 350 years before astronomers figured out enough physics to understand supernovae and the critical role they play in the creation of new stars, planets, and, well… you (more on this in a moment).

Now we know Tycho's supernova was likely a small white dwarf star that suddenly blew itself to bits in a planet-sized nuclear explosion after taking on too much mass from a close companion star. This is known as a Type Ia supernova.

And there's another type… the Type II supernova. This is a massive star that runs out of fuel and suddenly collapses upon itself, crushing its innards into a dense, scorching brew of radiation and atomic particles before rebounding outwards to release light and radiation and matter.

Both types of supernova create more energy in a few weeks than our Sun creates in its entire lifetime. Visible light is released, along with neutrinos and atomic and subatomic particles at high speed. The dangerous X-rays and gamma rays from a supernova would destroy or degrade life (as we know it) on any planet within an astonishing 50 light-year radius.

Supernova 1994D in the galaxy NGC 4526

But while they are fearsome events, you would not be here if not for supernovae.

Here's why…

Long before it explodes, a big star turns hydrogen and helium into carbon and oxygen and many heavier elements all the way up to iron. This material is blasted out during the supernova explosion into the space between the stars.

What's more, as the star collapses, neutrons get smashed into atomic nuclei to create and release all the naturally occurring elements heavier than iron, right up to uranium and beyond. The iron in your blood and your frying pan, the gold and silver in your jewelry, the copper and zinc and tantalum in your computer, were all created and released during long forgotten supernova explosions billions of years ago.

Now… how do you get to see one of these awesome beauties?

Well, they are quite rare… about one every 50-100 years in the Milky Way on average. While many of the stars we see in the night sky will blow up as supernovae, none has been seen in our galaxy since 1604. So we are way overdue. Most stars, including the Sun and nearby stars, are too small to explode in this way.

Here's a short list of nearby stars that will one day detonate as Type II supernovae: Betelguese in Orion, eta Carinae, rho Cassiopeiae, Spica, and Antares and Shaula in Scorpius. Astronomers don't know when any of these stars will blow… it might be next week, it might be a million years. But all will one day shine bright enough to see in our daytime skies and cast shadows by night for weeks before fading away. And though no star is close enough to be dangerous to us, gamma rays and neutrinos from nearby supernova will be detected on Earth.

Your best bet to see a supernova lies in looking at other galaxies. The last naked-eye supernova occurred in 1987 in a nearby dwarf galaxy, the Large Magellanic Cloud. At least one extragalactic supernova is discovered with large telescopes every year in more distant galaxies. Some are discovered by amateur astronomers, including a recent discovery by a 10-year-old Canadian girl who found the star in an image taken with a large telescope.

Occasionally, these extragalactic supernovae are bright enough to see in a small telescope. A supernovae bright enough to see with binoculars or a small telescope will surely be announced on the news, or in these pages, so stay tuned and you'll get your chance.

And keep an eye on Betelguese, Spica, and Antares… you just never know. While you're waiting for the "big one", you can gaze at scattered remnants of supernovae that are visible in small telescopes, including the Crab Nebula and the Veil Nebula. Most are beautiful sights in their own right.