

HOW FAR CAN YOU SEE?

BY JOHN JARDINE GOSS

We all enjoy peering into the heavenly realm. We all are amazed by the cosmic distances encountered every time we gaze skyward. Using only our eyes, we all are truly astonished by how far we can see from a dark site under crystal clear skies.

In our daytime earthbound lives, as we look across an expansive vista, we see 30, 40, 60 or more kilometres. When we gaze into the heavens, in comparison, we experience totally different distance scales, ones far outside our daily bounds, ones that we have a difficult time comprehending or expressing.

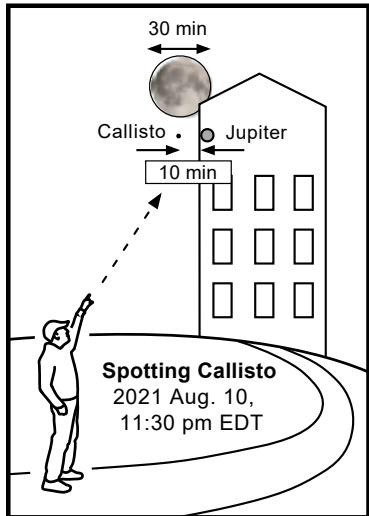
The Astronomical League gets it. Through its great many observing programs and activities, the League encourages stargazers to venture under the starry canopy and see for themselves how far their gaze takes them. They will quickly be astounded that the unaided eye can see incredibly far.

Moons. Let's put forth a rather strange question. What's the farthest "moon" you can see? Our planet's only natural satellite orbits just 386 000 kilometres away, and is by far the closest astronomical body. But two, or possibly three other moons of our Solar System can be spotted orbiting a planet moving nearly 600 million kilometres from observers on Earth—that's 10 million times farther than looking across an Earthly landscape.

If Jupiter is placed just out of sight behind the edge of a distant building, sometimes two of its four Galilean moons can be spotted from a dark site—if the sky conditions are favorable, and if the observer is sharp eyed. Because the giant planet's bright glare is obstructed by the building, its moons Ganymede and Callisto (with opposition magnitudes 5 and 5.5, respectively) can be discerned when they are on either the far western or eastern side of their orbits circling Jupiter.

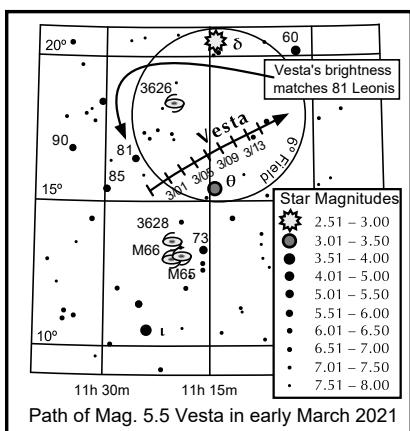
Callisto's angular distance at those times is around $10'$ (equalling one-third our Moon's apparent width in the sky), while Ganymede's is about half that. Another of its large moons, Europa, can swing $3'$ away from the bright planet. However, when Jupiter is placed out of view, the distance from the edge of the occulting building to Europa might very well be under $2'$ —an angular distance that's difficult to separate.

Why not give it a try in the month of Jupiter's opposition, August 2021? Be sure to confirm your observations with binoculars.



Asteroids. What is the smallest body in the solar system that can be seen with the unaided eye and how far away is it? Both Mars and the much more distant Jupiter are certainly visible. Between their orbits move innumerable small asteroids, with a few having diameters measured in the hundreds of kilometres. The brightest and the only one visible to the unaided eye—and only when it is near opposition—moves faint Vesta. It shines at 5.5 mag., making it visible from a rural dark-sky site. At that time, this 524-kilometre-wide agglomeration of rock lies nearly 200 million kilometres from Earth, making its angular diameter equal to that of a golf ball placed at 16 kilometres!

Look for Vesta on a night between Mar. 1 and 15, when no moon is in the sky, as it



Viewing from a dark site on a very transparent night, the keen-eyed sky watcher can spot the 5.7-mag. Uranus at over 2.5 billion kilometres away. That's about 2.5 hours at light speed, or 2 600 years by car.

Use the celestial chart here to find Uranus this fall as it slowly moves in Aries. Be sure to attempt this when no Moon glows in the sky, and, as with spotting Vesta, confirm your observations with binoculars.

Stars. Stars are another story entirely. Of the 20 brightest stars, Deneb is the most distant. By some estimates, this member of the Summer Triangle shines over 3 000 light-years away, while other calculations place it much closer at "only" 1 800 light-years.

Using the very precise parallax measurements from the HIPPARCOS satellite, accurate distances of up to 500 light-years can be determined. For extremely distant stars such as Deneb, though, spectroscopic methods are used, which can introduce a fair amount of inaccuracy—sometimes reaching 50%. Topping it off, undetermined amounts of interstellar gas and dust exist in the star's direction, causing stars that appear close to the galactic plane to dim by an appreciable, but unknown amount.

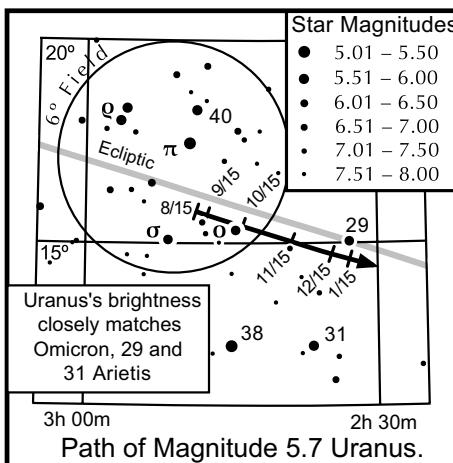
Regardless of the true amounts, stars that are thought to be very far, most surely are. Eta Canis Majoris, Mu Sagittarii, and Rho Cassiopeiae are just a few of the visible stars that are calculated to lie more than 2 000 light-years from observers on Earth.

The depth of deep-sky objects. The Ursa Major Moving Cluster, the Coma Berenices Open Cluster, the Hyades, and the Pleiades are easily seen galactic star clusters that are within a few hundred light-years of our blue planet. Probably the most distant open cluster that can be seen with certainty from the US with the unaided eye is the Double Cluster in Perseus. These two treasures of the late fall and winter skies

slides 1° north of the easily seen Theta Leonis. If you can see the similarly bright star 81 Leonis in Vesta's general vicinity, then you should be able to spot the asteroid. (As with seeing Callisto and Ganymede, confirm your observations with binoculars.)

Planets. Saturn is easy to pick out in the night sky shining between mag. +0.5 and 0. At 1.5 billion kilometres, it is the planetary long distance winner for city stargazers. How far is 1.5 billion kilometres? A car traveling at typical freeway speeds with no stops would need 1 500 years of constant cruising to reach that distance!

Rural residents can do a bit better.



are between 7000 and 7500 light-years away, placing them in the next outer spiral arm of our galaxy.

Just above the plane of the Milky Way, glow the globular clusters M5 and M13, which are both about 24 000 light-years distant. These two globulars, each of whose combined light is slightly brighter than a 6th-mag. star, can barely be seen with the unaided eye under pristine seeing conditions from dark-sky locations.

Now, for the long distance winner. Most people under dark, clear sky conditions can pick out M31, the Andromeda Galaxy at around 2.5 million light-years away. The light that we see today, or rather tonight, left our neighboring spiral galaxy when hominids on Earth were only beginning to evolve into something astronomically aware.

A small number of skilled observers viewing under very transparent skies with superb seeing conditions have been able to sporadically discern the 6.8 magnitude galaxy M81 with no optical aid. These people hold the long distance record of 12 million light-years. Or do they?

Even fewer observers report sightings of the peculiar galaxy Centaurus A, best seen from locations far south of the contiguous United States. Wavering on the edge of human eyesight, Centaurus A is thought to lie as far as 16 million light-years from our little world! A staggering distance, indeed.

Extreme Stellar Distances			
Magnitude	Name	Distance (Light-years)	Luminosity (= No. Suns)
1.25	Deneb	1800 – 3000	196,000
2.45	Eta Canis Majoris	2000	105,000
3.85	Mu Sagittarii	3000	200,000
var. 4.1–6.2	Rho Cassiopeiae	3400 – 10,000	>300,000

intersects none of them, and proceeds far into the vastness of intergalactic space; then cruises by any of the galaxies of the local group, the Virgo cluster, and the Virgo supercluster, and all else that is visible in any amateur telescope, large or small.

Don't stop now. Your line-of-sight journey has just begun.

Carefully study the famous image of the Hubble Ultra-Deep Field, revealing galaxies 10, 11, and 12 billion light-years from us. Notice that, while the image unveils the existence of thousands of small wispy galactic glows, it still shows mostly blackness. No stars, no galaxies—just “nothingness.”

Your line-of-sight trajectory leads straight into the nothingness.

Your gaze, beginning with you standing in a grassy field on Earth, is now directed towards the edge of the observable Universe, some 13.8 billion light-years from our home. Expressed in more Earthly values, that incredible distance is nearly 1 600 000 000 000 000 000 000 000 kilometres!

Observations like these, distances like these, and thoughts like these are simply mind-boggling. Just by casually gazing into the heavens, an observer on Earth—you!—directly confronts the unfathomable concepts of infinity and eternity. Humbling? Quite.

John Jardine Goss is a Past President of the Astronomical League, the largest federation of amateur astronomers in the United States with over 18 000 members. He is Master Observer No. 25. John and his wife, Genevieve, live in Fincastle, Virginia.