

# Focused

The Valley of the Moon Observatory Association Newsletter  
(a non-profit science and astronomy education organization)



Spring 2016

Volume XIX Number 2

## Did You Feel that Gravitational Wave?

*By Loren Stokes*

My guess is probably not. The gravitational wave detected last September by the twin LIGOs (Laser Interferometer Gravitational-Wave Observatory) caused space to expand and contract rapidly, to nearly 200 times per second, as two orbiting black holes in-spiraled and merged. But the amount space expanded and contracted here on Earth was only one part in a billion-trillion, due to the great distance to the black holes, 1.3 billion light years, and the weakness of gravity itself. Consider the space occupied by the Milky Way galaxy, a disk 100,000 light years across. That size happens to be nearly a billion-trillion meters. So across our vast galaxy, space expanded and contracted by just one meter.

I expected the first direct detection of a gravitational wave to be a small signal buried in the LIGO noise. But the signal detected last September was huge, with a signal-to-noise ratio of 24. Anyone can see the clean signal increasing in frequency while maximizing in amplitude, then ring down, all in about two-tenths of a second. The Louisiana LIGO saw the signal first, followed in 7 milliseconds by the Washington LIGO. The two LIGOs are 1860 miles apart, 10

milliseconds flight time at the speed of light.

The signal matched that predicted by general relativity of two black holes of 29 and 36 solar masses in-spiral and merge to a single black hole of 62 solar masses. But 29 and 36 add to 65. What happened to the missing 3 solar masses? That energy ( $E = mc^2$ , where  $m$  is 3 times the mass of our Sun!) was converted to gravitational waves moving away at the speed of light. It is amazing to note that the peak gravitational wave frequency, 150 cycles per second, means that the two black holes were orbiting each other 75 times a second just before they merged!

By the time the gravitational waves reached Earth 1.3 billion years later, they caused a tiny displacement of space measured by the LIGOs. Each LIGO is an optical interferometer comprised of two 4-kilometer long arms perpendicular to each other. Laser light is split by a beam-splitter and half of the light enters each arm. Instead of merely reflecting off a mirror 4 kilometers away, each arm is an optical resonator where light circulates hundreds of times, on

*(turn to WAVE on Page 6)*

<http://www.rfo.org>

## Public Events at Robert Ferguson Observatory

### April 9, Saturday

Public Solar Observing 11 am – 3 pm

Public Observing Night 8 pm

### May 14, Saturday - Astronomy Day

Public Solar Observing 11 am – 3 pm

Public Observing Night 8 pm

### June 4, Saturday

Public Solar Observing 11 am – 3 pm

Public Observing Night 8 pm

### June 25, Saturday

Public Solar Observing 11 am – 3 pm

Public Observing Night 8 pm

### July 30, Saturday

Public Solar Observing 11 am – 3 pm

Public Observing Night 8 pm

### August 27, Saturday

Public Solar Observing 11 am – 3 pm

Public Observing Night 8 pm

Evening public viewing is \$3 per adult, 18 years or older, plus \$8 per car parking fee. Donations accepted. Dress for cold nights!

### **RFO Classes (see Page 3)**

#### Night Sky Spring Series

April 5

May 3

#### Night Sky Summer Series

May 31

June 7

June 28

July 5

August 2

August 30

#### New "Focus" Classes

June 15

July 7

Be sure to check out our website at <http://www.rfo.org> for the RFO weather forecast and other interesting information.

**Focused**

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**VMOA Mission Statement**

The VMOA is a group of volunteer amateur  
and professional astronomers organized as  
a non-profit association to provide educa-  
tional programs about science and astronomy  
for students and the public. To that end,  
the VMOA operates the Robert Ferguson  
Observatory in Sugarloaf Ridge State Park in  
association with California State Parks.

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# President's Message

By Steve Smith



We each have our ideal room: a room in which we sit, supreme and comfortable. Your room? Maybe it has that perfect reading chair. Next to the chair, that perfect reading lamp under whose warm glow you finished reading that perfect book. Maybe your ideal room was the one you had as an untethered child: free to create a fantasyland within it, partly real, mostly imagined, but always seen with eyes wide open and eager for new adventures. Or maybe—something to look forward to!—you haven't yet discovered your ideal room...

Twenty feet by twenty feet are the dimensions of my room. I've never considered whether that size is opulent or oppressive: that's just the size it is, and it doesn't need to be any different. There aren't any supremely comfortable chairs in it, and the perfect reading light would be, oddly enough, completely unwelcome. It's all quite peculiar.

The majesty of this room isn't defined by its size. Or rather, the majesty of this room isn't defined by its size as you see it in your imagination. A square room? Yes. Twenty feet by twenty feet? Yes. And mostly unremarkable, I admit, yes again.

But now look up, and see no limit. No boundary. Up there, there is no end, at least none that YOU can see.

All because my ideal room forgot its roof.

What's in the middle of your ideal room? In mine, anchored dead center, sits an unsightly metal Frankenstein with wires and glass, motors and gears, gizmos that whirr and buzz and whisper undecipherable things. Parts of it stick out at odd and entrancing angles, afterthoughts with deliberate intent.

My beloved monster is just a telescope (the missing roof no longer a mystery, I hope!), but when this monster moves, it's with the graceful strength and deadly precision of a tiger in its prime. And this tiger's vision is quite extraordinary: with its single camera eye, it can detect prey billions of light-years away and capture it with only the slightest of efforts.

This animal lives in the Robert Ferguson Observatory, in a room known simply as the East Wing. I've worked in this room, and with this tiger, for a few years, taking picture after picture of things seen only because a roof wasn't allowed to hold my tiger and me down.

The Robert Ferguson Observatory—RFO—is a special kind of zoo, and the tiger in the East Wing isn't the only animal in the house. Residing under the white dome is an elegant eight-inch refracting telescope, the kind Galileo would be using had he been lucky enough to be a fellow zookeeper here. This scope feeds regularly on a diet of planets and moons, and devours colorful binary star systems like a six-year old with a bowl of M&Ms.

Like any zoo, RFO occasionally

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## RFO 2016 Class Schedule

### Night Sky Classes

Each class includes a lecture on the constellations of the season, their history and mythology, and how to find objects within them. Learn the bright stars and deep-sky objects of the night skies. After each presentation (sky conditions permitting), you will enjoy a review of the constellations in the actual night sky and learn how to find them for yourself. The constellations, and the objects within them, will be viewed through binoculars and telescopes, including the Observatory's 40-inch reflecting telescope, until or beyond 10:30 pm (depending upon interest and enthusiasm).

The continuing Spring Series classes will be held on Tuesday, March 29, April 5, and May 3 at 7:30 pm.

The upcoming Summer Series classes will be Tuesday, May 31, June 7 & 28, July 5, and August 2 & 30 at 8:00 pm.

Fee: \$75 for 6-class series or \$23 for a single class

E-mail: [nightsky@rfo.org](mailto:nightsky@rfo.org) to reserve a space in this popular class

Find more information about RFO's Night Sky Classes online at <http://www.rfo.org>

### Observing Labs

An intensive telescope observing session after a brief presentation on the night's theme.

Handouts/Observing lists provided.

Attendance limited to 6.

#### Star Death: The End of Stellar Fusion

Sunday, September 25, at 7:00 pm [Raincheck date: Wednesday, September 28]

Fee: \$30.

For reservations, email: [nightsky@rfo.org](mailto:nightsky@rfo.org)

Find more information about RFO's Observing Labs online at <http://www.rfo.org>

## New RFO Class! Focus Nights

*by Rob Davis, Obe Lynd, & Greg Reynolds*

Have you ever wondered what's really out there in the night sky? Wished you could zoom in on cosmic marvels? What if you had a handful of astronomers at your elbow, showing the way, answering your questions in plain language?

That's the idea behind our new program, called "Focus Nights"; a personal learning and viewing experience at Robert Ferguson Observatory.

Focus Nights will be limited to 20 guests and will offer a more intimate and thorough introduction to astronomy and RFO. Focus Nights are an opportunity to have the RFO experience without the possibility of encountering a great number of fellow guests as often happens at public Star Parties.

The program will start at dusk with an in-depth presentation that is the evening's "focus." The first three scheduled Focus Nights are focused on the Moon, Saturn and Neptune. These are scheduled to coincide with good viewing of the evening's topic. Subsequent programs could include other subjects such as nebulae, galaxies, various other stellar groupings, as well as the other planets, as the chosen dates skies dictate.

After the presentation, guests will begin viewing the skies using our three featured telescopes and have

plenty of time to see the night's topic and the many other astronomical objects available on that evening. The Focus Nights will also be a great opportunity to showcase our new 40-inch reflector.

The first three upcoming Focus Nights are as follows:

#### Focus on the Moon

Tuesday, June 14, 2016, 7:30 pm

(Rain check: Wednesday, June 15, 2016, 7:30 pm)

The MOON... is the Earth's nearest cosmic neighbor and the only place in the entire Universe, other than Earth, that has been walked upon by human beings. The Moon is covered in vast lava flows so large you can see them from Earth with the unaided eye. Ancient observers thought they might have been seas but we now know there is no water on the Moon. At least not in liquid form. The Moon is covered with craters but there are also features known as rilles, scarps, swirls and dark halos.

In this lunar presentation you will learn all about these features and then view them through the telescopes. You will also learn how the Moon directly affects life on Earth every day by controlling the tides, how the phases work, why we have eclipses and why we only ever see the side

*(turn to NIGHTS on Page 7)*

## Watching the 2016 Spring Sky

by Jack Welch

*Jupiter* is just past opposition and is high overhead in the evening sky all spring providing lots of great observing opportunities. In particular, telescope observers can watch for many interesting Jovian satellite events, details of which can be found on our website. (For these and all details mentioned here, use the “What’s Up in the Night Sky” link on our homepage.) In particular, there will be *double shadow transits* on 3/21, 3/28, 4/5, & 5/6. Jupiter will be very near the moon around 9pm on 3/21, 10pm on 4/17, 1am on 5/15, and 9:30pm on 6/11. In *Leo* all spring, Jupiter ends retrograde motion on 5/9.

*Mars* and *Saturn* both reach opposition this spring. However both will be at far southern declinations so remain low in the south and offer us northerners somewhat inferior views and shortened observing periods. Nevertheless, oppositions of *Mars* are always special since they occur at intervals of more than 2 years and these are the only times when we have a chance to view Mars as something more than a small red disk. Mars rises around midnight in early spring and quickly becomes a good telescope target for a.m. hour observers. It begins retrograde motion on 4/16 and is near its famous “rival” the red super-giant star *Antares* during late April. By early May, Mars rises around 10pm and reaches opposition on 5/22. However, Mars isn’t closest to Earth, and thus largest for viewing, until 5/30 when its disk will reach a diameter of 19”. By this time Mars is rising shortly before sunset so will be a good late evening target. Mars ends retrograde motion on 6/30 by which time its disk diameter will be 16”. Good Mars observing will only last about another month after this.

*Saturn* is in *Ophiuchus* all spring, quite near *Antares* (which is in *Scorpius*), and rises around 1am in late March. By late April, it rises around 11pm and is joined by Mars. The moon joins this trio during morning hours from 4/24 to 4/26 (see Figure). Saturn is at opposition on 6/2 by which time it is rising at sunset and will reach a disk size of 18” with the rings spanning 42” and tilted 26°. It remains good for evening observing throughout June and July but not much beyond that.

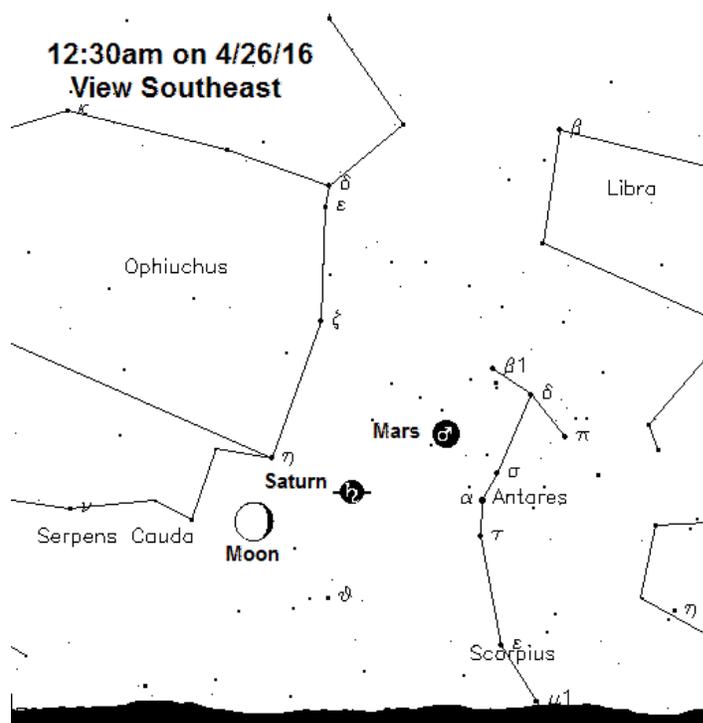
*Venus* is very low in the pre-dawn east at the start of spring and disappears into the rising sun during late April. At superior conjunction on 6/6, it is mostly not viewable this spring.

*Mercury* provides its best evening apparition of 2016 from 4/6 to 4/29, reaching a maximum altitude 45 minutes

after sunset of 10° on 4/17. Otherwise, Mercury only provides an extremely poor morning apparition in early June in which it is scarcely viewable. But something *very* interesting happens between these apparitions when Mercury is at inferior conjunction on 5/9: it will *transit the face of the sun!* This only happens 13 or 14 times per century. RFO will not be open for this event but RFO docents and Sonoma County Astronomy Society (SCAS) members plan to set up solar viewing telescopes in one or more public areas in the county. Consult our website as the date nears for more details. The sun will rise with the transit already in progress. Transit maximum (Mercury nearest the center of the sun’s disk) is at 7:58am. Mercury exits the sun’s disk from 11:39 to 11:42am. Important: Only scopes properly equipped for solar viewing can safely view this event.

*Neptune* begins retrograde motion in *Aquarius* on 6/14 and the minor planet *Juno* is at opposition on 4/26 about 3° southwest of the star 109 Vir. *Juno* will be quite dim (10<sup>th</sup> magnitude) and a finder’s chart is essential.

Besides conjunctions with planets already mentioned, the *moon* provides several nice events this spring. I mentioned in the last issue that there would be large tides in March near the new moon. This continues for two more months with VERY large tides from 4/8-11, and EXTREME tides around 4/9 since the new moon occurs less than 7 hours before an especially close perigee. Then



again in May there are large tides from 5/6-9.

There is a deep penumbral lunar eclipse on the morning of 3/23. While not as dramatic as an umbral eclipse, there should be noticeable darkening of the southern portion of the moon's disk for some time between 4:17 and 5:17am, with maximum darkening at 4:47.

Continuing a currently ongoing sequence, the moon will occult the bright red star *Aldebaran* in *Taurus* on 4/10. This is a daytime occultation. Aldebaran will disappear behind the moon's dark limb at about 2:21pm and then reappear from behind the bright limb at an axis angle of 281° (or 84° from the north cusp) at about 3:36pm. Those with tracking scopes can observe the reappearance by letting the scope track during the occultation. While the moon will be well away from the sun, it is safest to choose an observing point that is shaded from the sun. There will be two more occultations of Aldebaran viewable locally this year, one in August and the other in December. The moon will occult a number of other bright stars this spring. See our website for details.

Details are favorable for viewing the *Eta Aquarid Meteor Shower* this year, with the best time being from about 2 to 4:30am on the morning of 5/5. These are bright meteors with long trails and there should be about 30 per hour.

The *Zodiacal Light* is in the west after evening twilight from 3/25 to 4/7. This sky glow caused by sunlight reflecting off of fine debris in the plane of the solar system is easy to see from any site with a dark western sky free of light pollution. It appears as a tall tapering "pyramid" of sky glow that is centered on the line of the *ecliptic*. It is comparable in brightness to the Milky Way and can easily be mistaken for light pollution. That is why it is important to be sure you know that the western view is otherwise dark at your selected viewing location. Look for it between 9:10 and 9:40pm, just after twilight has ended.

Have you ever noticed that it is difficult to spot the Milky Way in a dark sky during late spring evenings? This is because one of our galaxy's galactic poles lies in the constellation of *Coma Berenices* ("The Hair of Berenice") and, at our latitude, Coma Berenices lies near our *zenith* during spring evenings. The galactic poles are those points in the sky that lie at the "ends" of a line perpendicular to the plane of the spiral disk of our galaxy. With the galactic pole near our zenith, the Milky Way lies near our horizon in every direction so isn't visible overhead. As you wait later into the night,

you will notice the Milky Way rise in the east and south as we get a preview of the summer sky.

Spring ends at the summer solstice which is at 3:34pm PDT on 6/20 this year.

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(PRESIDENT from Page 2)

replaces one animal with another. It's a difficult and time-consuming process, with great care given to both the retiring animal and the one coming in to replace it. RFO has been fortunate to have had the use of Bill Russell's 24" telescope for many years—it resided in the West Wing of the observatory and fed the imaginations of tens of thousands of visitors and volunteers. When I became a docent in 2008, I spent many hours on that scope with two wonderful and kind people: Jack Welch, who taught me the Night Sky and whose unending patience was tested by my unending questions and equally unending mispronunciations; also, Merlin Combs, who taught so many of us the intricacies of the Russell scope, and, with eyes sparkling, always challenged us to discover more and more hard-to-find objects. Merlin passed on several years ago now, but Jack still teaches the RFO Night Sky Classes and works many more hours behind the scenes. I'll always be grateful to Jack and Merlin for those moments in the West Wing--and to Bill for providing me and so many others with years of enjoyment and wonder from his amazing telescope.

Years before I arrived on the RFO scene, plans were in the works to install the T-Rex of telescopes in the West Wing. Steve Follett, Mark Hillestad, Larry McCune, and George Loyer were already at work on "Project 40": a 40-inch reflecting telescope. The primary mirror was meticulously ground and polished while the P40 design went through constant modifications and upgrades as the years passed. Last fall, the mirror was coated—as a donation—by Viavi Solutions, to whom RFO remains indebted. Large ambitions aren't realized overnight, but as the observatory sat quietly under the winter clouds of 2015-16, the fuzzy edges of that dream vanished, giving way to a remarkable reality.

We're thrilled to announce the latest beast in the RFO menagerie: the 40" telescope is in place, working perfectly, and has already delighted many docents and visitors with amazing views: familiar objects are seen afresh, with a depth and detail that often stuns viewers into awed silence.

New beasts can't do their best without being well cared for. Dave Kensiski has trained over 30 docents:

with the help of the P40 crew, he devised the protocols for its operation. RFO's T-Rex now has many loving handlers ready to show visitors that this telescope has a huge appetite! Fortunately, our T-Rex prefers to dine exclusively on stars, galaxies and nebulae: guests are in no danger unless they forget to start breathing again after gazing through the eyepiece.

RFO continues to grow in other ways as well. In 2015, we had the largest number of new docents join since the observatory's founding, and we set a record for the most number of visitors.

Sadly, 2015 was also a time of loss, as we said goodbye to docent Dave Stanfield. Dave was a quiet, gentle man who often set up his own scope in front of RFO for visitors. He was also an avid and talented astrophotographer: he and I spent many hours discussing equipment and technique, and he's greatly missed by all of us.

We also wished Carlos Anicetti well as he headed east to Princeton after several years of intense volunteer work and research at RFO: we're thrilled at his success and look forward to housing his future multiple Nobel Prizes in the observatory. Fortunately, Carlos always comes back to RFO on his breaks. Unfortunately, he also continues to bring puns.

As 2016 began, RFO recognized a number of docents whose 2015 volunteer work went beyond the ordinary: John Dillon, whose "Before Telescopes" series of talks to visitors and docents has been so engaging, and carpetmeister Michael Eckstein, who took charge of the fundraising and installation of new carpet. Michael was also awarded the 2015 "Docent of the Year": floor work is just the tip of the volunteer iceberg for him.

Finally, RFO recognized outgoing president Rob Davis: under his leadership, the observatory experienced unprecedented growth. Rob will continue to serve on the board and volunteer for various events at RFO, contributing his knowledge and humor to docents and visitors alike.

Looking ahead to the rest of 2016: wow, we're busy! In addition to our numerous Public and Private Events, RFO continues to offer the popular Night Sky Classes. We're expanding our Solar Observing, providing solar scopes on Bald Mountain as part of the Bill and Dave Hikes coordinated through Team Sugarloaf. We'll be participating in more and more offsite events: we have an ongoing partnership with the California Academy of Sciences in San Francisco to do live CCD astrophotography during various CAS events and provide RFO information to their visitors.

We're also pleased to announce a new public outreach

program for visitors coming to the observatory: "Focus Nights". See Greg Reynolds' and Obe Lynd's informative article elsewhere in this newsletter for the details of this exciting addition to the RFO menu.

As I close this, my first message as president, I want to say a few words about the RFO zookeepers: the volunteers that are the heart and soul of the observatory.

We have amazing telescopes that see amazing things. We could decide to invest in even more rooms, bigger than 20'x20', with more comfortable chairs, and better coffee (please!). We could relocate to the top of a 14,000 foot mountain, with ideal seeing and overnight accommodations for our visitors: helicopters could fly in Kip Thorne, Leonard Susskind and Alex Fillipenko to be our resident guest speakers.

But none of that really matters.

The telescope animals under RFO's care are wonderful, no doubt. In their roofless cages, they draw the wonders of the Universe down to us, and thereby lift us up, beyond the walls—real and imagined—that constrain us so tightly in our normal lives.

But the people of RFO, from those that design, build and operate the grandest telescopes, to those who vacuum, park the cars, or spend countless hours doing accounting and behind-the-scenes grunt work: those volunteers make the observatory such a wonderful place to simply BE.

Looking up beyond our roofless rooms, the unmeasurable vastness of what lies overhead is a gentle and profound reminder of where we came from, and where we are going. Our lives on this little rock hurtling through space is painfully short: yet, here we all are, living in the same moment as one another, together, sharing mutual experiences in our very special zoo.

And yes--the rooms are ideal.

To all of you who make RFO happen—to the wonderful volunteers, donors, subscribers, sponsors and visitors alike--simply put, thank you.

The best is yet to come...

*(WAVE from Page 1)*

average, before emerging back to the beam-splitter to interfere with light from the other arm. This increases the sensitivity by hundreds of times. Equally, you can think of each arm being effectively hundreds of times longer than 4 kilometers. The passing gravitational wave caused each arm length to expand and contract, out of phase with each other, many times over the 0.2-second event. The interfering light of the two arms was detected as a rather strong signal well above the noise level caused

by background vibrational noise and electronic noise.

But a fractional change in space of just one part in a billion-trillion, over the 4-kilometer long arms, is a displacement of just 4-thousands of a femtometer (a proton diameter). To detect such a small signal requires not just the recirculating nature of light in each LIGO arm, but also a large recirculating power of 100 kilowatts. A recent upgrade to both LIGOs increased their sensitivity 10-fold. For a traditional telescope, a 10-fold increase in sensitivity to light coming from distant stars would give a roughly 3-fold increase in how far away a distant star could be seen, due to the inverse-square law, and a roughly 30-fold increase in the volume of space we could see such a star. This is because a traditional telescope is measuring the starlight's *intensity*. However, the LIGO device measures a gravitational wave's *amplitude*, not intensity. So a 10-fold increase in sensitivity means a 10-fold increase in distance to where an event could be detected. That is a 1000-fold increase in the volume of space available for detection. Which is why the first gravitational wave event detected came from such a vast distance of 1.3 billion light years. Future events to be detected could be much stronger if the events were similar but closer. Also, given the large signal-to-noise ratio, similar events much further away should be detected.

When more LIGO-type observatories are up and running around the world, they can triangulate on the direction to an event, as each would record the event at a slightly different time. Then, traditional observatories on Earth and in space would know where to look for after effects of such cataclysmic events.

The event recorded last September was actually the first direct measurement of two predictions of general relativity: the gravitational wave itself, and the in-spiral and merger of two black holes. Truly one of the most significant experimental results in modern physics.

Reference: "Observation of Gravitational Waves from a Binary Black Hole Merger", B. P. Abbott, et al., Physical Review Letters, February 12, 2016. I have a PDF copy of this paper by 1,004 authors from 133 institutions. It is very well written and quite understandable with nice graphics. Email me for a copy. [lstokes@rfo.org](mailto:lstokes@rfo.org)

**Focused annual subscribers**, give yourself a gold star if you have already renewed for 2016! If you haven't, it's time to renew. Your subscriptions are an important part of RFO's funding. Please renew now online, or by mail using the form on the last page of the newsletter. Thank you for shining brightly through your continued support of RFO!

(**NIGHTS** from Page 3)

of the Moon that has "The Man" in it. You will discover what we know about the Moon and what mysteries have yet to be solved.

#### Focus on Saturn

Thursday, July 7, 2016, 8:00 pm

SATURN... a world that continues to dazzle and mystify. This iconic planet, sixth from the Sun, is home to an orbiting array of intriguing and unique worlds of its own. Yet even with a family of over 60 moons, where would Saturn be without its rings? Did you know its rings are disappearing?

If you've never seen Saturn in a telescope, you're missing out on the thrill of a lifetime. So, come learn more about this fascinating planetary system, and see Saturn with the eyes of our new massive reflecting telescope. We promise the rings are still there...for now.



#### Focus on Neptune

Thursday, October 20, 2016, 7:00 pm

(Rain check: Wednesday, October 26, 2016, 7:00 pm)

NEPTUNE... is the last of the major planets. It is a gas giant planet that has the fastest winds ever recorded in the solar system. Like the other gas giants, it is home to many moons but the real story of Neptune is how it was discovered. Mercury, Venus, Mars, Jupiter and Saturn have been known since ancient times. We needed the telescope to discover Uranus and to discover Neptune we needed a little imagination, a little trust in Newton and a couple of brilliant minds willing to take the time to work through hundreds of pages of mathematical calculations.

Neptune is a couple of billion miles away but we can see it in the telescope. It marks a boundary of space where objects known as TNOs (Trans-Neptunian Objects) exist and the story of its discovery is as entertaining as it is interesting. Neptune – the unseen planet that was discovered without a telescope.

Ticket prices are \$25 for General Admission, \$20 for Seniors (62+) and \$20 for Students (with ID), sold online through Brown Paper Tickets. For more information about the program and links to purchase tickets, please visit [RFO.org](http://RFO.org)

# Valley of the Moon Observatory Association

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