AOH Newsletter

Spring 2021

News and Notes

AOH continues its (new) tradition of monthly Zoom meetings on the weekends nearest the full moon. And we continue to encourage private observing on our traditional weekends nearest the new moon.

The next Zoom meetings are scheduled for March 27, April 24, and May 29. Observing weekends are March 12/13 (the Messier Marathon weekend), April 10, and May 8. Check the Upcoming Events page on the AOH website for any changes.

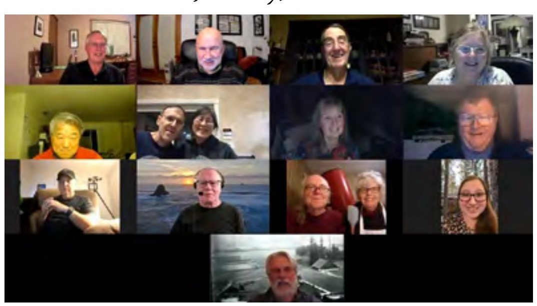
As always, send in articles, photos, sketches, or descriptions to ken@astro-hum.org.

And, thank you.

—Ken

December, 2020

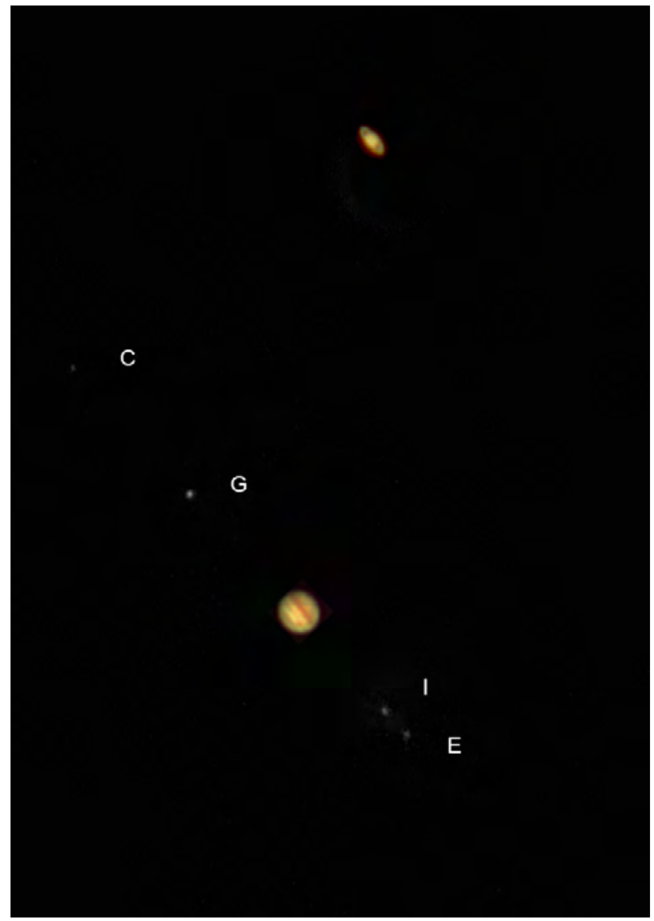
January, 2021



February, 2021

Jupiter and Saturn

by Grace Wheeler



This is a composite image of Jupiter, its Galilean moons (labeled), and Saturn, taken on December 20, 2020. There are three separate images, with the exposure optimized for each. Here are the nitty gritty details: I used a 4 inch refractor telescope, taking several images with a planetary webcam; I stacked them in Autostakkert, and did post-processing in Registax and Photoshop.

Conjunctions, Coincidences, and Physical Laws

by Ken Yanosko

So, what about that Jupiter-Saturn conjunction that the news was all agog about last December? When can we expect the next one? Well, there are conjunctions all the time, especially involving fast-moving Mercury and Venus, and to a lesser extent, Mars. Check the AOH Calendar, where the naked-eye ones are listed. Of course, last December's was unusual, in that Jupiter and Saturn appeared very close in the sky. At other times, Jupiter goes past Saturn, but usually a few degrees away; nevertheless, can we figure out, in our heads, or at least on the back of an envelope, when this will happen again?

The answer is yes, as it turns out. We just need to know how long it takes both Jupiter and Saturn to go around the Sun. This isn't something I carry around in my head, but we can figure it out using Kepler's Law, if we know how far the planets are from the Sun. I don't carry this around in my head either, but I can determine it using a formula called Bode's Law. (Actually it was discovered by Titius, but popularized by Bode; Bode discovered Bode's Galaxy, popularized by Messier as M81.)

So here's what Bode tells us: Write down the numbers 0 and 3. Then continue the sequence by doubling the previous term, getting 0, 3, 6, 12, 24, etc. Then, to each term add 4, and then divide each term by 10. You get the numbers in the second column in the adjacent table. Guess what? These turn out to be the orbital radii of the planets, measured in Astronomical Units!

Planet	Orbital Radius in AU
Mercury	0.4
Venus	0.7
Earth	1.0
Mars	1.6
--	2.8
Jupiter	5.2
Saturn	10
--	about 20

Wait, what about those blanks? Well, in Bode's day, 1772, the only planets known were the ones in the table. But sure enough, in 1781, Uranus was discovered out at 20 AU, right where it was supposed to be; and better still, in 1801, Ceres was found in between Mars and Jupiter. So there must be some underlying physical law here, right? Unfortunately, there is absolutely no reason why the planetary orbits should obey Bode's Law, and in fact, they don't. When Astronomers looked for Neptune out around 40 AU, where Bode's Law predicted, they were surprised to find it at only 30. And the recent discovery of all those exoplanets, with all sorts of orbital radii, shows that Bode's Law is little more than an example of the Law of Small Numbers—small data sets can show patterns that don't hold up in the long run.

But I digress. Bode's Law does give us pretty good approximations to the sizes of Jupiter's and Saturn's orbits. And Kepler's Law says that the orbital period of any orbiting body is proportional to the 1.5-power of its orbital radius. I.e. $P = C \times R^{1.5}$ for some constant C. Now, do we have to get out a physics book to see what that constant C is? No. Since for planet Earth, P = 1 year and R = 1 AU, that constant C, which is the same for everything in orbit around the Sun, must also be equal to 1. So for Jupiter we have $P = 1 \times 5.2^{1.5} \approx 12$, and for Saturn it's $P = 1 \times 10^{1.5} \approx 30$. I.e. one Jupiter year is 12 Earth years, and one Saturn year is 30 Earth years. So in T years Jupiter goes around the Sun T/12 times, and Saturn T/30 times. What remains is to figure out how many years it takes Jupiter to lap Saturn, that is, make one orbit more than Saturn does in the same time. The equation is $T/12 = T/30 + 1$. So all you have to do is find a high school kid to do the algebra for you! Alternatively you can ask Google. Type the equation into the search box and it shows you, step by step, how to get the answer: T=20. So in 20 years we'll have another Jupiter-Saturn conjunction. Well, more or less, actually. We are ignoring where Earth will be in its orbit; but since the Earth's orbit is quite small compared to those gas giants, we are probably okay if we say "20 years or so".

But what about this "Kepler's Law"? Another coincidence? No. It's true that Kepler published it in 1619, based on observations, just as Bode had done. But in 1687 Newton showed that Kepler's Law can be derived mathematically from Newton's own Laws of Motion and Gravitational Attraction. All the planets, all the planets' moons, and all the exoplanets heretofore discovered obey Kepler's Law. So I'm *really* confident about this prediction.

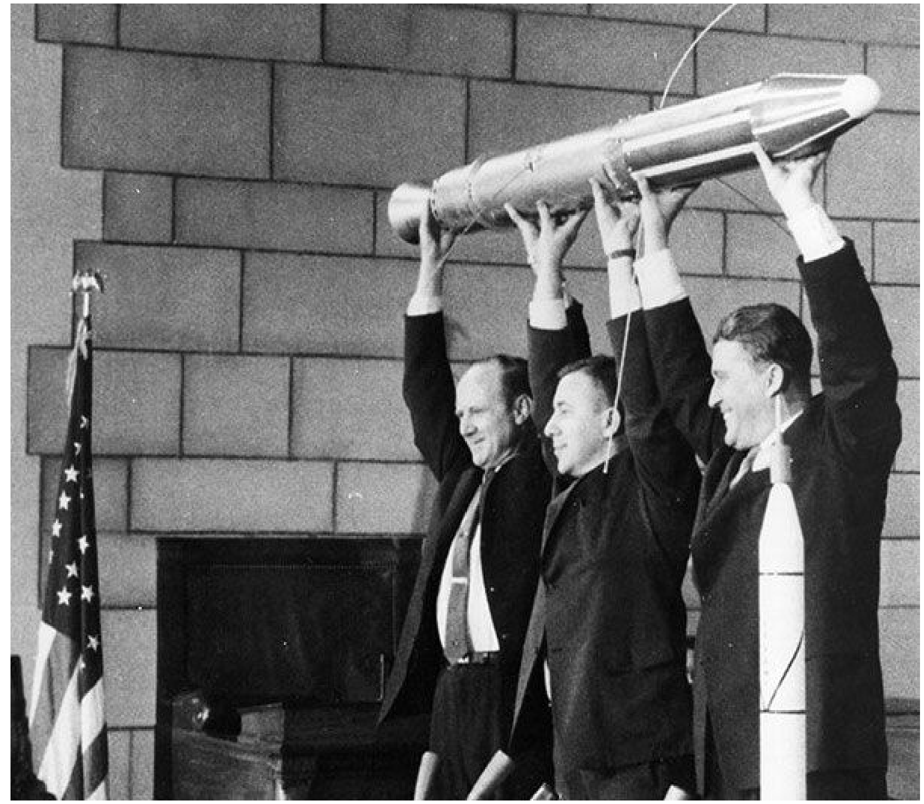
JPL and the Space Age

by Grace Wheeler

"JPL and the Space Age" is a series of historic documentaries written and produced by award-winning filmmaker Blaine Baggett. Baggett has been long associated with JPL where he headed the Office of Communication and Education from 1999 to 2017. Since 2017, he has been a JPL Fellow focused on producing documentaries about JPL and its role in space exploration. The first documentary, "Explorer One", was made in 2008 to commemorate the 50th anniversary of the satellite's launch. Since then, documentaries for this series have been made every one to two years. For many years these films were shown only at Caltech or sometimes on the local PBS station. DVDs of some of the episodes could be purchased at the Caltech bookstore, which ultimately made their way to eBay. In February of this year, JPL finally released the entire series on the JPL webpage; they are available at this link: https://www.jpl.nasa.gov/who-we-are/documentary-series-jpl-and-the-space-age.

The first three episodes are about the creation of the lab and how JPL transitioned from being a military contractor to doing trail-blazing work in space exploration. "American Rocketeer" is about a group of Caltech graduate students and amateur rocket enthusiasts that came together in the mid-1930s to form the core of what would become JPL. The group was led by Frank Malina, a graduate student of Caltech aeronautics professor Theodore Van Karmann. While Van Karmann and Caltech gave the group their blessing, they provided no financial support other than some lab space. The group was nicknamed the "suicide squad" for their work with noxious chemicals and explosives. The "jet propulsion" name came later when the Air Force, in anticipation of being drawn into WW II, contracted with Malina's group to develop jet-assisted takeoff (JATO). While the original intent of Malina and his rocketry group was to use rockets for exploring space, they found their work being co-opted for military use. For the next 20 years, JPL would be involved in military research which included developing guided missiles to carry atomic warheads. Malina, a lifelong pacifist, led JPL throughout WW II, but ultimately left because he opposed the lab's military work.

The second episode, "Explorer One", takes place during the late 1950s. By then, JPL and Caltech wanted to get out of working for the Army and were keen on exploring space. "Explorer One" focuses on America's space race with the Soviets, and how JPL (with grudging help from Wernher Von Braun's Huntsville group) launched the first successful U.S. satellite. Even though the Soviets had beat the U.S. into



The successful launch of Explorer One. JPL Director William Pickering, physicist James Van Allen, and Wernher Von Braun. Image credit: Caltech/JPL

space with Sputnik, JPL's Explorer satellite was the first to carry scientific instruments. Explorer's most important discovery was that of a radiation belt (Van Allen Belt) surrounding the Earth. The 1959 Explorer mission was JPL's entry into space exploration, and shortly afterward, JPL became part of a newly formed civilian space agency known as NASA.

Surveyor One lands on theMoon. Image Credit: NASA/JPL.

The third episode, "Destination Moon" takes place during the 1960s and is about JPL's first three space missions and how these tested the capabilities of JPL. Ranger and Surveyor were moon missions that were flown in support of NASA's Apollo program, while Mariner's mission was to fly to another planet. Of the three undertakings, the Ranger was considered the easiest since it only required JPL to send a spacecraft to the Moon, take photographs, and then crash land onto the surface. However, Ranger was plagued with problems, and it took seven attempts to successfully fly to the moon. JPL received a boost with its "first in space" flyby of Venus by Mariner Two. Mariner Two showed that a spacecraft could be controlled from great distances, and science data could be collected and transmitted back to Earth. The landing of Surveyor One on the moon in 1966 was the first time Americans had done a controlled landing on an extra-terrestrial body. The Surveyor program gathered information about the lunar surface that would be used for the Apollo landings.

The remaining eight episodes of "JPL and the Space Age" span the 1970s to the early 2000s. The missions covered are the early missions to Mars (Mariners and Viking), Voyager 1 and 2, Galileo, Magellan, Hubble Space Telescope, and the Martian orbiters and rovers. What makes these documentaries captivating is the telling of the stories behind the missions. The documentaries take an honest look at the spectacular successes and failures of the various JPL undertakings, as well how politics (Reagan's Star Wars, the Space Shuttle program) and dwindling funds ("faster, better, cheaper") determine how missions are carried out. The overarching theme of "JPL and the Space Age" is that science is a human endeavor driven by curiosity and creativity. Doing stunning science requires risks and the willingness to fail. Blaine Baggett's "JPL and the Space Age" does a first-rate job of conveying that spacecraft, from Explorer One, to the Voyagers, and to the Martian Rovers, are more than just metal and scientific instruments. They are emissaries that reflect the people who build them and send them into the unknown.

Voyager testing 1976. Image Credit: NASA/JPL/Caltech

The Great American Eclipse, Part Two

by Ken Yanosko

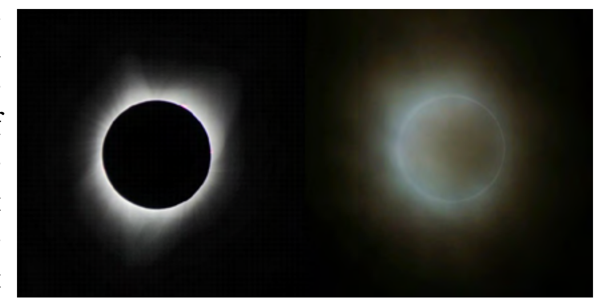
It wasn't too long ago, on August 21, 2017, that many of us trooped up to Oregon (or parts east) to see what was then billed as "The Great American Eclipse". The path of totality crossed North America from Oregon to South Carolina, prompting millions of Americans to squeeze into a narow band across the country, clogging motels, campgrounds, and highways, but enjoying what ought rightfully to be called "The Greatest Show on Earth".

Well, are you ready to do it again? In three short years, on April 8, 2024, we'll have another one. This time we'll have to share the path of totality with our neighbors Mexico and Canada. The path hits land at Mazatlán, Mexico, enters the United States northwest of Laredo, Texas, and sweeps northeasterly to Maine, crossing over into New Brunswick and Newfoundland. It's a little farther away, but any total eclipse is well worth the effort to get there. And it's not too early to begin planning.

A word of caution. If you make reservations, be sure the proprietor knows that there is going to be an eclipse; in 2017 some of our AOH members had reservations canceled when the properety owners belatedly found out that they could get triple the agreed-upon price from other eclipse-goers. I was lucky that year. Susan's brother still owns the house near Salem that was once their childhood home, so we were welcomed to observe from a backyard within the path of totality. And my luck extends to 2024. My sister still owns the house near Cleveland that was once *our* childhood home; it will be in the path of totality. I already have reservations (at the usual price).

Our hosts for the 2017 eclipse, observing the partial phase before totality.

Now what if you don't want to travel so far? You're in luck, if you are willing to settle for an annular eclipse. Remember the "ring of fire" eclipse we had in May of 2012? On October 14, 2023 an annular eclipse path runs from Oregon to Texas, and actually cuts across the northeastern corner of California. Of course an annular eclipse isn't anywhere close to the spectacle of totality, but it's still worth a short drive to see it.



Left, the total eclipse of 2017, with the sun's corona visible. Right: the annular eclipse of 2012; that's not the corona you're seeing, that's the "ring of fire" dampened by Humboldt County clouds.

And what if you don't want to travel at all? You can stay here and see two partial eclipses. In 2023 the sun will be 83% obscured, and in 2024 it's 27%. Or you can hang in there until August 12, 2045. The Great American Eclipse, Part Three, will pass right through Humboldt County! Stay tuned.

Map by 'Michael Zeiler, www.GreatAmericanEclipse.com'. Used with permission.

This article is distributed by NASA Night Sky Network. The Night Sky Network program supports astronomy clubs across the USA dedicated to astronomy outreach. Visit nightsky.jpl.nasa.gov to find additional articles, events, and more!

Turn Supermoon Hype into Lunar Learning

Illustration of the position of the Earth's moon at apogee and perigee. Source image credit: NASA (Earth) Gregory R. Revera (Moon)

Supermoons get lots of publicity from the media, but is there anything to them beyond the hype? If the term "supermoon" bothers you because it's not an official astronomical term, don't throw up your hands. You can turn supermoon lemons into lunar lemonade for your star party visitors by using it to illustrate astronomy concepts and engaging them with great telescopic views of its surface!

Many astronomers find the frequent supermoon news from the media misleading, if not a bit upsetting! Unlike the outrageously wrong "Mars is as big as the moon" pieces that appear like clockwork every two years during Mars's close approach to Earth, news about a huge full moon is more of an overstatement. The fact is that while a supermoon will indeed appear somewhat bigger and brighter in the sky, it would be difficult to tell the difference between an average full moon and a supermoon with the naked eye.

There are great bits of science to glean from supermoon discussion that can turn supermoon questions into teachable moments. For example, supermoons are a great gateway into discussing the shape of the moon's orbit, especially the concepts of apogee and perigee. Many people may assume that the moon orbits Earth in a perfect circle, when in fact its orbit is elliptical! The moon's distance from Earth constantly varies, and so during its orbit it reaches both apogee (when it's farthest from Earth), as well as perigee (closest to Earth). A supermoon occurs when the moon is at both perigee and in its full phase. That's not very rare; a full moon at closest approach to Earth can happen multiple times a year, as you may have noticed.

While a human observer won't be able to tell the difference between the size of a supermoon and a regular full moon, comparison photos taken with a telephoto lens can reveal the size difference between full moons. NASA has a classroom activity where students can measure the size of the full moon month to month and compare their results: "Measuring the Supermoon".

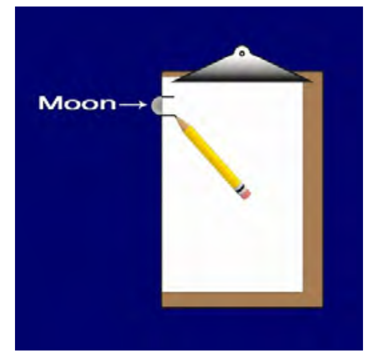
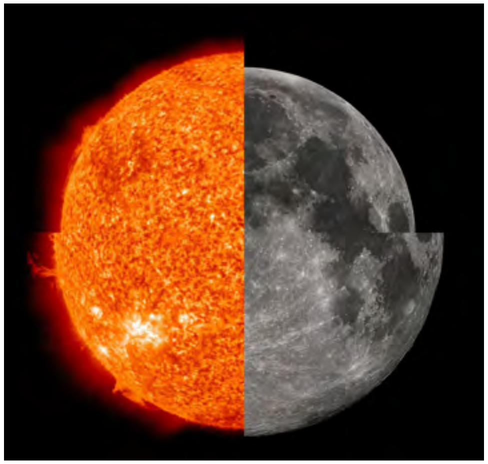


Image of the supermoon meaurement activity. (credit: NASA/JPL)

Students can use digital cameras (or smartphones) to measure the moon, or they can simply measure the moon using nothing more then a pencil and paper! Both methods work and can be used depending on the style of teaching and available resources.

Apparent size difference between a "supermoon" (left, full moon at perigee) and "minimoon" (right, full moon at apogee). This is an example of the comparisons curious individuals can make with a DSLR camera. Photo credit: NASA



Apparent sizes of the Sun and moon depicted to scale at apogee (top right) and perigee (bottom).

There actually is a way for naked eye observers to observe the different apparent sizes of the moon in our sky, but oddly enough it's not when the moon is full and brilliant, but the opposite: when the moon is new and dark, during eclipses! For eclipse chasers, the apparent size of the moon matters very much to what they will see. For example, a total eclipse can happen in conjunction with a supermoon as many in the USA saw on August 17, 2017. The apparent size of the moon was large enough to completely block the disc of the sun in our skies along a narrow path for a couple of minutes. If the moon was further away from the Earth, especially if it was at apogee—its furthest point—then a total eclipse would not occur. Instead, an annular eclipse would be seen instead, where a "ring of fire" would seem to circle the black disc of the new moon.

This discussion of the different phases of the moon can also make for a fun, simple, long-term project for a classroom. Students can observe the phases of the moon every day (when weather permits) over a thirty day period and write down their observations of the moon's phases and what times of day and night they can actually see the moon during this period. This can also be paired at some point with the crafty "Make a Moon Phases Calculator and Calendar" activity. You can find out more about the "Observing the Moon" classroom activity at: https://www.jpl.nasa.gov/edu/teach/activity/observing-the-moon.

A related moon phases activity, which is short and perfect for small interactive groups, can be found at: https://www.jpl.nasa.gov/edu/teach/activity/moon-phases/.

You can find a more detailed discussion of the science of supermoons on NASA's "What is a Supermoon and Just How Super Is It?" page from their "Teachable Moments" blog. You can find links to the above activities there, along with more lunar science that can be used to make the hype about Supermoons teachable moments for your star party visitors.

Addendum: We can expect the news to be awash with supermoon articles in the coming weeks and months. AOH members can check the AOH Calendar, where the March, April, May, and June pages all show that the Full Moons for those months are on dates that are same or adjacent to the dates for the Lunar Perigees. In fact all these differences are less than a day and a half.

2021	Full Moon		Lunar Perigee	
Month	**Date**	**Time**	**Date**	**Time**
March	28	11:50 am	29	11:16 pm
April	27	8:33 pm	27	8:22 am
May	26	4:14 am	25	6:50 pm
June	24	11:40 am	23	2:54 am

Data from Lunar Perigee and Apogee Calculator at Fourmilab.ch. Times are PDT.

Furthermore, the May 26 supermoon will be special—we will get a total lunar eclipse. The total and partial phases of this "blood supermoon" will be visible here in Humboldt County, weather permitting, of course. So schedule your afternoon nap on the 25th—you'll want to stay up through the wee hours of the morning.

Event	Time on May 26
Penumbral Eclipse begins	1:48 am
Partial Eclipse begins	2:45 am
Full Eclipse begins	4:11am
Maximum Eclipse	4:19 am
Full Eclipse ends	4:26 am
Partial Eclipse ends	5:52 am
Moon sets	5:59 am

Data from timeanddate.com. Times are PDT.

Could a human enter a black hole to study it?

by Leo Rodriguez and Shanshan Rodriguez

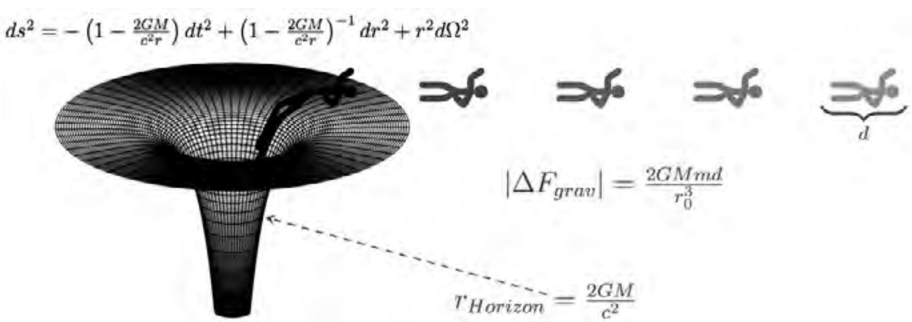
To solve the mysteries of black holes, a human should just venture into one. However, there is a rather complicated catch: A human can do this only if the respective black hole is supermassive and isolated, and if the person entering the black hole does not expect to report the findings to anyone in the entire universe.

We are both physicists who study black holes, albeit from a very safe distance. Black holes are among the most abundant astrophysical objects in our universe. These intriguing objects appear to be an essential ingredient in the evolution of the universe, from the Big Bang till present day. They probably had an impact on the formation of human life in our own galaxy.

Two types of black holes

The universe is littered with a vast zoo of different types of black holes.

They can vary by size and be electrically charged, the same way electrons or protons are in atoms. Some black holes actually spin. There are two types of black holes that are relevant to our discussion. The first does not rotate, is electrically neutral – that is, not positively or negatively charged – and has the mass of our Sun. The second type is a supermassive black hole, with a mass of millions to even billions times greater than that of our Sun.



Besides the mass difference between these two types of black holes, what also differentiates them is the distance from their center to their "event horizon" – a measure called radial distance. The event horizon of a black hole is the point of no return. Anything that passes this point will be swallowed by the black hole and forever vanish from our known universe.

At the event horizon, the black hole's gravity is so powerful that no amount of mechanical force can overcome or counteract it. Even light, the fastest-moving thing in our universe, cannot escape – hence the term "black hole."

The radial size of the event horizon depends on the mass of the respective black hole and is key for a person to survive falling into one. For a black hole with a mass of our Sun (one solar mass), the event horizon will have a radius of just under 2 miles.

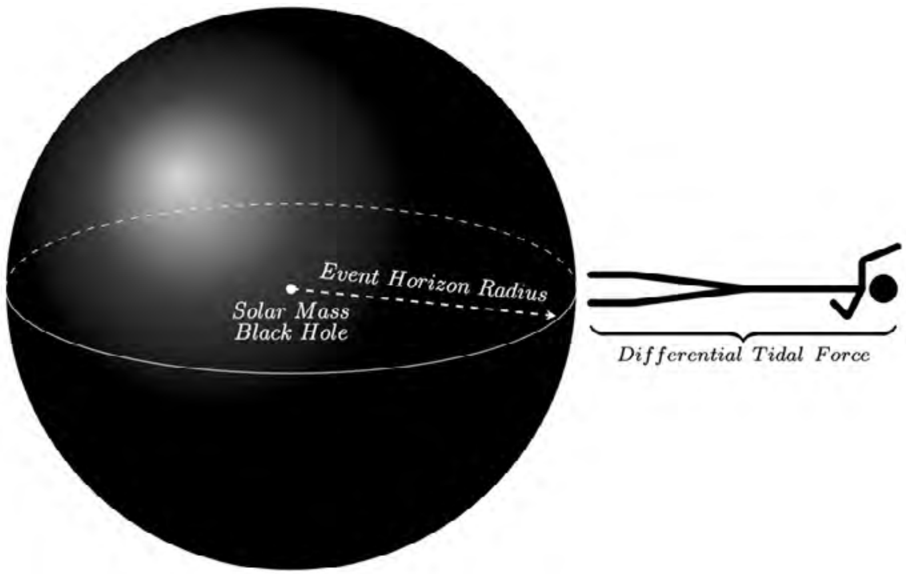
The supermassive black hole at the center of our Milky Way galaxy, by contrast, has a mass of roughly 4 million solar masses, and it has an event horizon with a radius of 7.3 million miles or 17 solar radii.

Thus, someone falling into a stellar-size black hole will get much, much closer to the black hole's center before passing the event horizon, as opposed to falling into a supermassive black hole.

This implies, due to the closeness of the black hole's center, that the black hole's pull on a person will differ by a factor of 1,000 billion times between head and toe, depending on which is leading the free fall. In other words, if the person is falling feet first, as they approach the event horizon of a stellar mass black hole, the gravitational pull on their feet will be exponentially larger compared to the black hole's tug on their head.

The person would experience spaghettification, and most likely not survive being stretched into a long, thin noodlelike shape.

Now, a person falling into a supermassive black hole would



As the person approaches the event horizon of a a Sun-size black hole, the vast difference in gravitational pull between theinidvidual's head and toes causes the person to stretch into a very long noodle, hence the term 'spaghettification'.
Leo and Shanshan Rodriguez, CC BY-ND

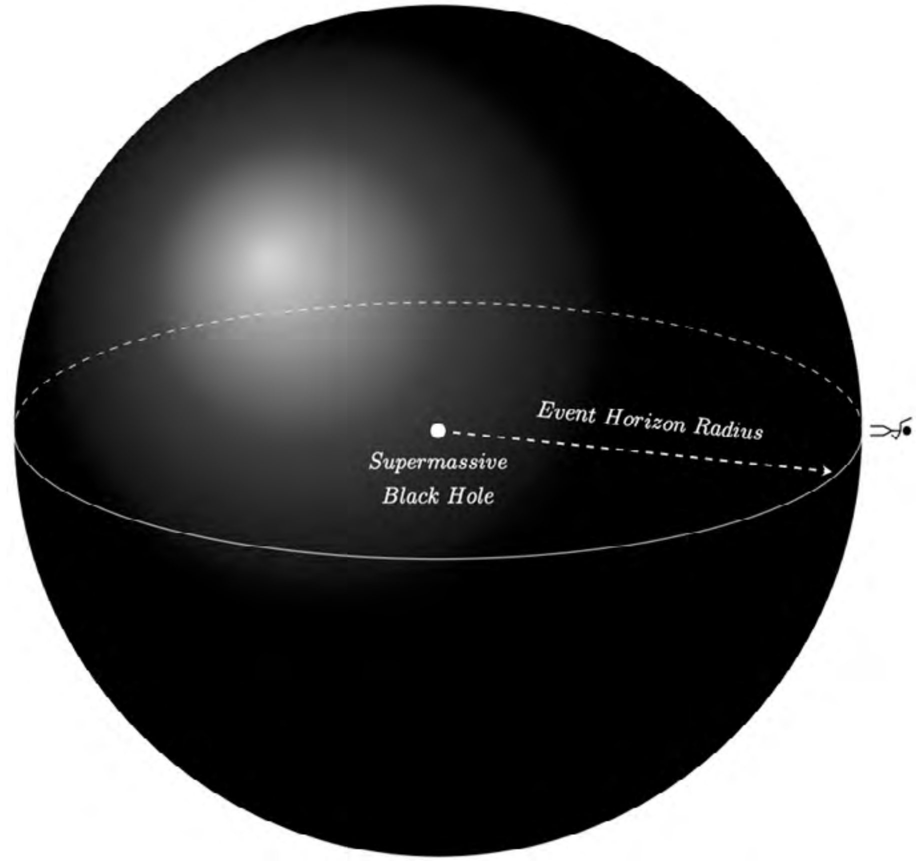
reach the event horizon much farther from the the central source of gravitational pull, which means that the difference in gravitational pull between head and toe is nearly zero. Thus, the person would pass through the event horizon unaffected, not be stretched into a long, thin noodle, survive and float painlessly past the black hole's horizon.

Other considerations

Most black holes that we observe in the universe are surrounded by very hot disks of material, mostly comprising gas and dust or other objects like stars and planets that got too close to the horizon and fell into the black hole. These disks are called accretion disks and are very hot and turbulent. They are most certainly not hospitable and would make traveling into the black hole extremely dangerous.

To enter one safely, you would need to find a supermassive black hole that is completely isolated and not feeding on surrounding material, gas and or even stars.

Now, if a person found an isolated supermassive black hole suitable for scientific study and decided to venture in, everything observed or measured of the black hole interior would be confined within the black hole's event horizon.



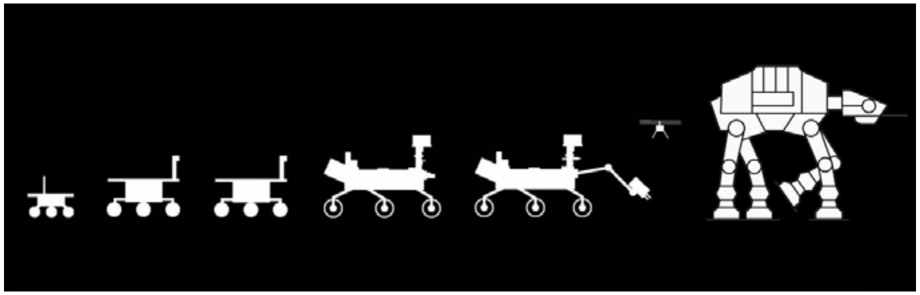
A person falling into a supermassive black hole would likely survive.
Leo and Shanshan Rodriguez, CC BY-ND

Keeping in mind that nothing can escape the gravitational pull beyond the event horizon, the in-falling person would not be able to send any information about their findings back out beyond this horizon. Their journey and findings would be lost to the rest of the entire universe for all time. But they would enjoy the adventure, for as long as they survived ... maybe ....

Leo Rodriguez: Assistant Professor of Physics, Grinnell College
Shanshan Rodriguez: Assistant Professor of Physics, Grinnell College

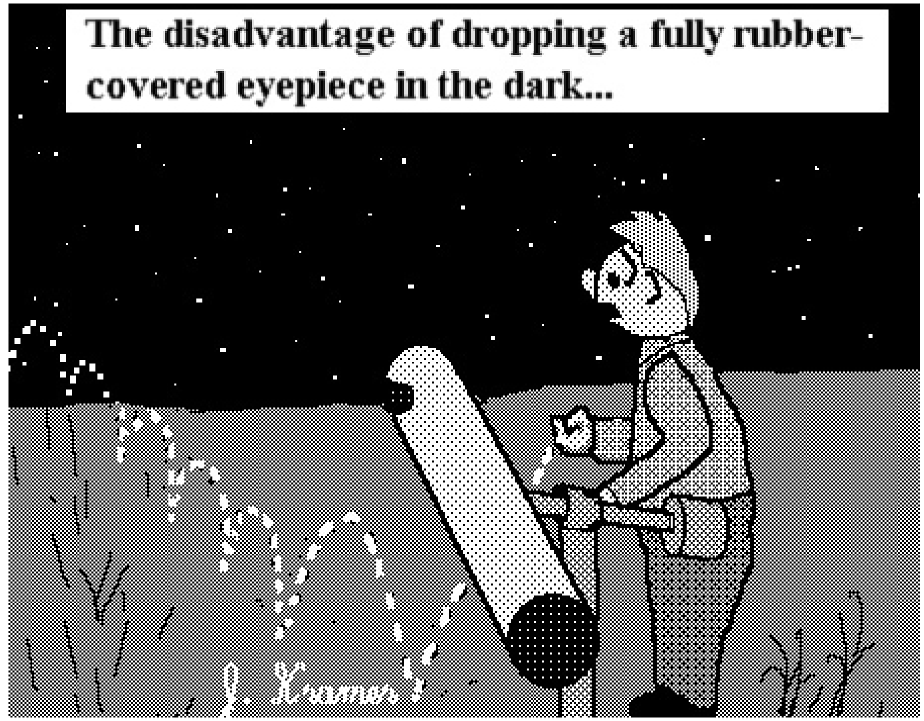
After Words

It has just been announced that NASA will be collaborating with Lucasfilm on the next generation of planetary rover:



And after a careful mathematical analysis I've determined that the media got it all wrong. This is what the secret code on the Perseverance parachute really said:

Above and right: NASA photos modified (without permission) by ky



Above: Jack Kramer, [Lake County (Illinois) Astronomical Society]; with permission
Below: Randall Munroe, [xkcd]; Creative Commons License