CORNELL ASTRONOMICAL SOCIETY NEWSLETTER

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LETTER FROM THE PRESIDENT

Hello students, amateur astronomers, Cornellians, telescope historians, Carl Sagan worshippers and lifetime learners alike. On behalf of the talented team of writers who have contributed I would like to extend a warm welcome to the first issue of the renewed Cornell Astronomical Society Newsletter. On the pages that follow we dive into the recent launch of the James Webb Space Telescope and discuss its multitude of scientific instruments, importance to research happening here at Cornell, and the controversial history behind its eponymous NASA administrator. Personally, I think this newsletter is a great opportunity for our club members to reach out to the community and share what they are learning while we are all socially distanced, and I expect that it will become a continued tradition for our club.

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With regards to social distancing, please note that the Fuertes Observatory is currently closed to the public and we will not be conducting open houses at the observatory until further notice. We are planning on continuing our lecture series online in the spring, and will inform our mailing list as soon as we have finalized our lecture plans with details on where and how to view them. With luck we will see you on a cold, dark night at the Fuertes Observatory again soon!

I hope you enjoy reading our newsletter as much as we enjoyed crafting it.

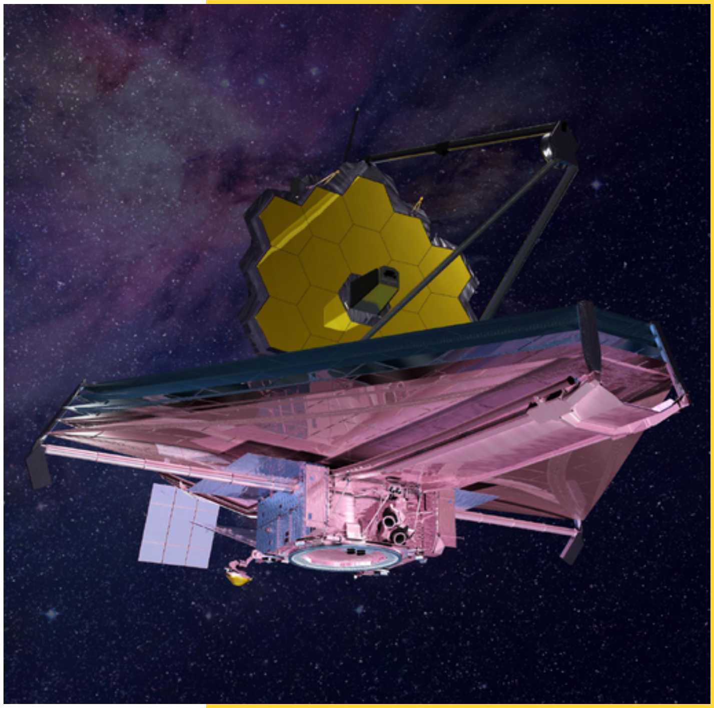
Chase Funkhouser
President, Cornell Astronomical Society

THE JAMES WEBB SPACE TELESCOPE

BY ANNIKA DEUTSCH

Twenty-six years ago, organizations from around the globe began work on the James Webb Space Telescope (JWST), destined to become the most advanced observatory yet launched into space. This telescope will have "a unique and profound role in transforming our understanding of astrophysics and the origins of galaxies, stars, and planetary systems," says Webb Media Kit.

It holds four imaging and spectroscopy instruments along with its mirrors, sunshield, and spacecraft bus.



Artist concept of the James Webb Space Telescope | Credit: NASA

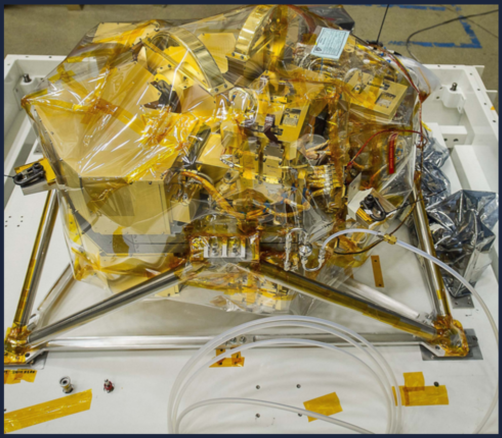


Image credit: NASA/Chris Gunn

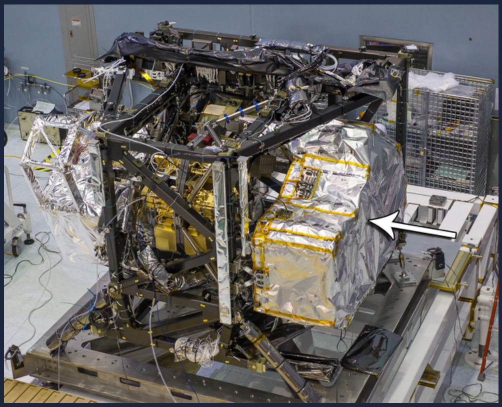


Image credit: NASA/Chris Gunn

THE CAMERA

The Near Infrared Camera (NIRCam), is the primary imager. It's equipped with coronagraphs, which take pictures of very faint objects around a central bright light source, like exoplanets. Like the other two near-infrared instruments, NIRCam operates in a wavelength range at which objects otherwise shrouded in interstellar dust shine through.

SPECTROGRAPH 1

The Near Infrared Spectrograph (NIRSpec) performs single-slit spectroscopy on individual objects, measuring the intensity of their light over varying wavelengths. A separate part of NIRSpec, the microshutter array, can observe up to a hundred objects simultaneously through thousands of windows, each the width of a human hair, with shutters that open and close magnetically. This piece of technology is one of many that had to be invented just for JWST.

SPECTROGRAPH 2

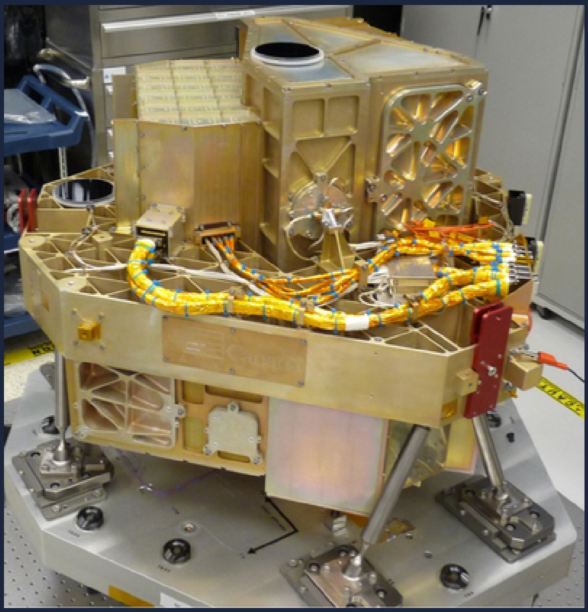
The Near Infrared Slitless Spectrograph (NIRISS) has an aperture mask for viewing bright objects, like active galactic nuclei, at higher resolution than the other instruments. To understand the function and utility of this device, which is employed for aperture masking interferometry (AMI), let's look first at JWST's primary mirror.

PRIMARY MIRROR

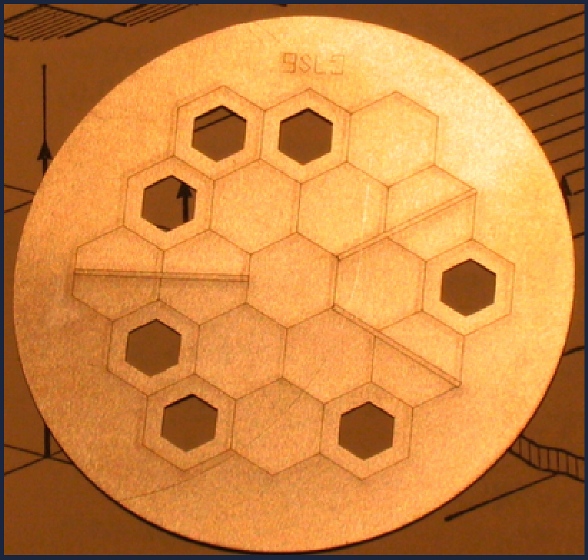
JWST's primary mirror is 6.5 meters across, one of its biggest advantages over its predecessors—by comparison, the Hubble Space Telescope's primary mirror is just 2.4 meters across. Getting such a big mirror into space was a huge engineering challenge, so engineers chose to make the mirror out of beryllium—a very light but durable material—with eighteen hexagonal segments that fit together with almost no gaps. Each segment is covered in a thin gold layer, which amplifies the reflection of infrared light.

NIRISS AND AMI

Now we return to NIRISS's aperture mask, an opaque layer with holes, or subapertures, that cover the telescope's actual aperture. This significantly improves our ability to resolve objects that are close together, allowing for detection of planets and stellar companions up to 9 magnitudes fainter than their host stars. This instrument holds special interest for Cornellians, as Cornell astronomy professor James Lloyd was directly involved in the development of NIRISS's AMI mode.



Credit: COM DEV Canada



A prototype of the NIRISS Aperture Mask
Photo credit: Anand Sivaramakrishnan (STScI)

MID-INFRARED

The Mid-Infrared Instrument (MIRI) views light at different wavelengths than JWST's three near-infrared instruments. It is equipped with cameras, coronagraphs, spectrographs, and four integral field units (IFU), each operating at different wavelengths. The IFUs enable JWST to look into every stage of the universe's development, from highly redshifted distant galaxies to objects within our own Solar System. Due to MIRI's extreme sensitivity, it must be kept much colder than all the other instruments.

TEMPERATURE

One of JWST's goals is to detect extremely faint heat signals in the universe. Because there are strong heat sources very close to us—like Earth and the Sun—the telescope must be far enough away that it can avoid interference from these sources. However, even going very far away is not enough to achieve ideal conditions. JWST is equipped with a five-layer tennis court–sized sunshield, which keeps its cold side at 39 K (-234˚C) so these instruments can operate without local interference. However, even this is not enough for mid-infrared observations, so MIRI has its own two-stage cryo-cooler to get the temperature down to a frigid 7 K (-266˚C).

For its relatively small size compared to most ground-based telescopes, JWST holds a remarkable amount of heavy instrumentation. The primary mirror alone weighs 705 kilograms! So what holds all these instruments? Many of the telescope's components are supported by a lightweight, cryogenic backplane, another feat of engineering that keeps everything very still during observation. You would have to be the size of an atom to detect any movement!

The JWST Sunshield
Credit: Northrop Grumman /Alex Evers

CORNELL AND JWST

BY ARIEL MARXENA

Cornell's involvement in JWST extends from building the apparatus to being prime researchers for the data that will be collected. In a large-scale astronomical project like JWST, scientists around the world will want to have telescope time, where they are able to request to look at particular astronomical bodies. This helps researchers focus on specific astronomical phenomena, like exoplanets, brown dwarfs, or neutron stars.

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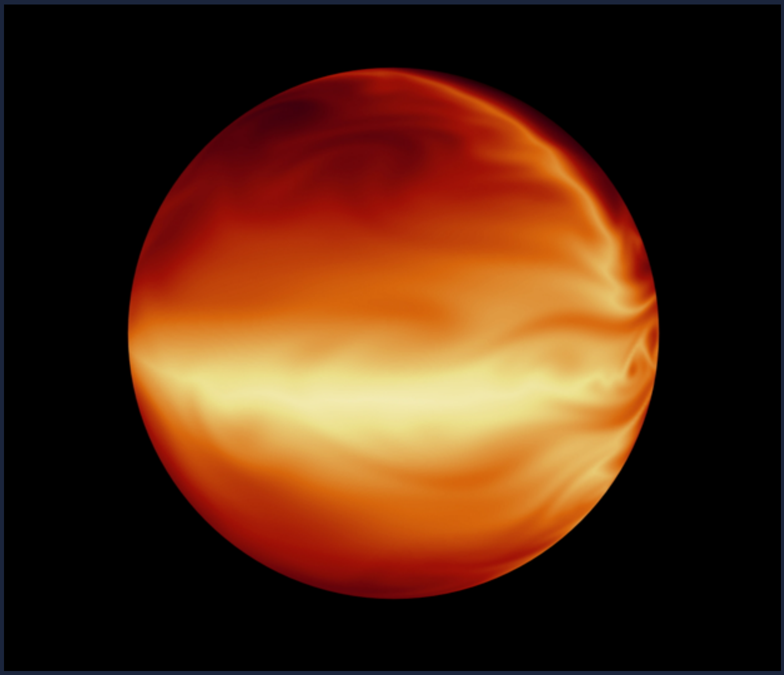
Many Cornell astronomy professors have hundreds of hours of JWST time guaranteed. Among these are Ray Jayawardhana, Dean of the College of Arts and Sciences; Lisa Kaltenegger; Nikole Lewis; and Jonathan Lunine. Dean Jayawardhana and his research team, who use the NASA Icing Remote Sensing System (NIRSS), are guaranteed 400 hours of JWST observing time. Half of those hours will be dedicated to characterizing exoplanets. Dean Jayawardhana states that they plan to "take spectra of 14 exoplanets that span a wide range of sizes and temperatures to learn what these alien worlds are like."

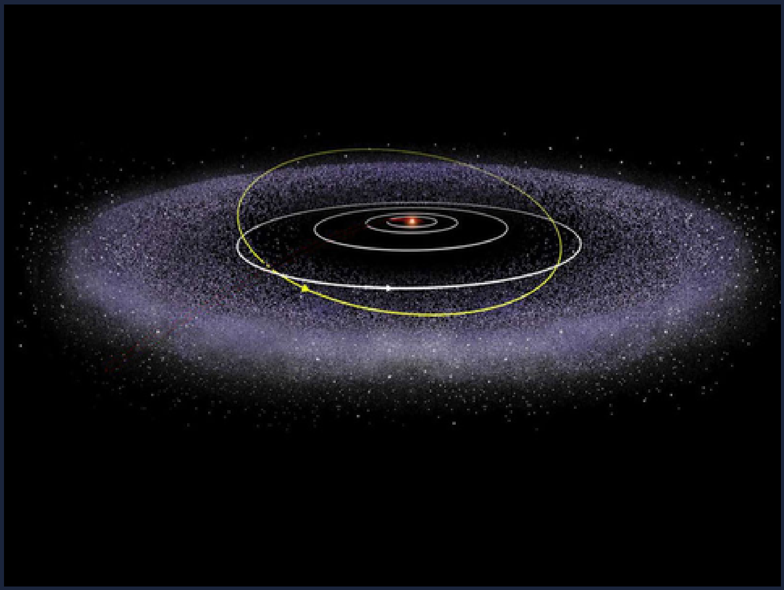
JWST will be able to look at previously discovered exoplanets in greater depth than Hubble, and will be able to discover new exoplanets that could potentially be habitable. Professor Kaltenegger, currently the director of the Carl Sagan Institute, is guaranteed 200 hours of observing time with JWST to study such exoplanets.

Meanwhile, Professor Lunine and his team will be using JWST to study hot Jupiters, very large exoplanets that are so close to their host star that "their atmospheres can exceed 1000 degrees Fahrenheit." They will be using JWST "to measure the presence and abundances of many molecules in their atmospheres."

In addition to exoplanets, Professor Lunine will also be studying objects in our stellar neighborhood. He states he "will be studying with Webb the composition of the surfaces of Kuiper Belt objects, also known as dwarf planets, some of which have temperatures down to -400 Fahrenheit." Studying planetary objects of many types will allow teams like Lunine's and Jayawardhana's to learn more about planetary formation, and in turn learn more about the Earth's formation.



Credits: NASA/JPL-Caltech/MIT/Principia College



The Kuiper Belt | Credit: NASA

JWST ushers in a new era of astronomy. The observatory has now arrived at its destination and astronomers around the world are waiting for the first official scientific observations. This is an exciting time for scientists both around the world and here at Cornell. "I'm tremendously excited about the prospect of doing remote sensing of worlds that are hundreds of light years away," Dean Jayawardhana says. JWST will be able to probe mysteries from the Solar System to hundreds of light years away. It's exciting that some of this great work is being done right here at Cornell.

WHO WAS JAMES WEBB?

BY BEN JACOBSON-BELL

James Webb (1906–1992) was NASA's second administrator, whose nearly eight-year tenure from 1961 to 1968 was marked by both unparalleled development and unmitigated disaster. Though he joined NASA at the end of a long career in the public sector, he is best known today for overseeing the incipient stages of the Apollo program: the program that landed Neil Armstrong and Buzz Aldrin on the Moon in 1969, and the program whose inaugural mission ended in flames and the deaths of three astronauts in 1967.

James Webb
Credit: Truman Library

For the United States, Apollo was to herald a new age of space exploration—a thrilling new development in the all-consuming mid-century Space Race. In other circumstances, its first mission's fate might have spelled catastrophe for the yet-nascent NASA. Multiple investigations were launched to assess the causes of the fire and distribute blame accordingly, but political space fervor in the country remained at an all-time high, and Apollo was barely slowed. NASA's records credit Webb, despite procedural errors and miscommunications by himself, his colleagues, and the government contractor in charge of Apollo 1's spacecraft construction, with "deflecting much of the backlash" and keeping the organization's progress on track in the years that followed.

In 2002, then–NASA administrator Sean O'Keefe took a departure from tradition when he assigned Webb's name to the former Next Generation Space Telescope (NGST), an unusual move for an organization that conventionally names its space observatories after astronomers. He said at the time, "It is fitting that Hubble's successor be named in honor of James Webb. Thanks to his efforts, we got our first glimpses at the dramatic landscapes of outer space," though it remains unclear what particular efforts he meant.

It is possible that O'Keefe felt some kinship with Webb. Neither came to NASA with a scientific background; both had been lifelong government officials—O'Keefe in the Department of Defense, Webb in the Department of State. Webb spent much of his career surrounded by the specter of the Cold War, a threat that led him as Undersecretary of State to undertake several military initiatives himself, including Project Troy, a "crack team of scientists" to help boost the US's psychological warfare campaigns.

Apollo 11
Credit: NASA

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The renaming of NGST after Webb has been controversial. In March 2021, four astronomers called on NASA in *Scientific American* to change the name again in light of Webb's involvement in State Department policies contributing to the Lavender Scare, the Cold War–era purging of LGBTQ+ employees from the federal government. A related petition with over 1,700 signatures mentions the case of Clifford Norton, a NASA employee arrested and fired in 1963—under Webb's tenure as administrator—on suspicion of homosexuality.

NASA opened an investigation in August 2021 into Webb's complicity in homophobic persecution, and concluded in October that JWST would keep its name. In a one-sentence press release, current administrator Bill Nelson said, "We have found no evidence at this time that warrants changing the name of the James Webb Space Telescope."

And now for something completely different.

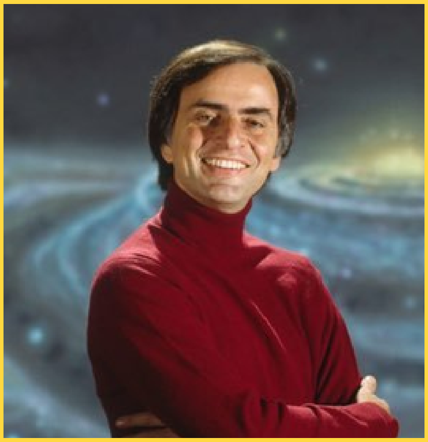
SPACE POETRY

A SNIPPET FROM ROBINSON JEFFERS' POEM "THE GREAT EXPLOSION"

The universe expands and contracts like a great heart.
It is expanding, the farthest nebulae
Rush with the speed of light into empty space.
It will contract, the immense navies of stars and galaxies,
    dust clouds and nebulae
Are recalled home, they crush against each other in one
    harbor, they stick in one lump
And then explode it, nothing can hold them down; there is no
    way to express that explosion; all that exists
Roars into flame, the tortured fragments rush away from each
    other into all the sky, new universes
Jewel the black breast of night; and far off the outer nebulae
    like charging spearmen again
Invade emptiness.
                No wonder we are so fascinated with
    fireworks
And our huge bombs: it is a kind of homesickness perhaps for
    the howling fireblast that we were born from.

SPACE TRIVIA

Named after astro-physicist and science popularizer Carl Sagan, the unit of one "sagan" measures how much?



Carl Sagan
Credit: Tony Korody / Sygma / Corbis

Answer:

at least four billion (Carl Sagan was associated with the phrase "billions and billions"!)

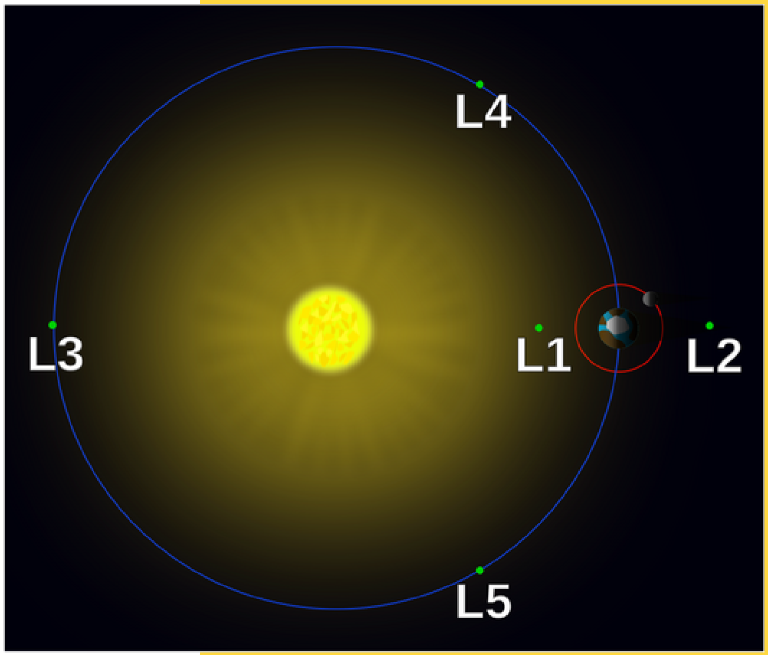
Poem and trivia selected by Gillis Lowry

LAGRANGE POINTS

BY BEN JACOBSON-BELL

Last week, after a month-long, million-mile voyage, the James Webb Space Telescope reached its destination: the Lagrange point known as L2. But what does that mean?

Lagrange points are a staple of two-body systems like the Earth–Moon system and the Earth–Sun system. They're points of gravitational equilibrium, where the forces from the two bodies "cancel out." Every two-body system has five of them, named L1 through L5 (see figure at right).



Credit: Wikimedia Commons / Xander89

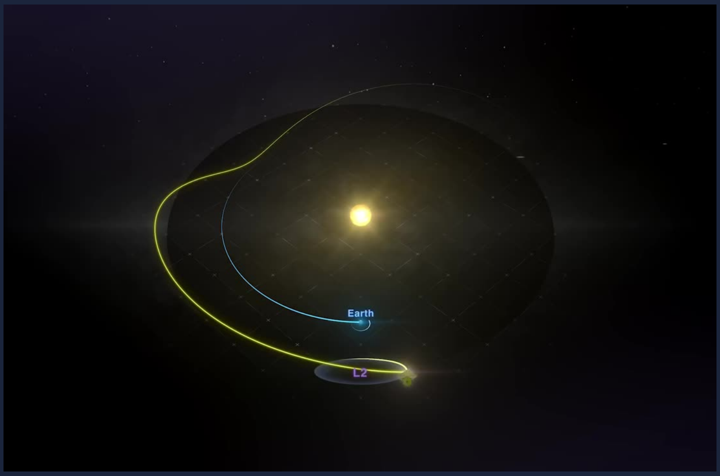
L1 is easy enough to understand: the gravitational pulls from the Sun and the Earth effectively cancel each other out somewhere between the two bodies. But what about the others?

For L2, it's useful to remember that the stronger the force of gravity on an object in orbit, the faster it moves. Usually, this means that objects closer to the Sun, like Mercury, move faster than objects like Earth that orbit farther away.

L2 is farther from the Sun than Earth is, so we would expect it to move slower than Earth in a Sun-centric orbit. But at this precise point, Earth's gravity "adds" to the Sun's just enough to drag the point along, resulting in a Sun-centric orbit that, despite a radius of almost a million extra miles, has the same angular speed as Earth's.

L3 works on a similar principle—it looks like it lies on Earth's orbit in the figure above, but in fact it's just outside it, made to move just *slightly* faster by the combined gravitational influence of the Sun and Earth.

L1, L2, and L3 are all unstable equilibria—like a ball on top of a hill, a slight perturbation can send them cascading away into space. Closed solutions called halo orbits allow spacecraft to remain at those points with only minimal support from their thrusters. JWST's halo orbit around L2 can be seen in a NASA animation below.



Credit: NASA's Goddard Space Flight Center

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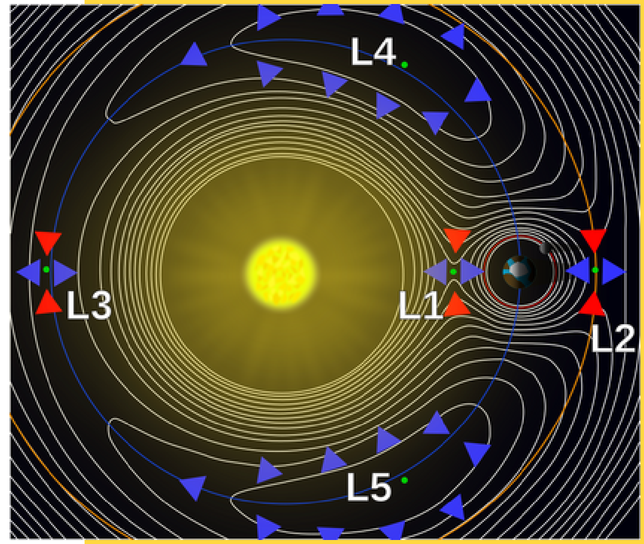
L4 and L5, on the other hand, are stable equilibria—objects placed at these points can remain there with no support even for astronomical timescales. The Jupiter–Sun system has several known asteroids called trojans at these points, and even Earth has had two of its own ([2010 TK7]() and [2020 XL5]()) discovered over the years.

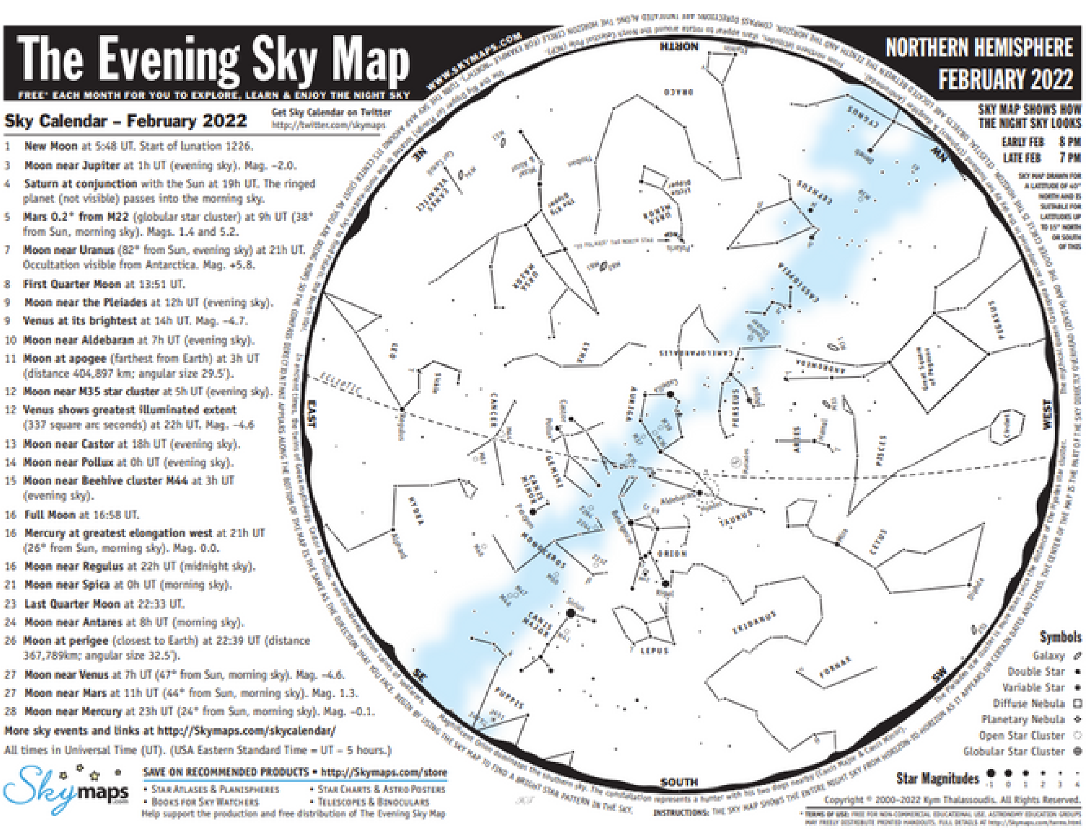
L4 and L5 are probably the most enigmatic of the Lagrange points. They exist due to the centrifugal and Coriolis forces (associated with objects in rotating reference frames) balancing the gravitational forces exerted on them by each of the two bodies in the system. Their stability is not immediately obvious (and requires [a good-sized mathematical proof]() to justify), but can be seen from a contour plot of the effective potential around the Sun and Earth in a co-rotating reference frame (see figure at right).



Credit: Wikimedia Commons / Xander89

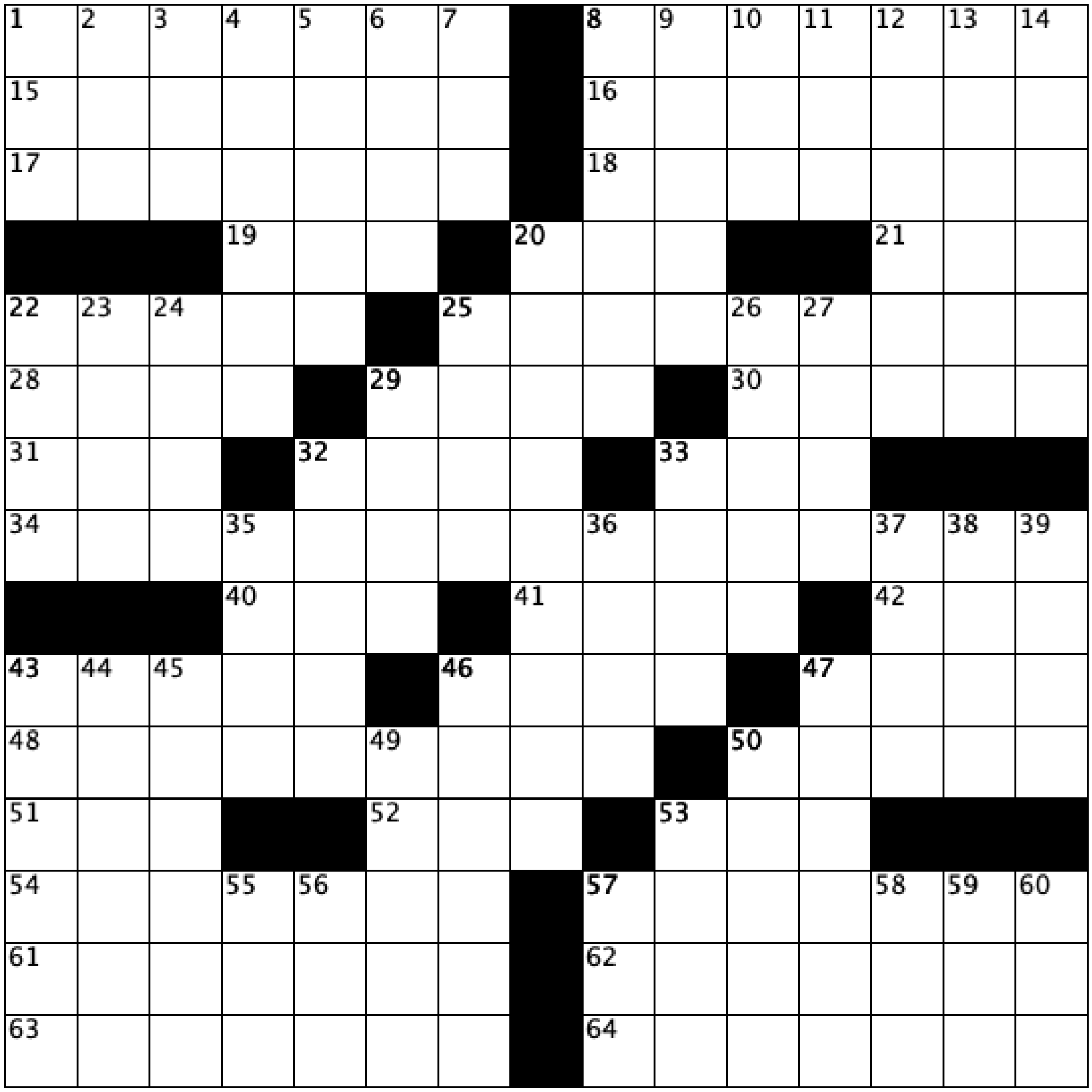
Red arrows indicate directions to lower potential, blue arrows to higher.

For JWST to safely reach its destination at L2 is very exciting news indeed—and with [enough fuel]() for course corrections that could extend the mission significantly beyond the expected ten years. The [next few months]() will be devoted to aligning, calibrating, and cooling the telescope's instruments, with the first images expected in early July.



Here is a preview of an evening sky chart for the month of February in the Northern Hemisphere from SkyMaps.com. Go out at 7–8 PM this month if you're in Ithaca, and you can use this chart as a guide for your personal star viewing! The center of the circle is straight above you, and the edges are towards the horizon. The map itself has everything you need to know about using it, but a first hint is to go for the brightest stars: those'll be the largest dots on the map! For a full version of this month's map, go [here](), download the pdf or keep it on your phone for handy, on-the-go viewing.

BY BEN JACOBSON-BELL



ACROSS
1. One-size-fits-all
8. Pool, in Spanish
15. Wind instrument in a Nintendo title
16. Held gently
17. Golden Record carrier
18. First spacecraft to orbit an outer planet (Jupiter)
19. Microwave frequency regime
20. User of echolocation
21. New Deal prez
22. Automaton
25. Space telescope launched December 25, 2021
28. Like 2, but not 3
29. Paid assistant
30. They're raised by the sun and the moon
31. Munch on
32. Resistance units
33. "Keep an Eye on ___" (2021 ABBA hit)
34. Large-scale NASA project (like 17-, 18-, 25-, 48-, 54-, or 57-Across)
40. Tiebreaker periods, for short
41. "Yeesh"
42. Perkins who co-hosted "The Great British Bake Off"
43. Photoshop developer
46. Greek life grp.
47. Understands
48. Gale crater explorer
50. Colgate competitor
51. "___, Galatea e Polifemo" (Handel cantata)
52. Dashes shorter than ems
53. Charlamagne ___ God
54. Taker of the mosaic photograph "The Day the Earth Smiled"
57. X-ray observatory in orbit around Earth
61. Anticlimactic answer to 45-Down
62. More resistant to adversity
63. Fred who danced and sang alongside Ginger Rogers
64. One of 27 for the Very Large Array

DOWN
1. URL ender for NASA
2. Green prefix
3. Dissenting vote
4. 2003 fantasy best seller by Christopher Paolini
5. Dominant hand for about 90% of the population
6. Name related to Agnes
7. Subaru product
8. It might run out of Steam
9. Cranky
10. Khan of Khan Academy
11. 401, in old Rome
12. All skin and bones, say
13. If ___ (as required)
14. Too cute, informally
20. Sore losers, e.g.
22. Coral structure
23. Egg shape
24. Testing stage
25. Hendrix of electric guitar fame
26. Often-hidden trove
27. Victories
29. Sounds of relaxation
32. Prefix having to do with the bones
33. Merriam-Webster, for one: Abbr.
35. Desert along the China-Mongolia border
36. ___ Thai (martial art)
37. "Makes sense"
38. Excuses
39. Place for a robin's eggs
43. Pod-bearing tree
44. Old coins with a name derived from "duke"
45. Question often followed by dramatic chords
46. Not forever
47. Coffee size below venti
49. Honorific typically written with a tilde
50. Sky map, e.g.
53. Greater follower?
55. US federal agcy. that distributes nine-digit numbers
56. Pasta suffix
57. Syllable repeated before "Slide"
58. Commotion
59. Kylo of "Star Wars"
60. Southern constellation between Norma and Pavo

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