New Jersey ASTRONOMICAL Association

# The Journal

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## Contributors Needed

The NJAA Journal is soliciting contributions for future issues. Click here if you would like to submit an article to The Journal. Any submission is welcome and will be reviewed for publication. This is a great opportunity for younger members to see their work published in a periodical.

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## We Value Your Feedback

We hope you're enjoying The Journal, but tell us what you think. Suggestions are welcomed at this email address: Membership@njaa.org.

## Rocks from Space – The Sikhote-Alin Meteorite

**By Don Holtaway**

As a result of the way meteoroids form, and ablation (losing mass through melting, vaporization, and fragmentation as it travels at hypersonic speeds through Earth's atmosphere), most meteorites are roughly round in shape.

However, in the "Rocks from Space" meteorite collection at NJAA, we have samples of meteorites that look more like shrapnel left over from a bomb explosion, pieces of metal that are torn, twisted and many with sharp edges. These meteorites are from the famous Sikhote-Alin meteorite, which fell to earth in the Sikhote-Alin Mountains, Primorye, Soviet Union,




at 10:38 am on February 12, 1947, and was witnessed by many people. One of the people who witnessed the event happen to be an artist who was just preparing to do a painting, so he immediately painted the incredible scene he had just seen. The painting was later made into a postage stamp to commemorate the event. *(Continued)*

The original mass of this iron asteroid before impacting the atmosphere is thought to be about 200,000 pounds, with about 51,000 pounds of fragments surviving the fiery passage through the atmosphere and reaching the ground. It was traveling at about 31,300 mph when it hit the atmosphere, and at an altitude of about 3.5 miles, the aerodynamic forces acting on it caused it to explode, creating the shrapnel fragments. The explosion was heard 190 miles away, and a 20-mile-long smoke trail in the sky lasted several hours.

The meteorite fragments landed in an elliptical area (known as a strewn field) of about ½ square mile. Some of the larger fragments created craters, over 100 were discovered in a densely wooded area, the largest being 85 feet across and 20 feet deep. It's reported that the area looked like it had been bombed, the trees were ripped apart, deep holes gouged into the ground, giant and small scraps of metal were strewn about, with some fragments embedding themselves in trees. The largest recovered fragment weighs 3,847 pounds. The composition of the meteorite is 93% iron, 5.9% nickel, 0.42% cobalt, 0.46% phosphorus and 0.28% sulfur, with trace amounts of germanium and iridium.

In addition to the shrapnel pieces, while the body was moving with a significant cosmic velocity in the upper atmosphere before exploding, individual pieces separated from the main body, and ablated. These pieces have aerodynamic surface shaping, some with very smooth orientated bodies, and others with strikingly beautiful regmaglypts, which are shallow, thumbprint-like depressions on the surface of a meteorite caused by ablation (melting and eroding) as it travels through the atmosphere.

On YouTube (https://www.youtube.com/watch?v=69ib4Er17wc&t=32s) there is a 17-minute video about the first three expeditions between 1947 and 1950 to study and collect samples from the event. The video is in Russian, with English subtitles, made in the 1950's, so the quality is low, but it shows how the meteorites were recovered.

*Ancient Astronomy - Aristarchus of Samos (310-230 BCE): Measuring the Cosmos (Part 2 of 3)*

## Aristarchus and the Distance to the Sun: A Magnificent Failure

In the previous journal, we discussed the keen observational skills of ancient astronomers. During this period, some Greek thinkers increasingly began using observation, mathematics, and rational thought to explain the universe. Instead of attributing every celestial event to the whims of fickle deities, they asked measurable questions: How far away are the objects in the sky? How large are they? How do they move? What are they made of?

Aristarchus of Samos, who lived from about 310 to 230 BCE, was one of the earliest astronomers known to have tried to calculate the sizes and distances of celestial objects. His surviving work, *On the Sizes and Distances of the Sun and Moon*, was probably written during the third century BCE. Aristarchus was born on the Greek island of Samos and may later have studied in Alexandria, Egypt, but we do not know exactly where he made this particular observation.

In the previous article, we discussed how Aristarchus used a lunar eclipse to estimate the relative sizes of Earth and the Moon. This article focuses on his attempt to determine the distance from Earth to the Sun. His result was dramatically wrong, but his method was brilliant. It was, as we will see, a magnificent failure.

**Building a Triangle in the Sky**

Aristarchus understood that when the Moon appears exactly half illuminated, the Earth, Moon, and Sun form a right triangle. This happens near first quarter and again near third quarter.

“First quarter” does not mean that only one-quarter of the Moon is illuminated. Half of the Moon is always illuminated by the Sun, except during a lunar eclipse. First quarter means that the Moon is approximately one-quarter of the way through its cycle of phases. From Earth, we see half of its visible disk illuminated.

At the moment of the half Moon, the angle at the Moon between Earth and the Sun is approximately 90°. Aristarchus could then measure the angle separating the Moon and Sun as seen from Earth. His surviving work gives this angle as 87°.

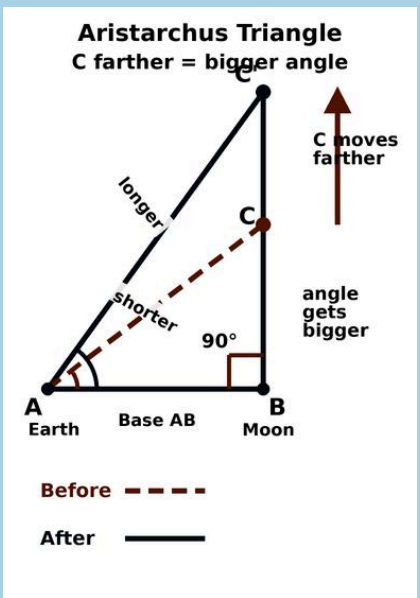
Because the angles of a triangle add up to 180°, the remaining angle at the Sun would be 3°:

$$90° + 87° + 3° = 180°$$

Using geometry, Aristarchus concluded that the Sun was more than 18 but less than 20 times as far from Earth as the Moon was. In modern trigonometric terms, an angle of 87° gives a ratio of approximately 19.1:

$$\text{Sun–Earth distance} \approx 19.1 \times \text{Earth–Moon distance}$$

Why did Aristarchus give a range of 18 to 20 instead of simply saying 19? He did not have modern trigonometric functions or decimal notation. He used geometric bounds to prove that the ratio was greater than 18 but less than 20. The range also appropriately reflected the limited precision of the observations available to him. We do not know exactly what instrument or observational procedure he used. Even so, ancient instruments would have made such a tiny angular difference extraordinarily difficult to measure, especially because the observation required determining the Moon's exact half-phase as well as looking directly at the Sun to set the triangle.




**A Triangle You Can Walk Through**

Here is a simple demonstration of the geometry.

Imagine drawing a right triangle on the ground. Place point A in front of your right foot and point B in front of your left foot. Draw a line from A to B. This is the base of the triangle.

From point B, draw a line straight ahead to point C so that line BC is perpendicular to the base. You now have an L shape and a 90° angle at point B.

Finally, connect point A to point C. Line AC is the hypotenuse, the longest side of the right triangle.

As you move point C farther away, the angle at point A becomes larger and approaches 90°. At the same time, the hypotenuse becomes longer in relation to the base.

If the angle at A is 45°, the hypotenuse is approximately 1.41 times the base. If the base is one mile long, the hypotenuse is about 1.41 miles. If the base is 10 miles long, the hypotenuse is about 14.1 miles.

If point C is moved farther away until the angle at A reaches 75°, the hypotenuse becomes approximately 3.86 times the base. A one-mile base would then correspond to a hypotenuse about 3.86 miles long.

| Angle at A | Hypotenuse compared with the base |
|---:|---|
| 45° | 1.41 times the base |
| 75° | 3.86 times the base |
| 80° | 5.76 times the base |
| 85° | 11.47 times the base |
| 87° | 19.11 times the base |
| 89.85° | 381.97 times the base |

The same pattern continues as the angle approaches 90°:

At exactly 90°, no finite right triangle could exist. Both long sides would be perpendicular to the base and therefore parallel to each other. They would never meet at point C, so the measured distance would approach infinity. This demonstrates why an angular difference of only a few degrees can produce an enormous change in the calculated distance.

### Applying the Triangle to the Sun

In Aristarchus's celestial triangle, the Earth–Moon distance served as the base. He did not need to know that distance in miles. He could express the Sun's distance as a multiple of the Earth–Moon distance.

His estimated angle of 87° gave him a distance of approximately 19.1 Earth–Moon distances. This led to three important results.

First, the known universe suddenly became much larger. Second, Aristarchus demonstrated a mathematically sound way to estimate the distances of celestial objects. Third, his answer was seriously incorrect.

The universe became larger, a method of measuring celestial distances was born, and the final distance was wrong. It was a magnificent failure.

**What Went Wrong?**

To borrow a line from Monty Python, “It was the salmon mousse.” In this case, it was the angle.

Aristarchus's geometry was sound, but the angle in his calculation was not accurate enough. The fundamental difficulty was determining the precise moment when the Moon was exactly half illuminated and then measuring its angular separation from the bright Sun.

The actual angle at Earth is approximately 89.853°, not 87°. That leaves an angle at the Sun of only about 0.147°. The difference between 87° and 89.853° is less than 3°, but it changes the calculated distance from about 19 times the Earth–Moon distance to about 389 times that distance.

The commonly quoted figure of 400 is a useful approximation. An angle of exactly 89.85° produces a ratio of about 382, not exactly 400. Because the Moon and Earth follow elliptical orbits, their distances and the exact angle vary somewhat. Using average modern distances gives a ratio close to 389.

The Moon's average distance from Earth is approximately 238,855 miles, while the Sun's average distance from Earth is about 92,956,000 miles:

$$92{,}956{,}000 \div 238{,}855 \approx 389$$

Using the rounded Earth–Moon distance of 239,000 miles gives:

$$239{,}000 \times 389 = 92{,}971{,}000 \text{ miles}$$

That is extremely close to the accepted average Earth–Sun distance of approximately 93 million miles.

**A Magnificent Failure**

Aristarchus underestimated the Sun's distance by a factor of about 20. Nevertheless, he showed that distances across the heavens could be investigated through observation and geometry rather than mythology.

His answer was wrong, but his reasoning pointed in the right direction. He expanded the scale of the known universe, established a valid method for measuring celestial distances, and helped transform astronomy into a mathematical science. The idea was revolutionary, the answer was incorrect. Aristarchus set the science of astronomy on a course that would unlock the understanding the celestial mechanics in the third century BCE. This is how a scientist has a magnificent failure.

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# The Iris Nebula (NGC 7023)

**By Michael Sweetman**

The Iris Nebula is a reflection nebula located in the Constellation of Cepheus. A reflection nebula is a cloud of gas and dust that is illuminated or excited by nearby stars. It was first discovered by William Herschel in 1794. It is located approximately 1400 light-years away from Earth. It is approximately 6 light-years across, with an apparent size of 18 arcminutes.

This nebula is illuminated by a pair of blue-white stars in its center, designated HD 200775. However, it also exhibits filaments of deep red, due to fluorescence, indicating the presence of complex hydrocarbons. The composition of the gas cloud is an area of active research, and in 2010, observations from the Spitzer Space Telescope were used to confirm the presence of fullerenes excited by UV radiation. These are the largest molecules confirmed to exist in interstellar space. Additionally, while fullerenes were known to be capable of forming in supernovas, the location and concentration in NGC 7023 suggested that additional formation mechanisms exist to allow formation in cold interstellar gas.



*The Iris Nebula (NGC 7023). Photographed by the author.*

**Photography Details**

My goal with this photograph was to capture the rich colors both within the illuminated portions of the nebula and contrast it with the dark clouds surrounding it. The bright region showed well after the first night of capture, but I elected to gather data for two additional nights to bring out the dark regions.

To process the data, I used PixInsight, applying gradient removal with the Multi-scale Gradient Removal, using BlurX and NoiseX for deconvolution and noise reduction. I then stretched the background with the Multi-scale Adaptive Stretch tool, separately stretched the stars with the Histogram tool, and recombined the image with Pixelmath.

**Technical Card:**

Mount: Celestron AVX

Camera(s): ZWO ASI 2600mc pro, ZWO ASI 120 mini guide camera in a Williams Optics 50mm Uniguide

OTA: ZWO FF80 APO

Filters: None

Exposure: Approximately 300 Lights @ 180 seconds taking in June and July over 3 nights

**References:**

Caldwell 4 https://science.nasa.gov/mission/hubble/science/explore-the-night-sky/hubble-caldwell-catalog/caldwell-4/

C60 in Reflection Nebulae

https://arxiv.org/pdf/1009.0539

Blushing dusty nebula

https://esahubble.org/news/heic0915/

## Dodging the Moon and Sun to Capture the Milky Way

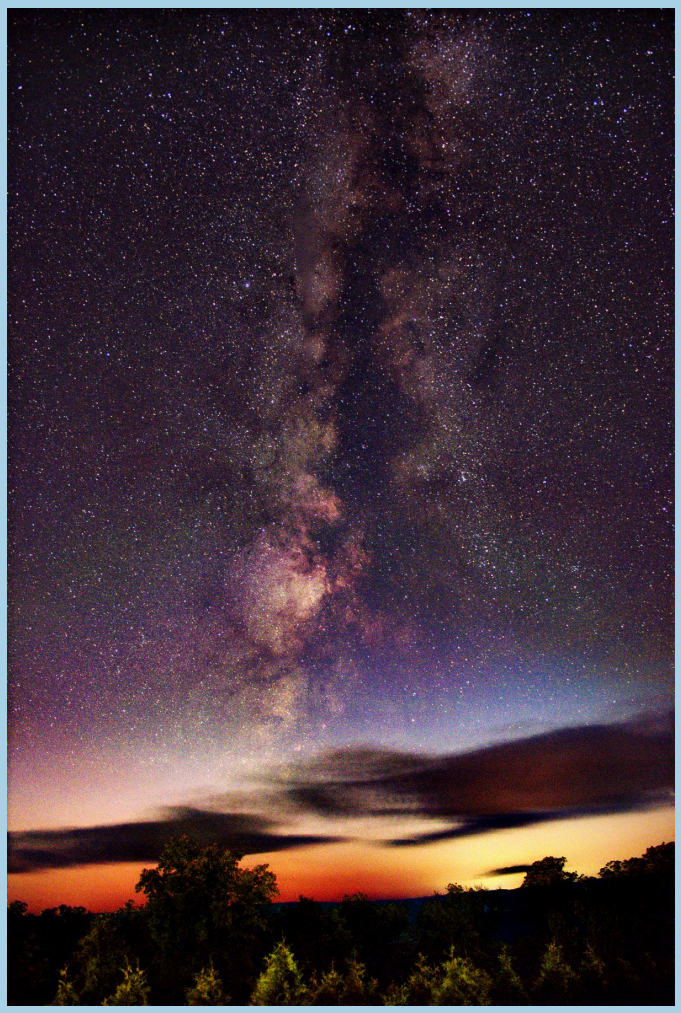
**By Joe Link**

My wife and I love road trips. Essential items when we pack for our trips include my digital camera and tripod (and more recently, my Seestar telescope) because there's always a chance one will have an opportunity to capture images of the stars from a remote location.

In July 2024, we took a trip to the Finger Lakes region of New York. My hopes for getting a picture of the Milky Way were high for that trip because the bed and breakfast where we stayed near Seneca Lake was under Bortle 4 skies that were much darker than the Bortle 8 skies at our home in New Jersey.

**Moon Issues**

There was a problem. My window of opportunity would be very small. Even though the sky was clear, a nearly full moon would be positioned almost in front of the Milky Way, making a photo of the galaxy impossible to capture during evening hours. I had a slim chance, however, to acquire an image in the early morning. My star chart showed that the Moon would set at 3 am. Because it was summer, that didn't leave me much time because astronomical twilight would begin at 3:25 am, preceding a 5:35 am sunrise. Morning astronomical twilight is the time when the sky ceases to be at its darkest.



That meant if I was going to photograph the Milky Way, I would have to try for the 30-minute period between moonset and twilight.

I set my alarm for 2:45 am. My plan was to set up my equipment on the grounds of the B&B, but I found that several spotlights trained on the lawn made that impossible. However, a vineyard, well away from lights, was across the two-lane road, so that's where I headed.

It was already 3:15 am once I found a good position in the vineyard. In the few minutes remaining before twilight, I set up my camera, a Fujifilm X-T20 with an 18-55mm zoom lens. I put the camera in full manual mode and set the ISO to 3200. I zoomed to 55mm toward the Milky Way and then focused manually on a bright star. I then zoomed back to 18mm and left the aperture wide open at f2.8. The night before I had set my interval timer to capture 15-second exposures with an eight-second gap between exposures. I managed to capture 13 RAW images between 3:24 am and 3:29 am, finishing just after the start of twilight. I actually captured 15 images, but in my nervousness over the timing, and because the vineyard was so dark, I kicked the tripod just before the final two images, spoiling its alignment. No time for a do-over! Finally, I replaced my lens cap and created one dark frame, using the same settings, for later processing.

Back home, I began processing my images. At the time, I was just starting my astrophotography journey and my experience with specialized software was practically nil.

**Photo Stacking**

I turned to Sequetor, the same software that I used for two earlier Milky Way photos, to stack my 13 images. The dark frame was included to reduce digital noise. Sequetor is free software developed by Yi-Ruei Wu in Taiwan. While more sophisticated applications exist, Sequetor works quite well with Milky Way photography because it has the ability to freeze the foreground while it stacks the star images that have shifted slightly over multiple exposures because of the Earth's rotation.

I then took the tiff file produced by Sequetor and loaded it into Starnet to remove the stars from the image and place them in a separate file. This way, I could process the Milky Way highlights and shadows and later have control over how prominently I wanted the stars to show.

I then loaded the starless image into my copy of Photoshop Elements 2022, a less-sophisticated version of full-featured Photoshop. I created layers to remove haze, improve contrast, deepen shadows and control highlights. I then imported the image of the stars that I saved with Starnet++ into another layer and used the Photoshop paintbrush feature to gradually reveal the image containing the stars. Once I was happy with the adjustments, I saved the output to a jpeg file.

I'm pleased with how the image turned out. Even though I couldn't photograph the bright core of the Milky Way at that point in the early morning, I did succeed in capturing the upper region, called the Great Rift, where massive clouds of galactic dust appear to cut through the star field. Also, golden light from the nearby village of Watkins Glen as well as a low-lying cloud, added a bit of drama to the image.

If I were to process the stacked tiff file today, I would probably use Siril and the tools it contains to remove haze and improve contrast. But I'm happy with the result that I got just by using the basic software available to me at the time.

## NJAA Members Train Telescopes on the Sky at Two New Jersey Events

The New Jersey Astronomical Association fosters community engagement by hosting "star parties," where the public can view celestial objects ranging from planets to nebulae to galaxies through a variety of member telescopes.

More than 700 enthusiastic visitors attended two star parties in August and September.

On Friday, September 18, 2026, 22 members of the NJAA held a **NASA International Observe the Moon Night.** The event took place at Wagner Farm Arboretum in Warren, NJ, and nearly 500 people turned out. The evening was organized and hosted by Bill Funcheon, a NASA Solar System Ambassador (SSA) and long-time NJAA member. The 22 astronomers generously donated their time, knowledge, and enthusiasm. They gave guided tours of the Moon, Saturn and many deep sky objects, using optical aids ranging from binoculars to a

massive 17" Dobsonian telescope. Other scopes included all varieties of reflectors, refractors, SCT's, dedicated Astrophotography rigs and many "smart" telescopes (Seestars, etc.). In addition, a tent and tables were set up with NJAA promotional materials and NASA stickers and informational giveaways. The table was staffed throughout the evening by volunteers, including fellow SSA and NJAA member, Paul Cirillo. This was the third large-scale astronomy event held at Wagner Farm and they have invited the group to come back soon.





International Observe the Moon night is an annual world-wide event, designed by NASA as a celebration of lunar observation, science and exploration. According to NASA, in 2025, 1 million people participated in 129 countries around the world.

**The second annual NJAA Space & Science Event** at Spruce Run Recreation Area in Clinton, NJ, was held on August 15, 2026, and welcomed approximately 200 people. The event brought together 12 observation stations and featured telescope viewing, a scale model of the solar system, Apollo 11 audio, NJAA history, meteorite displays, and the opportunity to touch a real piece of the Moon. Thank you to everyone who volunteered and helped make the event a success.





# A Probability Model for Observing Saturn's Satellites

**By Andrew J. Salthouse**

*Reprinted with permission from the Association of Lunar and Planetary Observers (ALPO)*

Abstract

The author made over 3000 visual observations of Saturn and its satellites at multiple apertures from 1965 to 2022. Based on this data, he develops a probability model that allows an observer to estimate the odds of visually observing a given Saturn satellite at a given aperture. He introduces the notion of an effective magnitude, rather than the published nominal magnitude, as input to the model.

## Background

The planet Saturn was known in antiquity, with records dating back to the 7th century BCE(1). The satellites have been observed since the invention of the telescope in the 17thcentury CE(2).

The author's interest in observing the moons of the giant planets began as a teenager, when he read how Galileo's discovery of Jupiter's four great moons was an epochal event of the scientific revolution. The author immediately resolved to observe these moons in his 2.4" refractor in the spring of 1965, and thereby feel a connection to that event. He followed up with observations of Saturn and its moons later that year. Naturally, the moons of Saturn were far more difficult in that small telescope (only Titan and occasionally Iapetus were visible), which led to the desire for ever larger apertures. Over the ensuing years and decades, the author always returned to Saturn and its moons at every opposition, trying to see which moons were visible in his telescopes.

Ten different apertures were used, ranging from 2.4" (6cm) up to 26.0" (66cm), at roughly 30% intervals (the two largest apertures, 21" and 26", were not the property of the author). Each aperture was used for at least 30 years, representing Saturn's complete circuit of the ecliptic. These are shown in Table 1. The limiting magnitude $m_A$ is derived from the formula:

(1) $m_A = 8.6 + 5\log(A)$, where A is measured in inches.

Table 1. Telescope Apertures.

| Inches | Cm | Lim Mag $m_A$ | Years | Remarks |
|---|---|---|---|---|
| 2.4 | 6.0 | 10.5 | 1965-2019 | |
| 3.0 | 7.6 | 11.0 | 1973-2019 | includes 7.6-8.0cm |
| 4.0 | 10.1 | 11.6 | 1966-2019 | includes 9.0-10.8cm |
| 6.0 | 15.2 | 12.5 | 1966-2019 | |
| 8.0 | 20.3 | 13.1 | 1968-2011 | |
| 10.0 | 25.4 | 13.6 | 1971-2001 | |
| 12.5 | 31.8 | 14.1 | 1973-2019 | includes 30.5-33.0cm |
| 17.5 | 44.5 | 14.8 | 1989-2022 | includes 43.2-45.7cm |
| 21.0 | 53.3 | 15.2 | 1989-2021 | |
| 26.0 | 66.0 | 15.7 | 1986-2022 | |

Each aperture has a nominal visual magnitude limit $m_A$, and each satellite has a nominal visual magnitude $m_S$. Theoretically, if $\Delta m = m_A - m_S$ is positive then the satellite S is visible in telescope aperture A, and not otherwise.

However, the author found that there is no sharp "yes/no" boundary, but rather a probability distribution. Positive values of Δm increase the probability that satellite S is visible in aperture A, and negative values of Δm reduce the probability. In other words, when Δm is positive, the satellite is usually, but not always visible, and when it is negative, the satellite is usually, but not always invisible.

Thus, there exists a probability curve that extends from zero to one over some range of Δm from negative to positive values.

Saturn's satellites are the best choice for testing observability at different apertures. Jupiter's moons can be seen at virtually every aperture, while those of Mars, Uranus, and Neptune require mostly large apertures.

There are eight satellites, I through VIII, that are visible in amateur telescopes, shown in Table 2[3]. They range in magnitude from roughly 8½ to 14, making an excellent test for apertures of all sizes. Were it not for Saturn's bright disk and rings nearby, they would be fairly easy targets.

Table 2. Saturn's Satellites.

| Number | Name | Discoverer | Period (days) | Magnitude ($m_S$) |
|---|---|---|---|---|
| I | Mimas | Herschel, 1789 | 0.9424 | 12.9 |
| II | Enceladus | Herschel, 1789 | 1.3702 | 11.7 |
| III | Tethys | Cassini, 1684 | 1.8878 | 10.2 |
| IV | Dione | Cassini, 1684 | 2.7369 | 10.4 |
| V | Rhea | Cassini, 1672 | 4.5182 | 10.0 |
| VI | Titan | Huygens, 1655 | 15.9454 | 8.3 |
| VII | Hyperion | Bond/Lassell,1848 | 21.2766 | 14.2 |
| VIII | Iapetus | Cassini, 1671 | 79.3215 | 11.0 |

Source: *"Classic Satellites of the Solar System"*, Observatorio ARVAL, April 15, 2007.

The data

The author observed and recorded visibility data at each opposition from 1965 to 2022, 56 oppositions in all. 93% of these were made from several sites in New Jersey and about 7% were made in Michigan. All the sites suffered from light pollution.

The author made 3,085 observations on 2,366 nights, averaging about 55 observations per opposition. Whenever he used two different apertures at the same time, he found that a given satellite was never visible in the smaller aperture, if it was not visible in the larger aperture. This implies that the faintness of the satellite is more important than the glare from the planet and rings for determining visibility.

During the study period, Saturn travelled twice around the Sun. Thus, the data captures the high and low points on the ecliptic, perihelion and aphelion, and rings edge-on and wide open. As a result, the author's results should be representative of any long-term average. However, it is only fair to point out that the observations were not uniformly distributed over time, with some oppositions heavily observed and others more sparsely.

Table 3 shows the number of times each satellite was observed at each aperture over the study period.

Table 3. Raw Data from 56 Oppositions.

| Aperture | # Obsvns | I | II | III | IV | V | VI | VII | VIII |
|---|---|---|---|---|---|---|---|---|---|
| 2.4 | 90 | | | | | 31 | 81 | | 25 |
| 3.0 | 90 | | | | 1 | 49 | 87 | | 35 |
| 4.0 | 95 | | | 6 | 8 | 72 | 93 | | 63 |
| 6.0 | 96 | | | 28 | 39 | 90 | 95 | | 72 |
| 8.0 | 175 | 1 | 6 | 123 | 136 | 164 | 173 | | 155 |
| 10.0 | 379 | 11 | 62 | 318 | 319 | 368 | 378 | 1 | 350 |
| 12.5 | 205 | 8 | 62 | 201 | 202 | 204 | 205 | 5 | 203 |
| 17.5 | 1,828 | 108 | 1,245 | 1,813 | 1,820 | 1,826 | 1,828 | 136 | 1,828 |
| 21.0 | 12 | 3 | 10 | 12 | 12 | 12 | 12 | 3 | 12 |
| 26.0 | 115 | 47 | 102 | 115 | 115 | 115 | 115 | 46 | 115 |

Table 4 shows these results expressed in decimal form.

Table 4. Fraction of Time that each Satellite was Visible in each Aperture.

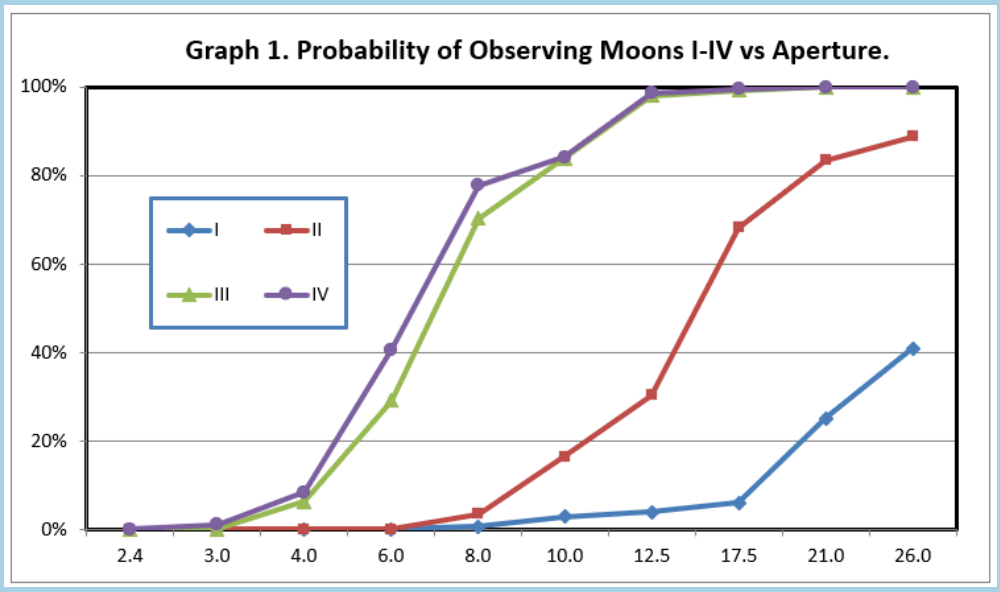
| Aperture (Inches) | I | II | III | IV | V | VI | VII | VIII |
|---|---|---|---|---|---|---|---|---|
| 2.4 | 0.000 | 0.000 | 0.000 | 0.000 | 0.344 | 0.900 | 0.000 | 0.278 |
| 3.0 | 0.000 | 0.000 | 0.000 | 0.011 | 0.544 | 0.967 | 0.000 | 0.389 |
| 4.0 | 0.000 | 0.000 | 0.063 | 0.084 | 0.758 | 0.979 | 0.000 | 0.663 |
| 6.0 | 0.000 | 0.000 | 0.292 | 0.406 | 0.938 | 0.990 | 0.000 | 0.750 |
| 8.0 | 0.006 | 0.034 | 0.703 | 0.777 | 0.937 | 0.989 | 0.000 | 0.886 |
| 10.0 | 0.029 | 0.164 | 0.839 | 0.842 | 0.971 | 0.997 | 0.003 | 0.923 |
| 12.5 | 0.039 | 0.302 | 0.980 | 0.985 | 0.995 | 1.000 | 0.024 | 0.990 |
| 17.5 | 0.059 | 0.681 | 0.992 | 0.996 | 0.999 | 1.000 | 0.074 | 1.000 |
| 21.0 | 0.250 | 0.833 | 1.000 | 1.000 | 1.000 | 1.000 | 0.250 | 1.000 |
| 26.0 | 0.409 | 0.887 | 1.000 | 1.000 | 1.000 | 1.000 | 0.400 | 1.000 |

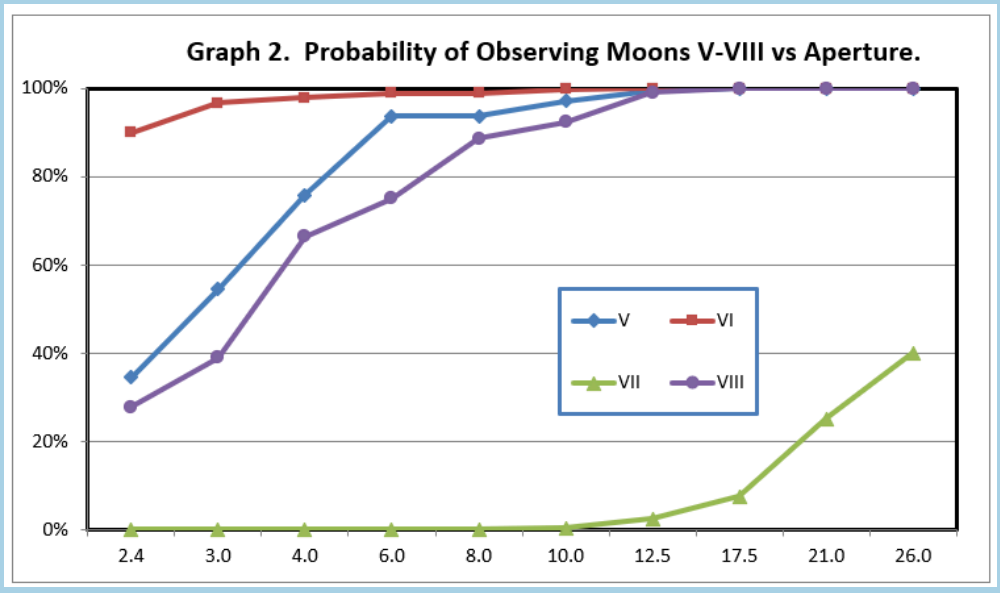
From these tables, it is clear that some of the satellites are much more difficult to observe than others. Satellites I and VII were visible only a small percentage of the time, even at the largest apertures, whereas VI was visible almost all the time at every aperture.

The author graphed all the data in Table 4. The results are shown in Graphs 1 and 2. Several points were immediately evident:

- Satellites I and VII had the lowest probabilities
- Satellites V and VI had the highest probabilities
- Satellites II, III, IV, and VIII had the greatest range of visibility from low to high

The shape of the graphs suggested a logit function. This function is commonly used in statistics to model "pass/ fail" outcomes.



The model

The author selected a logit model with the following form:

(1) $Prob(x) = \exp(\beta x)/(1+\exp(\beta x))$

where $x = (m_A - m_S)$

Note that when x = 0, the probability function is ½ and the slope is β/4. β is a measure of how rapidly the probability function changes with magnitude differences; a higher value implies greater sensitivity to aperture. The first derivative of Prob(x) is always positive; the second derivative is positive for negative x and negative for positive x.

From observations of the probability curve, the author concluded that each of the satellites was more difficult than would be implied by the published values of $m_S$. This led the author to introduce an "effective magnitude" $m_E$ for each satellite, representing the true level of difficulty of observation.

Note that the author did not attempt to estimate the visual magnitudes of the satellites; rather, the effective magnitudes $m_E$ (and slopes β) were estimated from the best fit of the probability model applied to the data (i.e., minimal $\chi^2$)[(4)].

The author concluded that a better model for the probability of observing Saturn's satellites is:

(1) $Prob(z) = \exp(\beta z)/(1+\exp(\beta z))$

where $z = (m_A - m_E)$

Not surprisingly, the effective magnitude $m_E$ was larger (fainter) than the nominal magnitude $m_S$ for all eight satellites.

Conclusions

The parameters β and $m_E$ were estimated independently for each satellite. However, for satellites with probabilities clustered near zero (I and VII) and those clustered near one (VI), the estimates for β have higher uncertainty, due to the smaller range of observed probabilities. The data at each aperture was weighted by the

number of observations made at that aperture. Thus, the data at 17.5" and 21.0" were given the highest and lowest weights, respectively. Unfortunately, only a small number of observations could be made at 21", resulting in wider confidence intervals for that aperture.

Satellite VIII is a special case. As is well known, this satellite varies from roughly mag 10 when west of the planet to about mag 12 when east. This introduces an additional source of variability into the results over and above the variance due to aperture. As a result, the probability curve is more spread out, resulting in a smaller value β = 1.20 for satellite VIII. Thus, the visibility of Iapetus is less sensitive to aperture than is the case for the other natural satellites.

Some of the other satellites are also somewhat variable, but to a much smaller extent.

Additional exogenous sources of variability include sky transparency, moonlight, light pollution, Saturn's altitude above the horizon, ring tilt, observer fatigue, and others. All of these would contribute to increasing the range of probabilities, and therefore to reducing the modeled values of β.

Table 5 shows both the nominal ($m_S$) and effective ($m_E$) magnitudes and the difference for each satellite. The estimates for β are also shown. As a general rule, both the magnitude difference $m_E - m_S$ and the parameter β appear to trend downward from satellite I to VIII. This makes sense, as it implies that the planet's glare has less impact on the visibility of outer vs inner satellites.

Table 5. Published vs. Effective Magnitudes.

| Number | Name | $m_S$ | $m_E$ | $m_E - m_S$ | Beta |
|---|---|---|---|---|---|
| I | Mimas | 12.9 | 15.8 | 2.9 | 2.74 |
| II | Enceladus | 11.7 | 14.4 | 2.7 | 2.05 |
| III | Tethys | 10.2 | 12.8 | 2.6 | 2.37 |
| IV | Dione | 10.4 | 12.7 | 2.3 | 2.14 |
| V | Rhea | 10.0 | 10.9 | 0.9 | 1.50 |
| VI | Titan | 8.3 | 9.2 | 0.9 | 1.67 |
| VII | Hyperion | 14.2 | 15.8 | 1.6 | 2.45 |
| VIII | Iapetus | 11.0 | 11.3 | 0.3 | 1.20 |

References

(1) Alexander, A.F.O'D., *"The Planet Saturn"*, Faber & Faber, 1962, ch. 2 pp 41-46.

*(2) Ibid*, ch. 4 pp 91-93.

*(3) "Classic Satellites of the Solar System",* Observatorio ARVAL, April 15, 2007

(4) Modified $\chi^2 = \Sigma\ (obs - exp)^2$

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# Guidance for QOs who Plan to Target Saturn on Their Next Public Night

**By Robert Starcher**

In this issue of the NJAA Journal, we've republished, with the permission of the Association of Lunar and Planetary Observers (ALPO), a paper that Andrew Salthouse, a longtime NJAA member and former QO, published in the ALPO Journal's Spring 2023 issue. In that paper, he discusses several points that should be of interest to any QO that plans to target Saturn on a public night at NJAA. The subjects related in Andrew's paper include:

1. the probabilities of successfully observing each of the eight brightest moons of Saturn, based on thousands of his own observations in our moisture-laden light-polluted skies, during 56 oppositions of Saturn (between 1965 and 2022), with telescopes of ten different aperture diameters ranging from 2.4 to 26 inches, and

2. the establishment of a practical "effective" magnitude for each of these moons that considers our less-than-ideal viewing conditions, in place of the published nominal magnitude, when considering which of Saturn's satellites are likely to be identifiable in a telescope with a given aperture and associated limiting magnitude.

The probability of observing a given satellite of Saturn on the average night, with a telescope of a given aperture can be obtained by inspecting Table 4 of Andrew's paper. The table shows the number of times each

moon was successfully observed with a given aperture, divided by the number of times that observing the satellite was attempted. The table expressed these relative frequencies in decimal form, but they can be converted to percent probabilities of successfully observing each of the eight satellites with each of the apertures used in the investigation. These probabilities are plotted against telescope apertures, in Graph 1 of his paper (showing I Mimas, II Enceladus, III Tethys, and IV Dione) and Graph 2 (showing V Rhea, VI Titan, VII Hyperion, and VIII Iapetus).

In ideal viewing conditions, one would expect that when the magnitude of the targeted object has a smaller value (i.e., the object is brighter) than the limiting magnitude of a given telescope, it should be visible in that telescope. However, Andrew points out that this does not apply to our light-polluted skies. In fact, even the brightest moon (Titan) with a nominal magnitude of 8.3, was not always visible at apertures less than 12.5 inches, which has a calculated limiting magnitude of 14.1. Consequently, he recommends a more practical "effective magnitude," equal to the aperture-dependent limiting magnitude of a telescope through which the satellite would be observable 50 percent of the time.

An aperture with a limiting magnitude that is equal to the effective magnitude of one of Saturn's moons can be interpolated from its probability plot shown on Graph 1 or Graph 2 in Andrew's paper. One can find where the satellite's probability curve equals 50 percent probability on the vertical scale and then interpolate that point's aperture coordinate on the horizontal scale between the apertures used to collect observation data in the study.

In describing uncertainty in the observed data, Andrew's paper points out the curves interpolated between the apertures he used did not all appear to be very smooth. However, he determined that the curves appeared to resemble portions of the logit function, which is used in astronomy to model binary outcomes, including whether a targeted object is detected or not. He then fitted the logit function to the observation data for each satellite and calculated an effective magnitude for each satellite. The values of these eight effective magnitudes are shown in his paper's Table 5. These can be used to determine the minimum aperture that can be used with a 50 percent probability of successfully observing a given satellite of Saturn, by inverting the limiting magnitude equation to solve for aperture.

From Andrew's paper, the equation for a given telescope aperture's limiting magnitude ($m_A$) is:

$$m_A = 8.6 + 5\log A$$, where A is the diameter of the telescope's aperture, in inches.

Setting the limiting magnitude to the value of the effective magnitude ($m_E$) and (inverting the equation, we obtain the minimum aperture diameter of a telescope in which the selected satellite would be visible 50 percent of the time in our skies:

$$A = 10^{[(mE-8.6)/5]}$$

The resulting minimum telescope aperture for each satellite is shown in the table below:

| Name of Selected Moon of Saturn | Recommended Minimum Aperture (inches) |
|---|---|
| I Mimas | 27.5 |
| II Enceladus | 14.5 |
| III Tethys | 6.9 |
| IV Dione | 6.6 |
| V Rhea | 2.9 |
| VI Titan | 1.3 |
| VII Hyperion | 27.5 |
| VIII Iapetus | 3.5 |

Note that even with the 26-inch telescope, there is less than a 50 percent chance of observing Mimas and Hyperion. However, it I were planning to display Saturn in the 26-inch and that night's seeing promised to be better than average, I would include familiarizing myself with their locations among my preparations.

It is unlikely that Enceladus would be observable with anything less than a 14.5-inch aperture. However, we do have an 18-inch Dobsonian in the Tower Room that should be able to find it, even with slightly poorer-than-average seeing. Also, a QO stationed in Luna 2 during a public night might consider Enceladus to be a respectable challenge for the 14-inch Celestron EdgeHD located there. On a good night, you might even be able to see it with the 12-inch Light-Bridge Dobsonian.

The remaining five satellites (Tethys, Dione, Rhea, Titan, and Iapetus) should be relatively easy for any of the 8-inch Dobsonians or the 8-inch Schmidt-Cassegrain in the Tower Room, as well as for the 8-inch Celestron EdgeHD in Luna 3. Rhea is bright enough to be visible in the 3-inch binoculars on a night with average seeing and have a 35 percent chance of being seen in the 2.5-inch binoculars. Titan should be visible in all our unfiltered instruments, in all but the worst viewing conditions.

In practice, these satellites might be difficult to distinguish from background stars, Consequently, it is important to inform yourself where they will be with respect to Saturn and its rings beforehand, if you hope to identify them in your telescope's field of view. There is a Sky and Telescope website that will provide you with a chart that shows the relative positions of Enceladus, Tethys, Dione, Rhea, and Titan with respect to Saturn and its rings. You only need to go on their website (at the link provided below) and enter the date and time and whether the image will be inverted from left to right, rotated, or directly viewed. Images that are reversed from left to right are produced by telescopes that use a diagonal to hold the eyepiece, such as a classical Cassegrain, SCT, or refractor. Newtonian telescopes (including Dobsonians) rotate the image 180 degrees, but it is only inverted, not reversed from right to left, and therefore a true image. Binoculars show an enlarged, but otherwise erect and true image.

https://skyandtelescope.org/wp-content/plugins/observing-tools/saturn_moons/saturn.html

It is very important to the note that this Sky and Telescope website requires the entered time to be in terms of Universal Time. Since we are four hours behind universal time during DST, one would need to add four hours to the time one plans to look for these satellites. For example, if your expected viewing time is 9:00 PM on October 17, 2026, the Universal Time that must be entered should be four hours later, or 1:00 AM, October 18, 2026.

Although it is the third brightest of Saturn's moons, Iapetus is omitted from the Sky and Telescope web application. This is probably because its orbital diameter is very large, which may make the nearer moons difficult to distinguish from each other in the chart. Mimas is omitted because it is relatively dim. Hyperion is both dim and nearly as distant from Saturn as Iapetus is. If you are interested in finding these three moons, you can use the Stellarium Web on-line application, which can locate all of Saturn's satellites:

https://stellarium-web.org/

Stellarium Web runs on your internet browser, and is not difficult to use on a desk-top computer or a laptop. You can purchase a Stellarium version that can run on your smartphone, but it may not be as easy to use. After accessing the website, the application asks permission to determine your location. Clicking on "Allow" lets you enter your selected local viewing time directly, without requiring you to convert to Universal Time. Find the time and date block in the lower right of the screen and enter the desired local viewing time and date.

Select the search bar in the middle of the top edge of the screen and enter "Saturn" in the search field. If Saturn is above the horizon at the selected time, the application will center it in the screen. Zoom in until the moons appear with their respective name labels. In order to be able to distinguish the moons that are dimmer and closer to Saturn, you may need to zoom in so closely that the simulated movement of Saturn across the sky is too fast for convenient viewing or screen capturing. If this happens, click on Saturn or one of the moons and an information field will open in the upper left of the screen. Just below the lower left corner of this information field is a center-the-selection icon. Clicking on the icon will stop the drifting when you zoom in.

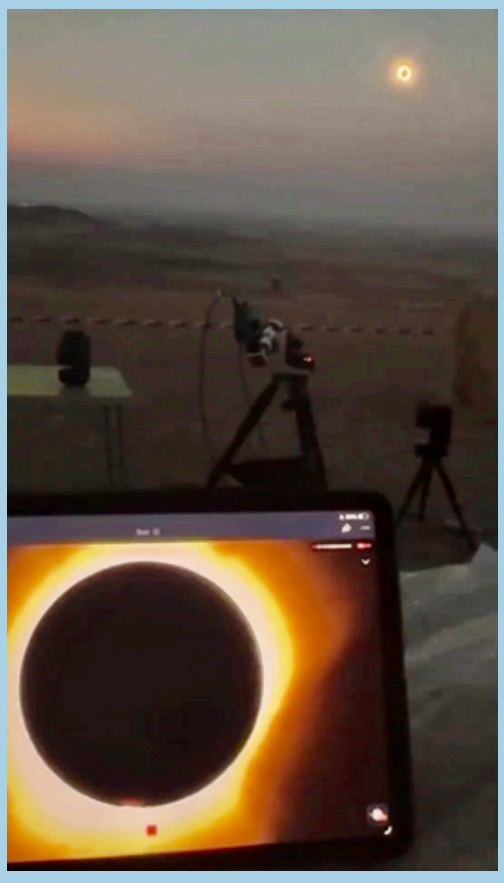
Zooming in will show the locations of Mimas, Enceladus, Tethys, Dione, Rhea, and Titan, unless they are behind Saturn and therefore out of view. Iapetus may be outside of the zoomed-in field of view. You may want to preserve multiple images at different zoom scales in preparation for the public night. Hyperion also orbits very far from Saturn and may not be in the zoomed-in field of view. For some reason, the label for

Hyperion is not shown on the Stellarium Web application unless you specifically target “Hyperion” in your search. After finding Hyperion, you can zoom out and get a small-scale image that shows the position of Hyperion relative to Saturn and Iapetus and other bright, less-distant satellites.

Note that when you are showing the public the satellites of Saturn, you may need to change eyepieces to alternatively resolve the nearer moons and then to provide enough field of view to show the more distant ones.

## Astronomy: A Language Larger Than Words

**By Bilal Siddiqui**



On August 12, 2026, the University of Valladolid brought students, researchers, educators, local residents, and visiting observers to Autilla del Pino for the total solar eclipse. CosmicNearness traveled from the United States to attend the event and share it through a live telescope with people who could not travel to Spain or were outside the path of totality.

The original plan was to capture a clear view of the Sun and broadcast the eclipse as it unfolded. Months had been spent preparing, but the experience quickly became about more than image quality. Many of the students, researchers, and organizers were being met for the first time, yet their welcome made an unfamiliar place feel like a second home. Conversations moved between Spanish and English, sometimes pausing for translation or continuing through an image, diagram, or familiar term from physics. Discussions of solar physics, orbital motion, and celestial scale created common ground without requiring every word to be understood. The University of Valladolid had created an environment where knowledge moved naturally among researchers, students, visitors, and the local community.

That experience showed how quickly astronomy can connect people.

When attention is limited to immediate surroundings, language, nationality, and background can feel like large divisions. A conversation about the Sun places those differences inside a much wider frame. They remain part of who people are, but they no longer prevent connection.

This change in scale also changed how the telescope was used. CosmicNearness arrived prepared to prioritize the sharpest possible solar images. As people gathered around the equipment, it became clear that protecting a perfect technical setup would limit their experience. They wanted to understand the telescope, discuss what it was showing, and participate in the observation.



The focus shifted from perfect performance to shared access. The telescope still needed to provide a clear and accurate view, but it also needed to be available to the people standing nearby. Time was spent discussing the Sun, demonstrating the equipment, and allowing others to experience solar observing directly.

Performance can be optimized, but experience cannot be ignored.

That became CosmicNearness's role at the event: keep the science clear while bringing people closer to it. Totality was extraordinary, but the more lasting experience was seeing astronomy create a connection without a shared language.

That connection did not require anyone to ignore language or culture. Looking toward the Sun simply placed those differences within a larger frame. Its light reaches people without regard for nationality, the Moon's shadow crosses borders without recognizing them, and Earth continues moving as one planet regardless of the lines drawn across its surface.

These may be familiar astronomical facts but experiencing them among people from another country gives them a different meaning. Looking at the Sun together made the distance between people feel smaller.

There was also a strong sense of being present. During the eclipse, attention was not on regrets from the past or worries about the future. It remained with what was happening in the sky and with the people experiencing it together.

An eclipse follows its own timing. It cannot be delayed or repeated. Everyone meets the moment when it arrives. That shared attention creates a sense of belonging that can be difficult to find in everyday life.

Thinking on a cosmic scale does not make life on Earth less important. It makes this shared world feel more important. Language, nationality, and culture remain part of who we are, but they exist within something much larger.



The eclipse ended, the telescope stopped broadcasting, and the people at the event returned to their separate lives. What remained was more than a memory of the Moon covering the Sun. It was the realization that people can feel a sense of belonging when they think beyond the scale of their surroundings.

On a cosmic scale, we are tiny creatures living on a small rock floating in infinite space.

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## Contributors Needed!

The NJAA Journal is soliciting contributions for future issues. Click here if you would like to submit an article to the Journal. Any submission is welcome and will be reviewed for publication. This is a great opportunity for younger members to see their work published in a periodical.




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