AOH OBSERVER

April-May 2016

The Newsletter of the Astronomers of Humboldt

It's been a busy two months at the AOH, and despite the persistent rainy weather, we have managed to do several public outreach events. Because of our outreach efforts, we managed to make the Night Sky Network's "Stars in the Network" honor roll https://nightsky.jpl.nasa.gov/stars.cfm within the first quarter of joining the NSN. Many thanks to the members who braved the cold, and occasionally the rain. You can read about our events in the "AOH Outreach News" section of our newsletter.

You may have noticed that the AOH logo has changed at the top of the page. Behind the scenes, we have been busy re-designing our AOH logo and putting together the AOH CafePress Store. The colorized logo represents a month-long effort by Ken Yanosko, Mark Wilson and myself. If you like our color treatment of the logo, we now have a CafePress store at www.cafepress.com/astrohum. The logo is featured on clothing, bags, coffee cups, car magnets, etc. The purchase of items in the store support our AOH public outreach programs, and the maintenance of the telescopes at the Kneeland Observatory.

Speaking of telescopes, we continue to upgrade the telescopes owned by the AOH as well as those at the Kneeland Observatory. On page 2, Mark Wilson has issued a challenge to the AOH membership for the purchase of a new focuser.

In this latest issue we welcome Mark Bailey as a contributor to our newsletter. He has written an excellent article on Planet 9 (pages 7-12). Mark recently joined the AOH, and is a long time astronomy enthusiast who has taught many science courses including various astronomy courses through the HSU Osher Institute.

The AOH started off the year with a number of new members: Ron Asher, Linda Chaffee, Susie Christian, Mark Bailey, Ketcher Arnett, and Peter Johnson. We welcome all to the AOH.

For those of you would like to join or have not yet renewed, the membership application can be found on our website at http://www.astrohum.org

Finally, I want to invite members to submit articles and/or images to the newsletter. Science articles, reviews of astronomy-related books and movies, accounts of interesting visits to space-related venues, descriptions of DIY astronomy equipment, and the like are all welcomed. Contact me, Grace Wheeler, at president@astrohum.org if you are interested in submitting something for the newsletter.

Acknowledgements: Many thanks to Mark Bailey and Mark Wilson for contributing to the newsletter, and to Ken Yanosko and Donald Wheeler for their thorough proofreading of this issue and helpful suggestions.

Club Calendar and Dates of Interest for April- May 2016

Friday April 1 or Saturday April 2. **Messier Marathon**. Postponed from the weekend of March 11-12. We will hold the marathon on either Friday night or Saturday night, depending on the weather forecast. The location is Kneeland Airport. Go to www.astrohum.org for details and updates under upcoming events.

Saturday April 9. **Regular Monthly Meeting**. Possibly cancelled if Messier Marathon was held April 1 or 2. Location and program tba.

Monday, April 18th. **Night Sky Network Webinar:** Mercury Messenger with Larry R. Nittler, Primary Investigator for NASA's Messenger Mission. Webinar registration information will be emailed out a week before the event.

Saturday May 7. **Regular Monthly Meeting**. TBA

Monday May 9. **Transit of Mercury.** Transit is in progress at local sunrise, 6:05 am PDT. Maximum transit is at 7:57 am, last contact is at 11:42 am.

Wednesday, May 11. **Night Sky Network Webinar:** Juno's Arrival at Jupiter with Steven Levin, NASA. Webinar registration information will be emailed out a week before the event.

Saturday, May 14. **International Astronomy Day.** The AOH has nothing planned at the moment, but this doesn't mean that we as individuals still can't celebrate. This may be a good opportunity to invite your friends and neighbors over to show them various stars and planets. The quarter moon will be visible in the afternoon and evening, Jupiter is out early, and Mars rises around 9 p.m.

Monday, May 30. **Mars' Closest Approac**h. (See Celestial Events for more details about viewing Mars)

Club Announcement: Upgrades to the AOH 17.5 inch DOB

by Mark Wilson

During our last meeting at the Eureka Co-op, I gave a short presentation on options for upgrading the 17.5 inch Dob to make it more portable and user friendly. I indicated I would put $200 toward achieving this goal. Our colleague Don Wheeler suggested that the most immediate upgrade would be a new 2 inch focuser. I agree. I checked out the GSO focusers at Agena Optical and a one speed focuser is $105 while a two speed focuser is $140 plus tax and S&H. To get this item going I am pledging $25 toward a new focuser. This money is in addition to the $200 I originally pledged. S o I am now challenging my astronomy buddies to pledge whatever you can toward the purchase of a new focuser. Google Agena Astro for details. For ideas, details and pricing on options for upgrading the scope's structure google dobstuff and Astro Systems Telekits.

Celestial Events April-May 2016

A comprehensive listing of events can be found at http://rfo.org/jackscalendar.html

		Moonrise (PDT)			Moonrise (PDT)
New Moon	April 7	07:11 a.m.	New Moon	May 6	06:23 a.m.
1st Qtr	April 13	12:08 p.m.	1st Qtr	May 13	12:55 p.m.
Full	April 21	07:46 p.m.	Full	May 21	08:28 p.m.
4th Qtr	April 29	01:50 a.m.	4th Qtr	May 29	02:24 a.m.

April 5: **Double Shadow Transit, Jupiter***

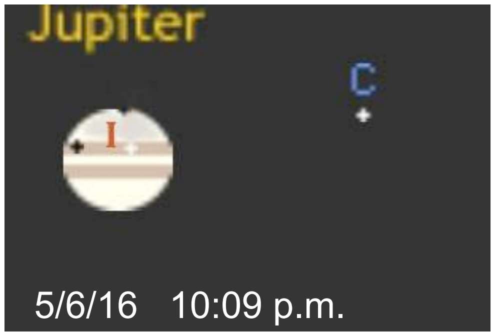
Io shadow transit.: 01:03 a.m.
Europa shadow transit.: 02:36 a.m. (Start Dbl Shad. Tran.)
Io shadow transit. end: 03:18 a.m. (End Dbl. Shad. Tran)

April 6-29. **Mercury Apparition**: Best views of Mercury for 2016 occur at sunset. On April 17, Mercury is at its longest eastern elongation and will be at its maximum altitude in the western horizon.

May 6: **Double Shadow Transit, Jupiter***

Callisto shadow transit*: 08:16 p.m. (not visible until after dark)
Io shadow transit: 09:38 p.m. (Start Dbl. Shad.Tran.)
Callisto shadow transit. end: 10:42 p.m. (end Dbl. Shad. Tran)

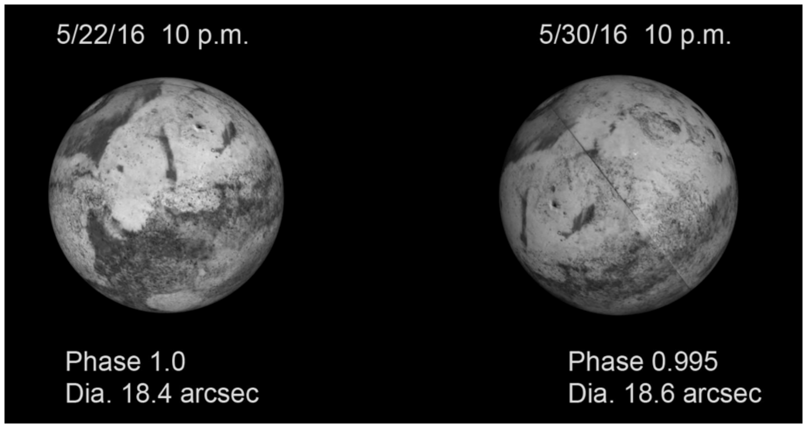
*Callisto Shadow is in the N. polar region of Jupiter



May 9: **Mercury transit of the Sun** will be in progress at sunrise. Next Mercury transit will be in Nov. 2019. *Never look directly at the sun without the proper protection. Only scopes properly equipped for solar observing with solar filters should attempt observing this event.*

May 22: **Opposition of Mars**
Notes: Mars rises at 8:25 p.m.; sunset is 8:30 p.m.; moon rises at 9:22 p.m. Syrtis Major is visible on the Martian disk.

May 30: **Closest Approach of Mars**
Notes: Mars rises at 7:41 p.m.; sunset at 8:40 p.m.; moonset at 2:28 p.m.



Mars simulation done on http://aa.usno.navy.mil/data/docs/diskmap.php

*Simulation of Double Shadow Transits of Jupiter was done using the "Jupiter's Moon" app at http://www.skyandtelescope.com/observing/interactive-sky-watching-tools/

AOH Outreach News (1)

Six Rivers Montessori School (Feb 1, 2016) Arcata, CA

After a nervous week beforehand of checking the weather and getting contingency plans in place because of rain, the day of outreach turned out to be one of the nicest days we had in February. The winds from the day before cleared out the clouds and the morning of the event turned out to be sunny and warm. Ken, Mark Wilson, and I met at 8 a.m. to set up scopes in the parking lot of the school, and by 8:30 we had several enthusiastic students of various ages lining up to peer through the telescopes. Ken set up his 8 inch Cassegrain with a solar filter so that the students could view the surface of the sun and sunspots. Mark had his refractor aimed at the quarter moon so that they could see the craters. I managed to slew in Venus in the daytime on my “GoTo” refractor telescope and show them Venus in gibbous phase (a nod to the power of the GoTo). We were impressed with how knowledgeable several of the students were on astronomy. They were all curious and asked some very good questions. Debora Jacobsen, the office manager of the School, was kind enough to forward these journal entries written by three of the students. These are a very nice summary of the day. Thank you Michele Gilbert and the students of Six Rivers Montessori School for making us feel so welcome. We look forward to visiting again soon.

By Violet

On February 1st, 2016, the astronomers came. We had three different stations that were set up to see different things in space: the moon, Venus, and the sun. We used a special kind of lens for the sun so when we looked at it through the telescope it didn’t hurt our eyes. The lens is called a reflector lens. The lens we used for the other telescope is called a refractor.

The Sun
Using the reflector lens we could look at the sun. There was a small spot on the sun. It’s called a sunspot. A sunspot is a never-ending storm that is twice the size of earth.

The Moon
The moon was a last quarter moon. You could see the craters. They were all different sizes. They brought a map of the craters so we could identify them by number. I could not find the crater I was looking for on the map.

Venus
Venus looks like a big glowing ball. You can see it at 6am. It is the same size as earth. Venus is actually hotter than Mercury.

Astronomers Visit
By Kyla

Today there are no clouds in the sky. A perfect morning for looking at the moon, sun, and Venus. Venus is the second easiest planet to see. Right now Venus looks like a half moon. That’s because Venus has phases like the moon. The sun looked white. It had a huge storm going on on it. The storm is two times the size of the Earth. The moon is at the last quarter stage. We could see craters on the moon. To look at the sun we used a reflector. It has a special curve so when light hits it, it bounces off, spreading out the light. We used a refractor to look at the moon. It works the same way as the reflector except it uses lenses unlike the reflector, which uses mirrors. We used a go to telescope to look at Venus. A go to telescope is electronic. If you find the moon, you can ask it to find Jupiter, and it will show you a star map with Jupiter on it.

Astronomy
By Lila Rose

Today, three astronomers came to our class. It is numbingly cold with blue skies but clouds on the horizon, so it is a perfect day for an astronomy lesson. Mark focused his special refractor telescope on the sun. it was right above the pine tree in the parking lot. With the bare eye it looked like an ultra- bright, yellow dot but through the telescope it was a huge white shimmering circle. I was able to spot a sunspot, “sun storm”, that was two times the size of Earth; although through the telescope it was simply a black dot. Ken had a reflector telescope to focus on the moon. Today the moon is in the last quarter phase. It is in the west part of the sky, a pearly white shape suspended in the sky. Through the telescope I can see many craters, their sizes varying. The biggest one I could identify was Picard. Grace focused in on Venus, but because it is so far away and small we were just able to see a big red dot. It was very interesting to be able to look at these objects in space so close up.

AOH Outreach News (2)

Eureka Arts Alive (Feb. 6, 2016)

After being overcast all day, the skies miraculously cleared up for the February Arts Alive. With my trusty refractor telescope in hand, I set up at the end of the line behind Mark Mueller, Russ Owsley, and Ken Yanosko. The three were already at the gazebo and had people cued up to look through their telescopes. We knew that this Arts Alive was going to be a challenge with no moon or planets to look at. Despite the limitations, we had a quite a crowd of people lining up and going from scope to scope. The Orion constellation was straight overhead so we pointed out Betelgeuse, Rigel, and the stars making up Orion's Belt. Through the telescopes and binoculars we showed them Orion's Nebula and told them about the star nursery. In Mark's scope, was the Trapezium, a group of very young stars residing in the Nebula. Russ was able to find the Hyades through the haze and city lights. For many people, it was the first time they had looked through a telescope, and they were appreciative of the experience.

Looking at Orion's Nebula through Mark's Newtonian telescope. February's Arts Alive

The AOH telescope demonstration was one of the popular stops at February's Arts Alive.

The AOH brought their own stars to Morris School Science Night.

Morris School (March 2, 2016) McKinleyville, CA

By now I was convinced that if we just wished for good weather, it would materialize…. no such luck with Science Night at Morris School. We knew that Science Night was always going to be a challenge because we were demonstrating the telescopes at 5:30 p.m. With no moon in the sky, and too much light for stars to be seen, the only option we had was a solar viewing. That option quickly disappeared with rain in the forecast. The solution came in the form of a "star mask" that was constructed with a large flashlight, layers of black plastic (from a garbage bag), masking tape, and a nail for poking holes https://nightsky.jpl.nasa.gov/download-view.cfm?Doc_ID=337 Despite the downpour, we had quite an audience of parents and students who lined up to view our "star field" which was situated about 50 feet away (our scopes were safely sheltered under the covered walkway). It was a lesson in the power of telescopes to resolve distant objects (or as one parent would say "show me how bad are my eyes"). Many thanks to Morris School for hosting us, and to the parents and students who stopped by in the rain.

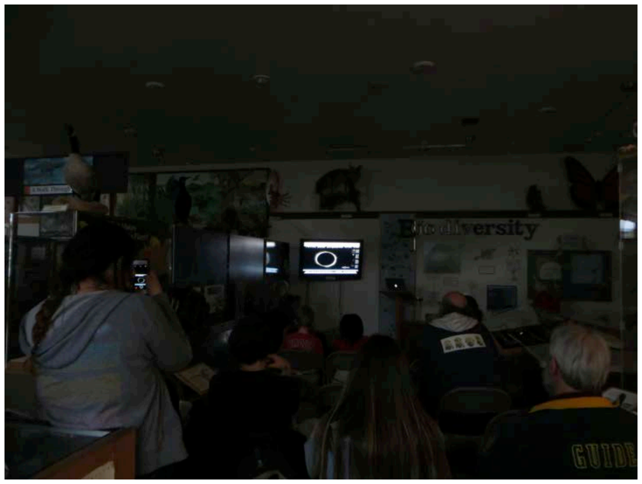
AOH Outreach News (3)

HSU Natural History Museum (March 8, 2016)   Arcata, CA

Our last outreach event of the quarter took place at the HSU Natural History Museum. Melinda Bailey, the assistant director of the Museum, invited the AOH to do a solar viewing for “Solar System Discovery Day”. This event featured the live webcast of the total solar eclipse in Micronesia (courtesy of the San Francisco Exploratorium). Unfortunately, our solar viewing was clouded out. Having dealt with rain in our last event, this time the AOH not only brought its own stars, but we also brought our own planets and sun in the form of a scale model of the solar system. http://nightsky.jpl.nasa.gov/download-view.cfm?Doc_ID=342. We set up the star field and Ken bought some small sized images of the 1991 total solar eclipse and one of Saturn taken from the Cassini spacecraft. We let the visitors view these objects from 25 feet away though our telescopes (my Galileoscope refractor and Ken’s 90 mm Maksutov-Cassegrain). The highlight of the event (besides watching a live broadcast of a total eclipse) was using Ken’s 60 foot solar system tape (scaled to the size of the solar system) and having the parents/kids stand at each orbit with the requisite planet.   We spanned the entire length of the museum’s main floor! I’m sorry I didn’t take a picture but I was busy holding Venus. At the end of the event, Mark Wilson gave a little talk about the upcoming Aug. 21, 2017 eclipse and where to best view it for totality.   Thank you to the HSU Natural History Museum http://www2.humboldt.edu/natmus/ for inviting us.   The Museum is a great place for families to visit, and a wonderful educational resource.

Mark Wilson giving his seal of approval on the scale model of the solar system.

Star mask (Pleiades)



Watching the solar eclipse at totality

Telescopes and planets among the animal displays

A New Ninth Planet?

By Mark Bailey
March, 2016

"Evidence For A Distant Giant Planet In The Solar System", a paper published in the January 20 issue of *The Astrophysical Journal* has brought yet more excitement to the planetary science community, presenting evidence for the existence of a ninth planet well beyond Pluto. Coauthored by Konstantin Batygin, and the famous Kuiper Belt object discoverer Michael Brown, their analysis of observational and mathematical models suggests strongly that this "Planet Nine" may well exist in the dark *scattered disk* of the Kuiper Belt .

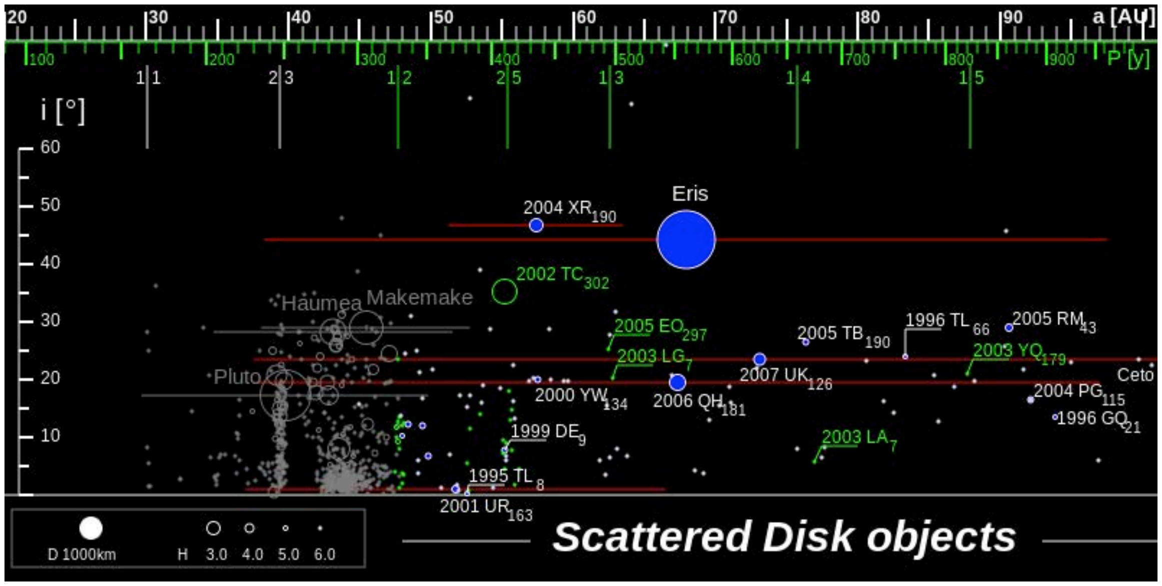


Figure 1. The Scattered Disk of Kuiper Belt objects has an impressive and growing number of minor planets. *Wikipedia*. Wikipedia Foundation, Inc., 4 March, 2016. <https://en.wikipedia.org/wiki/Scattered_disc>.

This proposed new object is a very deep object indeed but it is certainly not alone out there. As we train our instruments outward in the ever-widening search for more distant objects in the Solar System, their number keeps expanding (Figure 1).

Kuiper Belt objects are grouped with the broader classification of *Trans-Neptunian Objects* (TNOs) and have distinctive orbital and compositional characteristics. The Kuiper Belt is a disk-like part of this zone crowded with these *minor planets.* (A minor planet is any sun-orbiting object that is neither a planet nor a comet). Some researchers refer to these objects as Kuiper Belt objects , or KBOs. Presently, the count for such objects is over 1,750 with Pluto being the most famous. Perhaps well over 100,000 more of these minor planets are expected to be lurking out there in the cold darkness—not to mention *trillions* of comets. Temperatures at this distance are estimated to be near 30K or about -400 Fahrenheit!

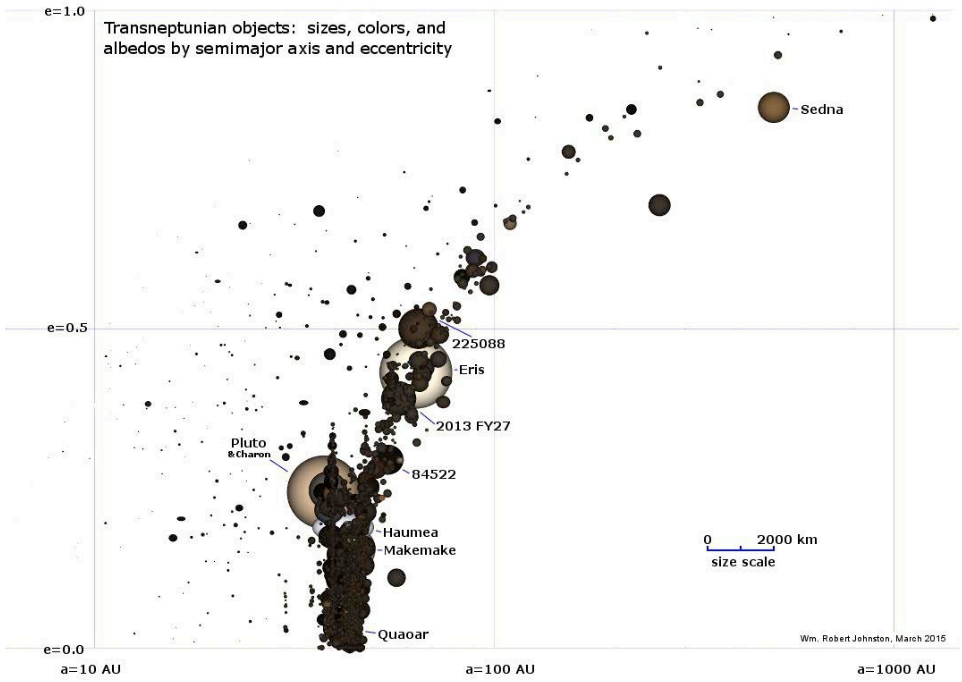


Figure 2. Known Trans-Neptunian Objects showing distance from sun and approximate colors. 15 March, 2016. *Johnstonarchive.* Web. <http://www.johnstonsarchive.net/astro/tnos.html>.

KBOs are extremely difficult to detect mostly because these objects are very *distant* as well as *dark*. A*lbedo*, a measure of how much light reflects off a surface, is largely based on color. Dark surfaces reflect little light, while whiter surfaces reflect much of the light that strikes them. The KBOs are generally *dark* in color and thus reflect back little of the small amount of light that reaches them in the first place (Figure 2). Which brings us to another confounding factor. KBOs only *reflect* incident light from their surfaces. That light comes from the sun. This means that at the distances which we find KBOs *very little* of the Sun's light makes it out to the surface of these objects. The object also has to reflect that light back. The farther the light has to travel the more attenuated it becomes. In other words, we can barely see the things at all because hardly any light is reflected back to us. It has taken the development of more technically advance equipment and a new cadre of determined astronomers to really start finding these objects.

To a large extent, we live in a two dimensional world. We walk on a surface and are very limited to how much above and below the surface we have access to. In space things are different. It's easy to under appreciate just how differently things move when drifting through the vacuum of space. Objects are free to move in any direction. It doesn't take much force in space to make a noticeable change in a small object's position or speed. Interplanetary space although rich with debris, albeit in low densities, is fairly close to empty.

Gravity often seems like it is the most powerful of the known forces. One good fall reinforces that notion but gravity is actually a very weak force. It is directly related to how much mass on object has and so large things, such as stars, have a lot of gravitational attraction. This becomes critical to the story because it is the relatively feeble yet influential gravitational tug of our proposed "Planet Nine" that has set up the conditions that were noticed and then lead to the "Planet Nine" proposal.

In this interplanetary environment where we have both freedom of movement and where the weak force of gravity from a celestial body can produce noticeable effects on other bodies, such as icy KBOs, a pattern has emerged who's significance has been noticed by a growing number of astronomers.

Astronomers have long wondered about and sought an explanation for these highly disturbed looking orbits that are unlike those of the known eight planets. The repeated tug of a hypothetical planet, as it passes a KBO in its orbit, may do one of the following things. The mutual gravity tug may slow the speed of the object, resulting in it "falling" in toward the sun, or it could speed it up, resulting in the flinging out of the object farther into the solar system or beyond. Computer modeling has recently reconstructed how our solar system has likely been scrambled by the gravitational perturbations of Jupiter, Saturn, Uranus, and Neptune. Astronomers have largely attributed the elongated and tilted orbital extremes of KBOs (Figure 3) to these perturbations by known planets—particularly Neptune.

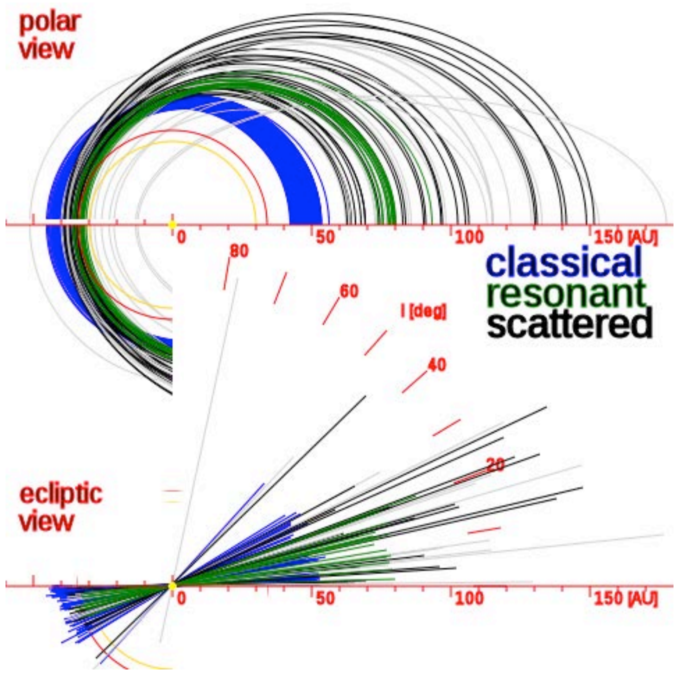
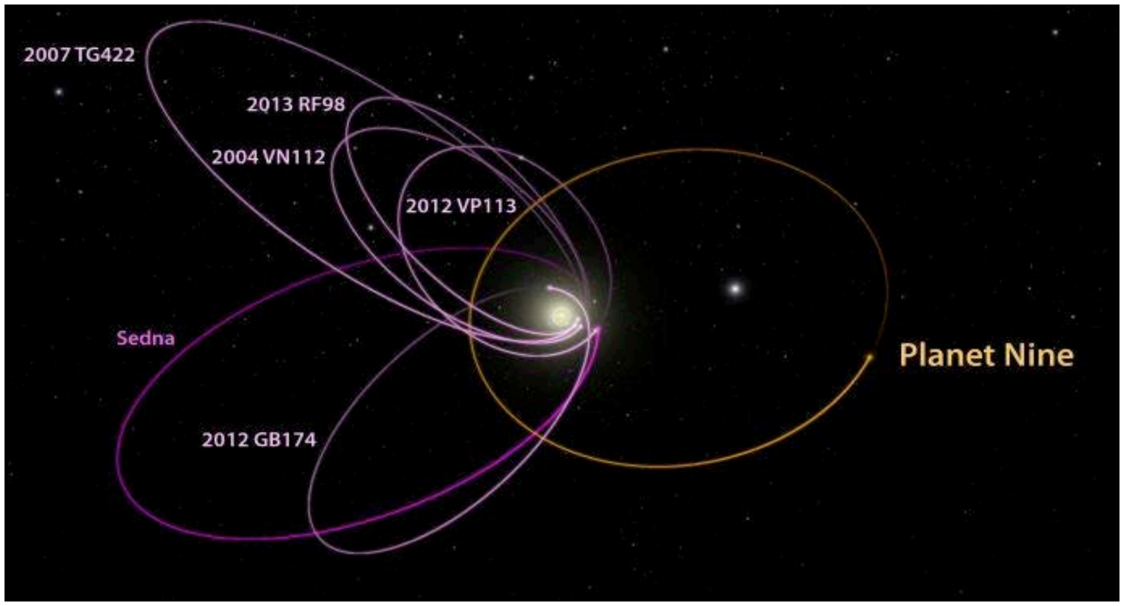


Figure 3. Known Kuiper Belt Objects (KBOs) and their orbital characteristics. Note the highly elliptical shapes, or *eccentricity*, of their orbits (polar view) and their steeply inclined orbital plane compared with the *ecliptic. Wikipedia*. Wikipedia Foundation, Inc., 4 March, 2016. <https://en.wikipedia.org/wiki/Scattered_disc>.

If an object is to stay in a stable, very elliptical orbit around the sun, but is also interacting with a passing neighbor gravitationally, after so much time has passed, it must generally reach a stable *resonance* with that object. For example, for every 3 orbits around the sun of an object that *perturbs* or gravitationally interacts with the hypothetical KBO, the KBO may make 6 orbits. This minor planet would be in a 3:6 resonance with the perturber. Astronomers have observed resonances with many bodies in the solar system and particularly the cluster analyzed by Batygin and Brown. They noticed an interesting pattern among some KBOs. *Six* objects with distinct resonances were being perturbed in their orbits producing an unlikely clustering (Figure 4).



COURTESY CALTECH / R. HURT (IPAC)
Figure 4. Kuiper Belt objects (purple) perturbed in a *resonance pattern* that became noticeable to Batygin and Brown. New Yorker magazine. Web. 20 January, 2016.
http://www.newyorker.com/tech/elements/discovering-planet-nine

The statistical unlikelihood of this pattern of resonances and their associated orbital clustering were reproduced by mathematical models Batygin and Brown developed, matching observed, real-life KBOs. Based on their model, Batygin and Brown claim there is only a 0.007% chance of such an arrangement occurring naturally—*unless* there is an unseen body out there perturbing them. The best match for the observed data lead to their proposed planet or “perturber”(as Batygin and Brown refer to it). And now, as of March 24, Brown has Tweeted in a lively exchange, that yet another KBO has been discovered using the Canada France Hawaii Telescope that is conducting the massive Outer Solar System Origins Survey. The newly discovered object fits nicely in a gap between the orbits of the other six and further bolsters the Planet Nine claim. Brown states that, although a complete analysis has yet to be undertaken, he feels this newest discovery of these, now seven, alignments being a “statistical fluke” is about 0.001%.

Residing in the dark outer reaches of our solar system, this planet would have an orbital period on the order of 10,000-20,000 years. This is, by far, the lengthiest orbital period of any other known planet in our solar system. It would also need to have a mass of more than 10 Earths, making it the largest object discovered in the solar system since the discovery of Neptune in 1746. Interestingly, astronomers were looking for Neptune based upon the parameters of a mathematical model developed earlier to explain the perturbations of the planet Uranus in its orbit.

With a diameter 2-4 times larger than Earth, this new “Super Earth” must be in a highly elliptical orbit with a proposed semi-major axis of approximately 700 *astronomical units* (AU). You may think of *semi-major axis* as a sort of “average distance” to the Sun of a planet in its elliptical orbit. The object could range from its perihelion of 200 AU (30 *billion* km) to an aphelion of 1200 AU (180 *billion km*), putting it in the *scattered disk,* well outside the normally defined 50 AU outer Kuiper Belt, more than 20 times the distance of Neptune from the Sun, and 600 times Earth’s distance out. With a highly inclined orbit of around 30°, it also puts it well outside the *ecliptic plane* where the rest of the known planets spin.

Since the January publication of Batygin and Brown, others have jumped on the bandwagon with a slightly different perspective but similar conclusion. In a paper titled *"Corralling a distant planet with extreme resonant Kuiper belt objects*", Renu Malhotra, Kathryn Volk, and Xianyu Wang a team from University of Arizona also reasoned that the resonances and other orbital characteristics of several KBOs must be the result of a larger body further out with nearly the same characteristics as Batygin and Brown's "perturber". This is an encouraging agreement with these different statistical models and tends to lend credence to the hypotheses of both groups.

Many experts agree that the results from these models are a plausible explanation for these minor planet orbital characteristics. Not all are in agreement though, believing other explanations will better explain the observed clustering or that it is an artifact of our incomplete sampling of objects that we have managed to discover to date. These are tough objects to find, after all.

Another recent explanation for the clustering of these KBOs suggests there could be a *second* Kuiper Belt out beyond the known one that is loaded with so many objects their cumulative gravity will produce the observed clustering. Only further observations can confirm or reject this hypothesis.

As mentioned above, using mathematical models for finding previously unknown worlds is not unprecedented. Brown said, "…after a long analysis, a year and a half of back-and-forth, we realized that the answer is—and we can't come up with any other answer—that there's a giant planet that is sculpting the orbits of these objects, forcing these objects into this one particular location". Even so, Brown gives their model a 68.3% chance of being correct. That makes it seem less "sparkly" than a sure thing but enough of a chance to crank up the planet hunting to a new fevered pitch. Batygin cautiously noted, "Until Planet Nine is caught on camera it does not count as being real. All we have now is an echo."

Further refinement of their model and contributions from other researchers have begun to set some limits on where this proposed object might presently be and where it likely is not (Figure 5). Interestingly, these excluded zones are hinted at based upon analysis of the orbital characteristics of the Cassini probe orbiting Saturn. Subtle orbital changes of Cassini over a ten year period seem to indicate a perturber out there is effecting Saturn's orbit in such a way as to help exclude certain sections of Planet Nine's proposed orbital path from consideration. Search strategies are being laid out and the hunt is on!

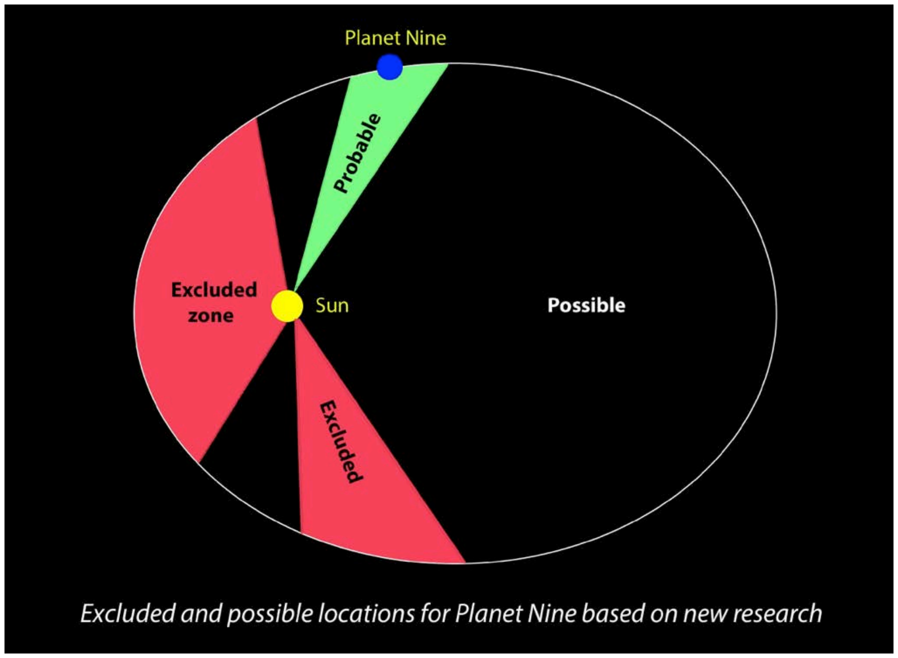


Figure 5. Where to look in that vast sky?
The most likely current location for "Planet Nine". *Universe Today.* Web. 25 February, 2016.
<http://www.universetoday.com/127570/search-narrows-for-planet-nine/>

Observing Trans-Neptunian Objects with amateur telescopes

Can we observe any of these most distant Solar System objects with an amateur telescope? Essentially, no. Under good sky conditions, Pluto can be seen at around 14.1 apparent magnitude with decent amateur telescopes. All of the others so far discovered have magnitudes in the low 20s range and are, alas, out of most amateurs' range. Michael Brown was quoted in *The New Yorker*: "No matter where it [Planet Nine] is in its orbit, it's within range of telescopes on Earth."—just not amateur ones! And when "Planet Nine" is near perihelion, it would become just visible with good amateur telescopes. Some have suggested that if this were the case, it would have already been discovered. This seems to ring somewhat hollow because even the naked eye visible planet Uranus was overlooked for millennia before being spotted. When at its farthest out, only an elite few giant Earthly telescopes would be able to spot this new object. Perhaps we will know soon.

A pretty creative YouTube video that shows the scale of this "new" Solar System in model form can be seen at this link:
http://news360.com/article/340553613

This article is provided courtesy of NASA Space Place

The Closest New Stars To Earth

By Ethan Siegel

When you think about the new stars forming in the Milky Way, you probably think of the giant star-forming regions like the Orion Nebula, containing thousands of new stars with light so bright it's visible to the naked eye. At over 400 parsecs (1,300 light years) distant, it's one of the most spectacular sights in the night sky, and the vast majority of the light from galaxies originates from nebulae like this one. But its great luminosity and relative proximity makes it easy to overlook the fact that there are a slew of much closer star-forming regions than the Orion Nebula; they're just much, much fainter.

If you get a collapsing molecular cloud many hundreds of thousands (or more) times the mass of our sun, you'll get a nebula like Orion. But if your cloud is only a few thousand times the sun's mass, it's going to be much fainter. In most instances, the clumps of matter within will grow slowly, the neutral matter will block more light than it reflects or emits, and only a tiny fraction of the stars that form—the most massive, brightest ones—will be visible at all. Between just 400 and 500 light years away are the closest such regions to Earth: the molecular clouds in the constellations of Chamaeleon and Corona Australis. Along with the Lupus molecular clouds (about 600 light years distant), these dark, light-blocking patches are virtually unknown to most sky watchers in the northern hemisphere, as they're all southern hemisphere objects.

In visible light, these clouds appear predominantly as dark patches, obscuring and reddening the light of background stars. In the infrared, though, the gas glows brilliantly as it forms new stars inside. Combined near-infrared and visible light observations, such as those taken by the Hubble Space Telescope, can reveal the structure of the clouds as well as the young stars inside. In the Chameleon cloud, for example, there are between 200 and 300 new stars, including over 100 X-ray sources (between the Chamaeleon I and II clouds), approximately 50 T-Tauri stars and just a couple of massive, B-class stars. There's a third dark, molecular cloud (Chamaeleon III) that has not yet formed any stars at all.

While the majority of new stars form in large molecular clouds, the closest new stars form in much smaller, more abundant ones. As we reach out to the most distant quasars and galaxies in the universe, remember that there are still star-forming mysteries to be solved right here in our own backyard.

Image credit: NASA and ESA Hubble Space Telescope. Acknowledgements: Kevin Luhman (Pennsylvania State University), and Judy Schmidt, of the Chamaeleon cloud and a newly-forming star within it —HH 909A—emitting narrow streams of gas from its poles

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Andromeda Nebula Lies Outside Milky Way Galaxy

Spiral Nebulae are indeed "Island Universes"

Editor's note: In honor of the upcoming Messier Marathon, the story of Edwin Hubble and the Great Andromeda Nebula

Astronomer Edwin Hubble, of the Mount Wilson Observatory at Pasadena, California, has solved the mystery of the spiral nebulae. The spiral nebulae look like hazy pin-wheels in the sky. He has determined that these objects are much more distant than previously thought. Therefore, they are distant galaxies and not part of our own Milky Way galaxy. In the process, Dr. Hubble was also able to determine the distance to the spiral Andromeda nebula.

Dr. Hubble's observations support the views Dr. Heber Curtis expressed in a debate with Dr. Harlow Shapley in 1920. Curtis stated that bright diffuse nebulae are fairly close to Earth and are part of the Milky Way, while spiral nebulae are at great distances and not part of the Milky Way.

On December 30, 1924, Hubble announced that he had taken photographs of a few bright spiral nebulae with the Mount Wilson Hooker telescope, the largest reflecting telescope in the world. According to Dr. Hubble, "The 100 inch reflector partially resolved a few of the nearest, neighboring [spiral] nebulae into swarms of stars." One of the nearby nebulae Dr. Hubble photographed was the Andromeda nebula. He estimates it is as large, and holds as much matter, as the Milky Way. It may contain some three to four billion stars that produce one-billion times the light of the Sun.

These photographs showed there were individual stars in the nebula. They also showed some of the stars changed in brightness over time. Known as Cepheid variable stars, these stars were the key to determining distances to the nebulae. The true brightness of the Cepheids in the nebulae.

Hubble studied was known from how the Cepheid changes its brightness. Scientists had already known exactly how light dims over distance.

The distance to the star, and the nebula it is located in, can be found by comparing the apparent brightness of these stars to their true brightness.

Image credit: Hale Observatories, courtesy AIP Emilio Segre Visual Archives

Dr. Hubble's work builds on earlier observations by Miss Henrietta Swan Leavitt of the Harvard College Observatory and by Dr. Harlow Shapley of the Mount Wilson Observatory.

In 1912, Miss Leavitt was the first to recognize the importance of Cepheid variables. They are giant stars, and each varies in brightness over time. Cepheids are named after the first such star of its type found: Delta Cephei in the constellation Cepheus. While studying Cepheids in the Small Magellanic Cloud, Miss Leavitt noticed that the Cepheids would brighten, then fade, and then brighten again. The length of time (the period) it took for the star to go through this cycle was directly related to its true brightness: the longer the period, the brighter the star. The Small Magellanic

Cloud is a large group of stars visible in the southern hemisphere. Since all of these stars were in the Small Magellanic Cloud, they were at roughly the same distance from the Earth. Each Cepheid's true brightness was directly related to its period.

Soon after Miss Leavitt's discovery, Dr. Shapley began searching for Cepheids in globular clusters in our own Milky Way galaxy. Globular clusters are sphere-shaped groups of tens of thousands of densely packed stars. He used the period-brightness relationship to determine the distance to more than 230 globular clusters. He assumed that Cepheids in distant globular clusters act the same as nearby Cepheids. Based on that assumption, he found the most distant clusters in the Milky Way Galaxy are about 200,000 light years away.

Hubble's Annotated image of the Great Andromeda Nebula showing the locations of variable stars.

Image credit: Hubble, ApJ, 69, 103 (1929)

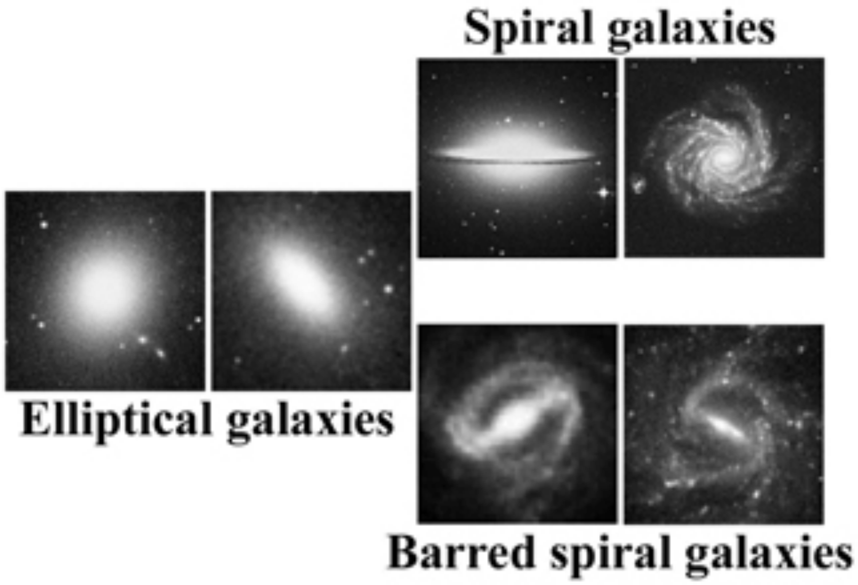
By studying the periods of the Cepheids in the Andromeda nebula, Dr. Hubble was able to determine the true brightness (or absolute magnitude) of each. He then made observations of their apparent brightness (or apparent magnitude). Once he knew the difference between how bright a star appeared and how bright it truly was, he was able to calculate its distance from the Earth. He found Andromeda to be 900,000 light years away – the most distant object known to-date.

Classifying Nebulae

For over a thousand years, astronomers wondered about the nature and development of nebulae. Nebulae appear to be faint clouds of gas and dust in the distant universe. Until recently, there have not been enough observations to classify nebulae based on their features or qualities.

During his studies of the spiral nebulae, Dr. Hubble proposed a system to classify all nebulae. He sorted them into three basic categories: elliptical, spiral, and irregular. These categories were further subdivided according to shape (spherical to elongated ellipses, for example) and structure (hazy to distinct spiral arms, barred spirals, etc.).

Hubble's system shows a sequence of evolutionary change but was "based primarily on the structural forms of photographic classification which should be entirely independent of theoretical considerations." Future astronomical studies and evidence will be the test for this new classification system.



Hubble's classification scheme

Image credit: NASA's Cosmic Times

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Ten Years of Discovery by Mars Reconnaissance Orbiter

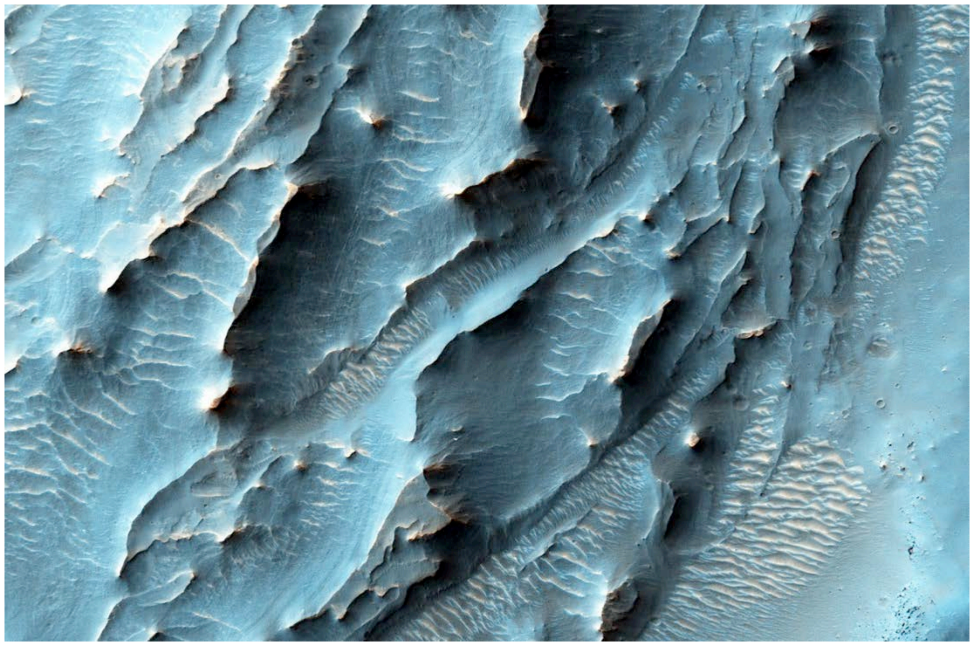
True to its purpose, the big NASA spacecraft that began orbiting Mars a decade ago has delivered huge advances in knowledge about the Red Planet.

NASA's Mars Reconnaissance Orbiter (MRO) has revealed in unprecedented detail a planet that held diverse wet environments billions of years ago and remains dynamic today.

One example of MRO's major discoveries was published last year, about the possibility of liquid water being present seasonally on present-day Mars. It drew on three key capabilities researchers gained from this mission: telescopic camera resolution to find features narrower than a driveway; spacecraft longevity to track seasonal changes over several Martian years; and imaging spectroscopy to map surface composition

Other discoveries have resulted from additional capabilities of the orbiter. These include identifying underground geologic structures, scanning atmospheric layers and observing the entire planet's weather daily. All six of the orbiter's science instruments remain productive in an extended mission more than seven years after completion of the mission's originally planned primary science phase.

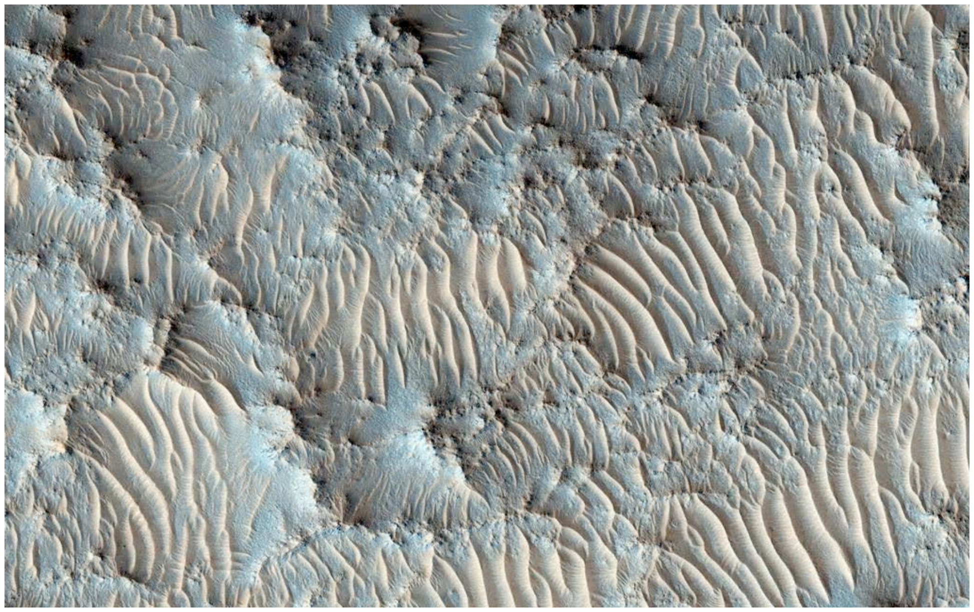
"This mission has helped us appreciate how much Mars -- a planet that has changed greatly over time -- continues to change today," said MRO Project Scientist Rich Zurek of NASA's Jet Propulsion Laboratory, Pasadena, California. JPL manages the mission. Data from MRO have improved knowledge about three distinct periods on Mars. Observations of the oldest surfaces on the planet show that diverse types of watery environments existed -- some more favorable for life than others. More recently, water cycled as a gas between polar ice deposits and lower-latitude deposits of ice and snow, generating patterns of layering linked to cyclical changes similar to ice ages on Earth. Dynamic activity on today's Mars includes fresh craters, avalanches, dust storms, seasonal freezing and thawing of carbon dioxide sheets, and summertime seeps of brine.



Unusual texture of the southern floor of the Gale Crater. Image taken with the HiRISE camera on the MRO. Image Credit: NASA/JPL-University of Arizona

Unconformities in North Polar layer deposits. Image taken with HiRISE on the MRO. Image Credit: NASA/JPL-University of Arizona

The mission provides three types of crucial support for rover and stationary lander missions to Mars. Its observations enable careful evaluation of potential landing sites. They also help rover teams choose routes and destinations. Together with NASA's Mars Odyssey, which has been orbiting Mars since 2001, MRO relays data from robots on Mars' surface to NASA Deep Space Network antennas on Earth, multiplying the productivity of the surface missions.



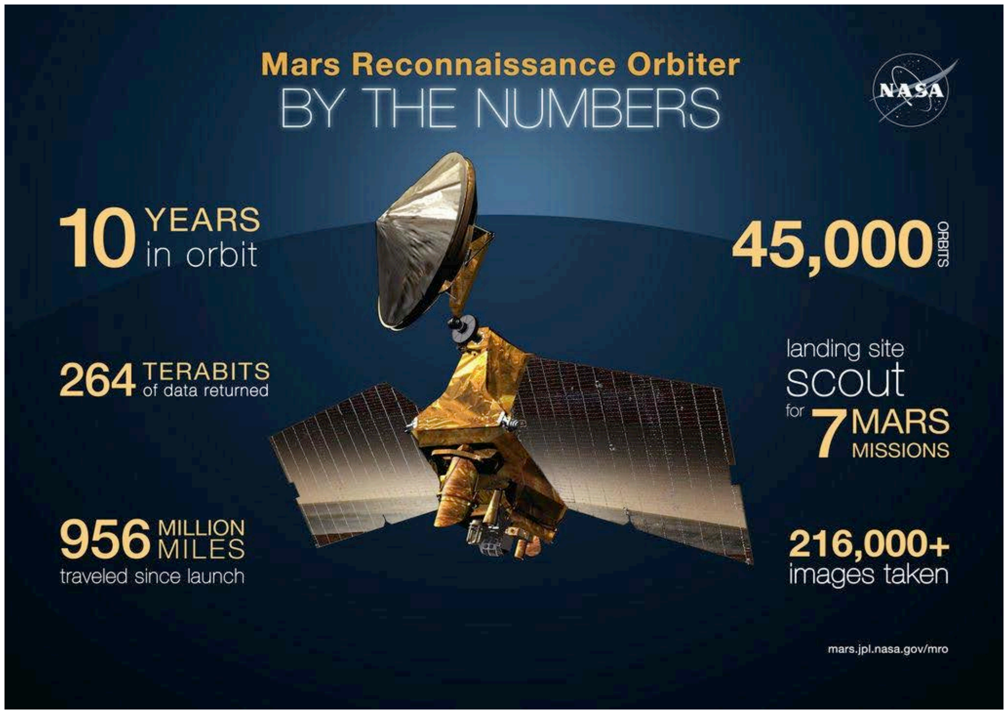
Jezero Crater: A possible landing site for the 2020 mission. Imaged with HiRISE on the MRO. Image Credit: NASA/JPL-University of Arizona

The mission has been investigating areas proposed as landing sites for future human missions in NASA's Journey to Mars.

"The Mars Reconnaissance Orbiter remains a powerful asset for studying the Red Planet, with its six instruments all continuing capably a decade after orbit insertion. All this and the valuable infrastructure support that it provides for other Mars missions, present and future, make MRO a keystone of the current Mars Exploration Program," said Zurek.

Arrival at Mars

On March 10, 2006, the spacecraft fired its six largest rocket engines for about 27 minutes, slowing it down enough for the gravity of Mars to catch it into orbit. Those engines had been used only once before, for 15 seconds during the first trajectory adjustment during the seven-month flight from Earth to Mars. They have been silent since arrival day. Smaller engines provide thrust for orbit adjustment maneuvers.



Ten Years Anniversary of the Mars Reconnaissance Orbiter. Image Credit: NASA/JPL

For its first three weeks at Mars, the spacecraft flew elongated, 35-hour orbits ranging as far as 27,000 miles (43,000 kilometers) from the Red Planet. During the next six months, a process called aerobraking used hundreds of carefully calculated dips into the top of the Martian atmosphere to gradually adjust the size of the orbit. Since September 2006, the craft has been flying nearly circular orbits lasting about two hours, at altitudes from 155 to 196 miles (250 to 316 kilometers).

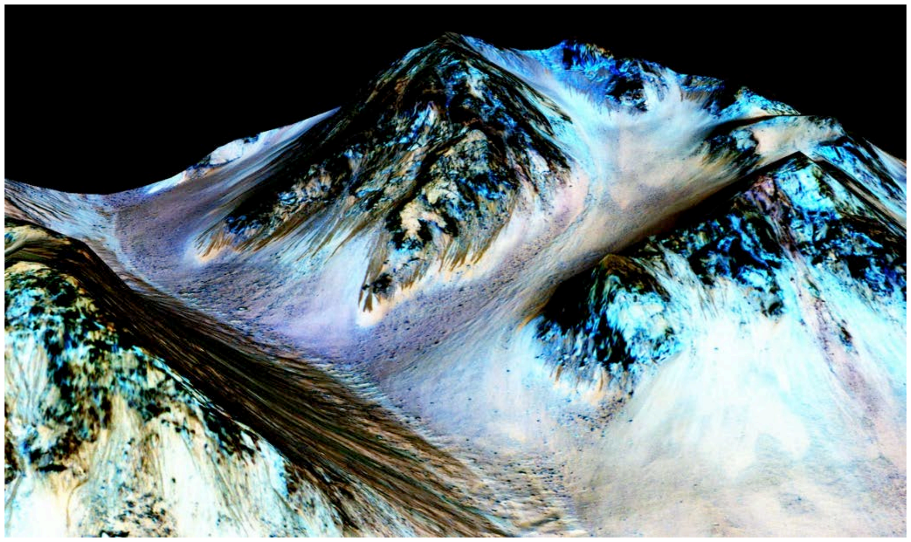
The spacecraft's two large solar panels give MRO a wingspan the length of a school bus. That surface area helped with atmospheric drag during aerobraking and still cranks out about 2,000 watts of electricity when the panels face the sun. Generous power enables the spacecraft to transmit a torrent of data through its main antenna, a dish 10 feet (3 meters) in diameter. The total science data sent to Earth from MRO -- 264 terabits -- is more than all other interplanetary missions combined, past and present.

Lockheed Martin Space Systems, Denver, built the spacecraft with the capability to transmit copious data to suit the science goals of revealing Mars in great detail, which requires plenty of data.
For example, the mission's High Resolution Imaging Science Experiment (HiRISE) camera, managed by the University of Arizona, Tucson, has returned images that show features as small as a desk anywhere in observations that now have covered about 2.4 percent of the Martian surface, an area equivalent to two Alaskas, with many locations imaged repeatedly. The Context Camera (CTX), managed by Malin Space Systems, San Diego, has imaged more than 95 percent of Mars, with resolution showing features smaller than a tennis court. The Compact Reconnaissance Imaging Spectrometer (CRISM), managed by Johns Hopkins University Applied Physics Laboratory, Laurel, Maryland, also has imaged nearly 98 percent of the planet in multiple visual-light and infrared wavelengths, providing composition information at scales of 100 to 200 yards or meters per pixel.

For more information about MRO, visit:
http://www.nasa.gov/mro

For more information about NASA's journey to Mars, visit: https://www.nasa.gov/topics/journeytomars

For HiRISE images of Mars:
http://www.uahirise.org/katalogos.php



Compact Reconnaissance Imaging Spectrometer for Mars (CRISM). Planetary scientists detected hydrated salts on these slopes at Hale crater, corroborating their original hypothesis that the streaks are indeed formed by liquid water. NASA/JPL-University of Arizona