NOVA
NEWSLETTER OF THE VANCOUVER CENTRE RASC
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Merritt Star Quest 2019

by Suzanna Nagy, VP for the Merritt Astronomical Society & RASC-Van Co-Membership Dir.

The annual Merritt Star Quest, hosted by the Merritt Astronomical Society, was held this year from dusk August 24 to dawn September 1, 2019. Attendance for the week was in excess of 100 observers. I reconnected with many regular attendees and became acquainted with quite a few first-timers, all of whom were enthusiastic to be there.

Photo by Doug Montgomery

Unlike September last year that rained six of the eight days/evenings (including one evening when we had a dusting of snow), this year the weather gods cooperated. We only had one day of rain and two evenings of cloudy weather. Of the seven nights that I attended, I was able to observe for five nights. The night sky was not as crisp as in years past when the Milky Way was so bright it cast a shadow, but even so, the nights that were clear offered great seeing.

For my own observing (which is strictly visual), prior to arriving I had gone online to search for some observing lists to challenge myself. My first two nights were spent finding as many Messiers as I could. My next night I did the Star Trek Observing Challenge (names of stars/objects mentioned in the episodes), and then I spent two evenings working through the RASC Explore the Universe list. In between, I spent time in my chair just gazing in awe at the Milky Way.

The days were filled with socializing including daily activities (something new MSQ tried last year and has continued after receiving positive feedback). The day-time activities included a meet and greet with pie, three lectures, a horseshoe tournament, and a short hike around the nearby 4 km Kentucky Lake loop trail. One afternoon there was also a

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SEPTEMBER 12 SFU
Colleen O'Hare from the Okanagan Centre: NOVA Jr., a Fun Way to Share Astronomy. See Meetup for details. Room SWH10041. SFU

OCTOBER 10 SFU
Drs. Linda and Tom Spilker from JPL will speak about Cassini and other projects they have worked on. See Meetup for details. Room TBA. SFU

NOVEMBER 14 SFU
Speaker TBA. See Meetup for updates. Room SWH10041.
SFU

Merritt Star Quest Gallery

Some photos from the 2019 Merritt Star Quest. Some impromptu sports in the form of “full-contact croquet” (above) and non-contact hockey (below). To the right is a shot of the Milky Way, looking towards Sagittarius with Saturn on the left and Juupiter on the right.

Photos by Doug Montgomery and Lynn Fearn.

Here are our Astronomy Day youth prize winners. The name of the young lady clutching the binoculars was lost somewhere along the line, unfortunately, but we do know the telescope was won by Ethan Huang. Congratulations to both our winners!

President's Message

by Leigh Cummings

I hope everyone has had a really great summer. Vacation time is over and our young people are back to school. The sounds of children playing in our neighbourhood has moved to the schoolground a block away. It is punctuated by the a noise we used to call the "bell," (not sure what to call it now) that attempts to regulate their lives. As a retired pensioner, I no longer have to live by the clock, other than for doctor appointments and RASC meetings. Now I live more by Mother Nature's clock, which, I must say, I do not obey as I am very much a nocturnal creature.

September is always a cheerful time for us astronomers because we are starting to get into the time of year when the days are getting shorter and the nights are getting longer. Pretty soon there will be more dark than light. Now, if only Mother Nature could grant us one of those pleasant fall seasons with just enough rain falling during the daytime hours to turn the grass green but leaving the night hours free of clouds for nice clear viewing. Is that too much to ask for? A dream season perhaps?

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About RASC

The RASC Vancouver Centre meets at 7:30 PM on the second Thursday of every month at SFU's Burnaby campus (see map on page 4). Guests are always welcome. In addition, the Centre has an observing site where star parties are regularly scheduled.

Membership is currently $89.00 per year ($52.00 for persons under 21 years of age; family memberships also available) and can be obtained online, at a meeting, or by writing to the Treasurer at the address below. Annual membership includes the invaluable Observer's Handbook, six issues of the RASC Journal, and, of course, access to all of the club events and projects.

For more information regarding the Centre and its activities, please contact our P.R. Director.

NOVA, the newsletter of the Vancouver Centre, RASC, is published on odd-numbered months. Opinions expressed herein are not necessarily those of the Vancouver Centre.

Material on any aspect of astronomy should be e-mailed to the editor or mailed to the address below.

Remember, you are always welcome to attend meetings of Council, held on the first Thursday of every month at 7:30pm in the Trottier Studio in the Chemistry wing of the Shrum Science Centre at SFU. Please contact a council member for directions.

2019 Vancouver Centre Officers

President	Leigh Cummings president@rasc-vancouver.com
Vice-President	Gordon Farrell vp@rasc-vancouver.com
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Past President	Suzanna Nagy
At Large	Howard Trottier, Bill Burnyeat
Honourary President	J. Karl Miller

Library

The centre has a large library of books, magazines and old NOVAs for your enjoyment. Please take advantage of this club service and visit often to check out the new purchases. Suggestions for future library acquisitions are appreciated.

On the Internet

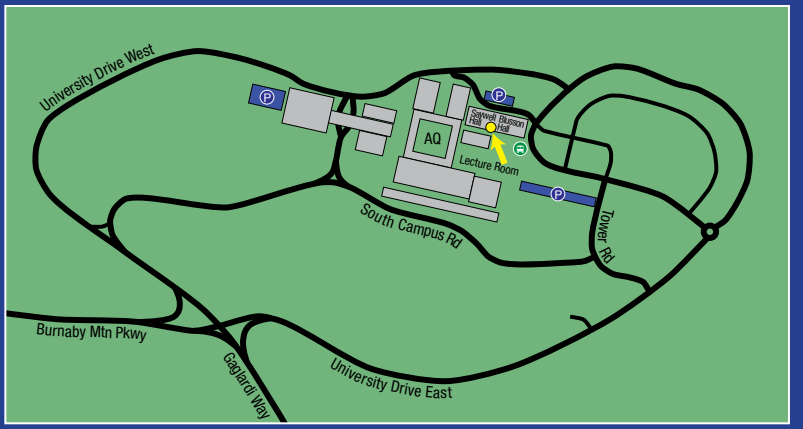
http://rasc-vancouver.com or
http://www.rasc.ca/vancouver
http://astronomy.meetup.com/131/
http://www.facebook.com/RASC.Van

@RASCVancouver

Mailing Address

RASC Vancouver Centre
PO Box 89608
9000 University High Street
Burnaby, B.C.
V5A 4Y0

Map to Meeting Site



Our Sept. and Nov. meetings are in room SWH10041 of Saywell Hall, about halfway down the main corridor as indicated by the arrow on the map.

Pay parking is available at several locations located around campus (indicated as "P" on the map).

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spontaneous hockey game.

Details for MSQ 2020 will soon be uploaded on their website, www.merrittastronomical.com, which includes directions and especially the page for star party rules/etiquette (we had issues this year with lots of late-night arrivals and looky-loos). As a result, the website will also be amended to educate attendees on the star party's very important "no white light" rule.

MSQ 2020 will be held on the week of the new moon, August 15 to the 23rd. Many of you might say, "Wait, that is Mt. Kobau week." MSQ Council discussed this in length and obtained a lot of feedback from this year's attendees. With the next new moon falling mid-September, it was determined that time of year would be just too cold at that elevation with concerns there might be snow. So, while not ideal, MSQ and Kobau 2020 will share the same week.

Hope to see you there. ✸

Photo by Lynn Fearn

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By the time you read this, we will be at our September monthly meeting hearing a very interesting talk by Colleen O'Hare from the Okanagan Centre. She will be talking about how to make learning about astronomy fun for kids. I'm looking forward to hearing of new ideas and methods and I hope our members will be able to share some of their experiences with her as well.

In October, we will once again be visited by Linda and Tom Spilker from the Jet Propulsion Laboratory (JPL) in California. They will be making a tour of our area, where they will give presentations, first at Victoria on October 9th, then our centre on October 10, and finally at the Sunshine Coast Centre on October 11th. It is a real whirlwind tour taking advantage of all three centres' meeting schedules. They plan on spending extra time in Victoria and Vancouver to take in the sights.

Linda is going to be presenting new updates of the highlights of Cassini's 13-year mission as scientists are continuing to sift through the huge amount of data to find even more intriguing discoveries about the ringed planet and its moons. As with most exploratory missions, I am sure new discoveries will lead to new mysteries.

Tom has retired from JPL and is now an independent consultant in the field of mission architect. His work carries him around the world working with universities, government space agencies as well as private space industries. I am really looking forward to hearing what a "mission architect" does and what exciting new projects he is consulting on now.

In October, we will also be helping out Manning Park Resorts with their Dark Sky Weekends. That's right, I did say weekends. Last year's event was such a hit that they have expanded it to two weekends. The first weekend will be for beginners to intermediate observers and the second weekend will be aimed at more advanced observers. Check out their website: https://manningpark.com/manning-park-dark-sky/ to get more information.

I urge you to discover the night sky in true darkness as our ancestors once did. Do not let unfounded fear of the dark deter you from enjoying our wonderful hobby. The longer you spend in true darkness, the sharper your senses become. A large percentage of urban dwellers never get to experience true night vision. Once you have that opportunity, you will realize that your senses are better than you think if you give them a chance.

I want to extend a big thank-you to our council and committee members who volunteer their time to keeping this centre ticking along so well. I also want to extend a warm thank you to all our volunteers who help us put on our many public events throughout the year. They will be the first to tell you how much fun it is to bring their knowledge of astronomy and its related sciences to the public of all ages. Without volunteers, our programs would grind to a trickle.

In closing, please use extra caution when driving at night. Our eyes can be fooled by the sharp contrast of lighting and shadows. ✸

Membership has its Privileges!

Are you tired of looking at the same objects again and again (planets, moon, etc.)? Is your telescope collecting dust because it's hard to locate deep sky objects? Would you like to bring your observing to a stellar level? Robert Conrad, our new observing director, revived the Vancouver RASC observing group and invites you to join by sending him an email at observing@rasc-vancouver.com. Some of the benefits of belonging to this group include:

- Hands on training on how to operate the SFU Trottier observatory
- Weekly observing sessions at the observatory or at dark sky locations
- One-one-one coaching on how to locate thousands of objects in the night sky
- Attend small interactive seminars delivered by Robert on a range of topics including failsafe star-hopping, charting challenging objects and understanding the motions of the cosmos
- Learn to make your telescope dance by locating objects such as asteroids, nova, and supernovae
- Spectroscopy and imaging training from Howard Trottier and an opportunity to collaborate on observatory research projects
- Updates on observable sky events happening during the week like asteroid/comet/deep sky conjunctions
- Access to observing guides and lists that Robert created that took hundreds of hours to create and will help with planning observing sessions
- Knowledge and expertise from other observing group members
- Learn how to quickly and efficiently find and star-hop to deep sky objects using a range of binoculars and telescopes

Upcoming Events

September
14 – Astronomy Night at Mundy Park

October
4 – Family Observing Night at HR Macmillan Space Centre
18-20, 25-27 – Manning Park Dark Sky Festival

December
12 – AGM

RASC Vancouver at Zajac Ranch

by Ken Jackson

RASC Vancouver worked with Zajac Ranch on an observing and learning event in August 2019. Zajac Ranch is a fully-inclusive summer camp where everything is accessible for children with medical conditions and disabilities. The ranch is located in a beautiful rural setting next to Stave Lake in Mission, BC, about an hour's drive east of Vancouver and outside of the worst of Vancouver's skyglow.

Zajac Ranch contacted us through our Facebook page because they had been donated a telescope and felt that their kids would love to observe the night sky with it—but they didn't know how to use the scope and were asking for some help. Suzanna Nagy and Leigh Cummings made an initial trip to the ranch to meet the staff but also found that the base of the telescope, a 8-inch Skywatcher Dobsonian, had water damage. Leigh contacted Markarian Fine Optics, a Vancouver telescope store, about the scope and they generously agreed to repair it at no charge. They also donated a Telrad and three eyepieces.

Leigh Cummings, Ken Jackson, Ron Jerome, and Sumo Kindersley made a subsequent trip out the ranch in early August with the newly repaired Dob for a viewing and learning session. We set up three scopes for the kids, including their repaired scope. Leigh also spent time teaching the Zajac staff how to set up and operate their Dob. About 50 kids met up with us after their evening routine finished around 9:30 pm. We just managed to show everyone the first quarter moon before it disappeared behind a hill. Then we were able to give them a look at Jupiter and its diamond-bright moons and Saturn with its remarkable rings. There were lots of "wows," a few "wtfs," and the kids were very enthusiastic and respectful. Enhancements included a step-ladder for the shorter participants and music based on NASA's "Moon Tunes" playlist on Spotify. Some of the staff were a bit nervous about keeping track of the kids in the dark, especially as it was their first night with this group. The kids had to retire fairly early but some of the staff stayed around later to learn more and see some deep sky objects and double stars. It was a very enjoyable and worthwhile evening and we are looking forward to working with Zajac Ranch in the future. ✸

Meteor Trail Radio Echoes

by Preston Thompson & William F. Wall

The celestial sky has been observed with ordinary light since life slithered out of the primordial ooze. Radio waves represent the first new spectral window on that sky, a window opened by electrical engineer Karl Jansky, who discovered radio emissions from beyond the solar system in the 1930s. The new science of radio astronomy was born. Radio astronomical observations probe the heavens on cosmological scales to solar system scales to disturbances within our own atmosphere. Submillimeter-sized grains from outer space, for example, plunge into our atmosphere as meteors at tremendous speeds, scorching the air around them, leaving trails of ionized gas or plasma in their wake. The free electrons in the plasma reflect the radio waves from man-made radio transmitters, creating radio echoes that are easily detected with modest radio equipment.

That radio detectability was confirmed by radio astronomer James Stanley Hey in 1944, while researching a radar system for detecting V-2 missiles. In the 1950s, the Canadian Defence Research Board made the first serious attempt at using meteor radio reflections to provide useful communications from Toronto to Prince Albert, Saskatchewan, a distance of over 2000 kilometres. By the mid 1960s, the American Natural Resources Conservation Service was routinely using meteor reflections to transmit climate data from remote sites in their SNOTEL program. Today, it's comfortably in the realm of possibility for amateurs.

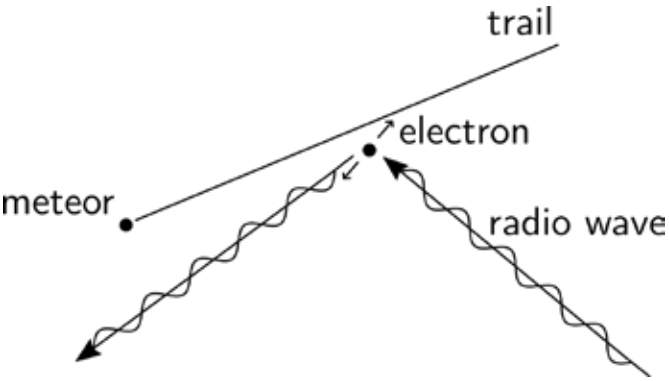

Figure 1: A radio wave can reflect off a free electron by vibrating it. The moving electron acts as a small antenna and reradiates the radio wave in different directions.

Most meteors we see with the naked eye are caused by a meteoroid roughly a millimetre in diameter, although the radio echoes can be due to meteors much smaller than this. The meteoroid enters the atmosphere at speeds of about 20 kilometres per second, superheating the air it contacts. The electrons on the molecules in the air are ripped off, which is to say that the gas becomes ionized, and the meteor leaves a trail of gas with free electrons in it. When a radio wave strikes this ionized gas, the free electrons vibrate back and forth with the changing electric field, and as a result, the radio wave is re-radiated in different directions (see Figure 1).

An important effect is that of the Doppler shift. When the radio wave bounces off the ionized gas trail, its frequency (the rapidity of the electric field oscillations in the wave) is shifted up or down based on how fast the trail is moving towards or away from the transmitter as well as from the observer. In effect, there are two Doppler shifts that determine the frequency of the signal received. Note that the Doppler shift of the radio wave does not indicate how fast the meteor was moving—it's a measure of the wind speed at that altitude.

The detection of meteors requires a strong source of radio waves to illuminate the meteor trails and a receiver capable of recording these events. The RASC Vancouver council graciously agreed to fund our new radio group, led by RASC Vancouver director of telescopes, Ken Arthurs, and primarily advised by radio astronomer Dr. William Wall, who works at the National Institute of Astrophysics, Optics, and Electronics (INAOE) in Tonantzintla, Puebla, Mexico.

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As for myself, Preston Thompson, working as an electronics engineer and with a history of dabbling in both radio and astronomy, I was put in charge of the technical direction of the group and am hands-on with the equipment. Our group is also being advised by Ken Tapping, a retired radio astronomer at the Dominion Radio Astrophysical Observatory, and Marcus D. Leech, director of the Canadian Centre for Experimental Radio Astronomy. Additional thanks go to Mohammad Ali Afsahi, a RASC member and retired electrical engineer volunteering with the radio group.

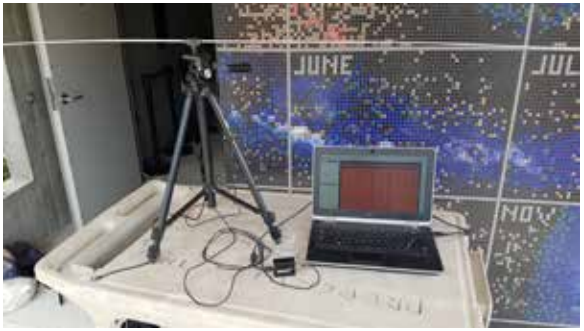

Figure 2: The radio telescope. A dipole antenna is mounted on top of a camera tripod. The legs of the dipole antenna are telescoping rods, which allows for simple tuning of the antenna's length for the frequency of interest. The antenna connects to an SDR unit, which connects to the laptop.

The meteor echo project was chosen first, because it requires only a simple dipole antenna, which is a T-shaped wire (see Figure 2), and inexpensive electronics. With the RASC council's funding, we bought an Airspy R2 Software Defined Radio (SDR). SDRs used to be the domain of high end research and military applications but in recent years have come down to a hobbyist price level, thanks perhaps to Moore's Law. SDRs allow much of the processing that used to be done in purpose-made electronic circuits to be done in a computer, with all of the flexibility that software provides.

A common and powerful way to visualize the radio frequency spectrum is using a waterfall plot. In a live waterfall plot, the screen scrolls vertically as time goes on with signals appearing as coloured lines. The horizontal axis is frequency (Hz) and the colours indicate signal energy. See Figure 3.

But what radio transmitter properties do we need? One useful feature would be a very narrow bandwidth signal—so that much power is dumped into a single frequency. These narrow bandwidth signals are often called pilot signals. This is useful for observing any Doppler shift effects which helps to distinguish different kinds of radio reflections.

It just so happens that we are surrounded by thousands of high power radio transmitters all over North America that feature narrow bandwidth signals in their outputs. These are over-the-air television stations! A very handy website, www.tvfool.com, allows you to enter in your location and get a report of what television stations you can receive from your location, where they're located and what channel they broadcast on.

The first thing I did was to tune the radio to the nearby CBC station, broadcasting on channel 43 at 647 MHz. I had the computer record screenshots of the waterfall with the display zoomed in on the pilot signal. When I reviewed the screenshots the next morning, I saw several radar echoes—the

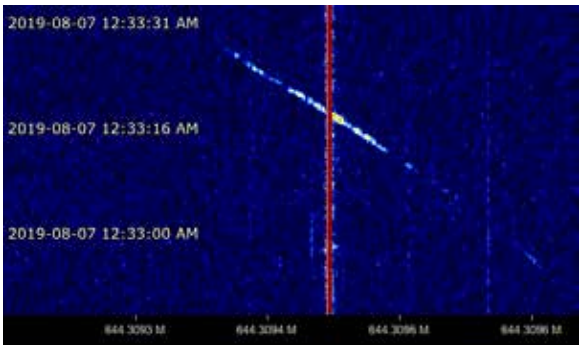

Figure 3: An example of a waterfall plot. The dark red line is a strong signal from a nearby transmitter. The lighter line sweeping from right to left as time goes on is caused by a passing airplane reflecting that signal. The airplane's velocity as it passes by the receiver Doppler shifts the signal, which sweeps it across the screen.

most common of which we identified as echoes from airplanes. However, there were several other radio echoes that we weren't able to identify. Based on experiments that others have performed, none of the echoes matched the signatures of meteors.

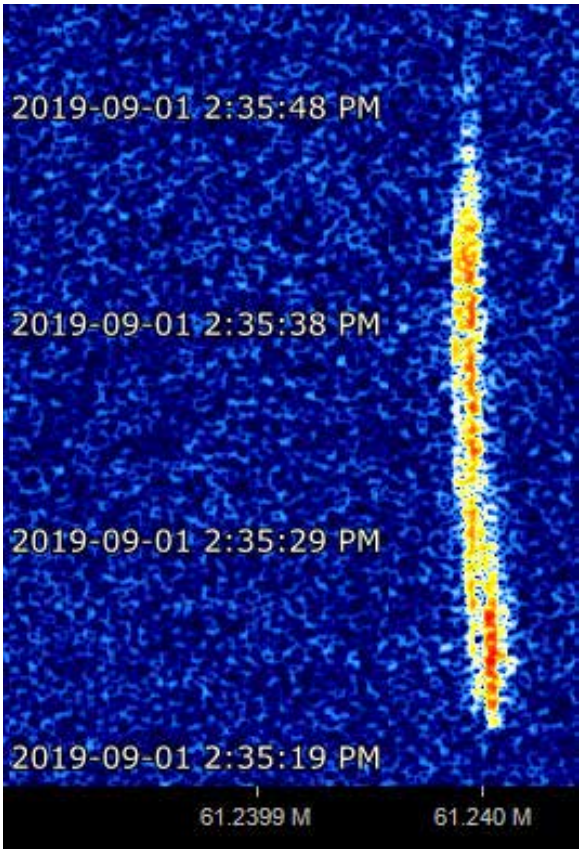

Figure 4: A powerful meteor echo observed during broad daylight on a cloudy day.

Later on, Ken T and Marcus reminded us of the plasma frequency—a frequency threshold that determines whether an ionized gas will reflect a radio wave or not, based on the density of the free electrons in the ionized gas. Their suggestion was to use a frequency below about 140 MHz. So with that in mind, the radio echoes we saw on our initial attempt were likely not meteor echoes.

Now, at this point, it was already the night of the peak of the Perseids meteor shower. Referring to the TV Fool website again, I saw that there was apparently a TV station on Bowen Island transmitting on channel 3 at 63 MHz, far below the 140 MHz threshold that Ken T and Marcus recommended. The website's map showed that the station was blocked from my place in south Vancouver. As a last ditch effort I tuned the radio to channel 3 and saw no signal. I let the system run over night.

The next morning I flipped through the screenshots. Finally, some echoes that looked like meteors! I let the experiment run for 3 days and counted roughly 194 events! Several of the echoes showed interesting structures—perhaps as a result of the meteoroid splitting into multiple pieces during ablation. A particularly strong echo was observed on 1 September of this year with our setup at the Trottier Observatory at SFU in less than an hour of observing. Note that this method allows us to easily observe meteors even in the daylight and even through clouds! See Figure 4.

Being skeptical still, I traveled out to Horseshoe Bay where the TV Fool website indicated that I should have strong signal reception of this Bowen Island TV station. However, to my dismay, there was no signal there either. Further research on the Internet turned up a 2014 document from the CRTC about a decision to move the TV station to channel 39 at 623 MHz. So if the signal I was receiving wasn't from Bowen Island—where was it coming from?

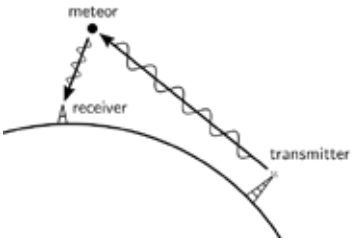

Figure 5: The curvature of the Earth allows for a horizontal TV transmission to illuminate a meteor above the receiver.

A TV station transmitter beams its signal primarily horizontally. Meteors occur around 100 km in altitude. How then, does a TV station's signal hit a meteor 100 km up? The answer lies in the curva-

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ture of the Earth—a TV station far enough away would see the meteor on the horizon (see Figure 5). In his meteor detector project report, Ken T estimates that the radius of detection could be about 500 to 2200 km—about half the United States and Canada. Looking through the FCC's database of TV transmitters shows 7 active TV stations in the US broadcasting on channel 3. The stations that are within a plausible distance are Miles City, Montana, Florence, South Dakota, and Eureka, California. See additional echoes in Figures 6, 7, and 8.

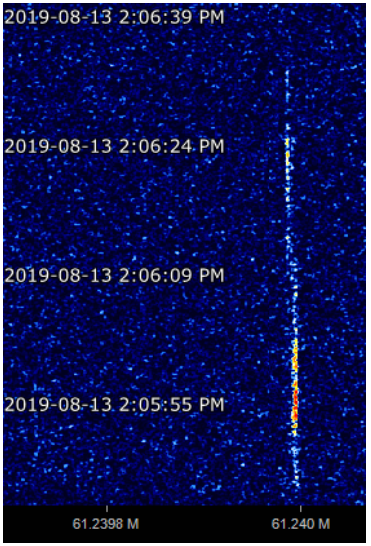


Figure 6: The trail behind the meteoroid has a length to it—the tail end of the trail of ionized gas is where the air is cool enough for electrons to recombine with molecules in the atmosphere. As the trail moves with the meteor, the angles between the transmitter, meteor and receiver all change. This causes the signal to fade in and out.

Now that the rush to get something working for the Perseids shower is over, and there is some time before the Draconids in early October, the meteor detector can be refined. In addition, there are some scientific issues that might be addressed by such observations, including distinguishing between comet and asteroid origins of meteors, linking to specific parent bodies, orbital elements, and more.

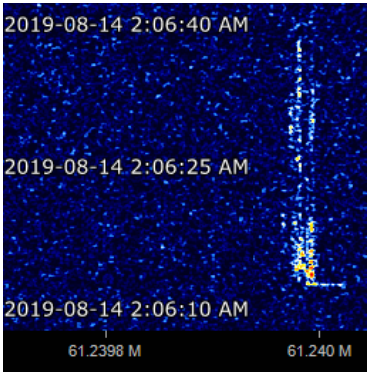


Figure 7: As the meteoroid burns up it may split into pieces. If these pieces start to fall in different directions, they can exhibit different Doppler shifts on the signal. This is potentially seen here in this capture, where three distinct Doppler shifts can be observed simultaneously.

Such investigations are carried out by the University of Western Ontario (see further reading below).

We've started experimenting with more sophisticated software, GNU Radio, and are beginning to look at other radio astronomy experiments to undertake in the meantime. Other projects on the horizon are detecting synchrotron emissions from Jupiter, solar radio observations, and hydrogen 21cm line observations. We are interested in the idea of building a 24 hour meteor detection system that publishes its results to the RASC Vancouver website, in addition to building a portable setup for observing during meteor showers.

There are exciting projects here and we seek the participation and help of other club members. Expertise in radio and science are not necessarily sought, but enthusiasm is. *If you want to be involved, please contact me, Preston Thompson, or Ken Arthurs for more information.* ✸

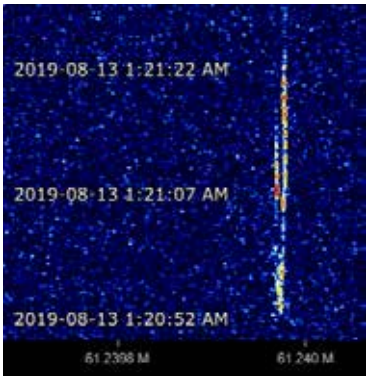


Figure 8: A nice-looking meteor echo.

Futher Reading:
Jansky, K. 1933 *Nature* 132, 66
J. Baggaley 2009, *URSI Radio Science Bulletin*, 329, 6
A. Pellinen-Wannberg 2011, *URSI Radio Science Bulletin*, 339, 32
https://en.wikipedia.org/wiki/Radio_astronomy
http://tvfool.com/
https://en.m.wikipedia.org/wiki/SNOTEL
http://aquarid.physics.uwo.ca/research/radar/cmor_intro.html

50-Year Anniversary of the Moon Landings

by Ted Stroman

Astronaut Neil Armstrong and fellow astronaut Edwin (Buzz) Aldrin became the first humans to land on the Moon on July 20, 1969. Many of us remember that sensational and special time. For a few days the world in a way slowed down, focused and become joined in fascination and joy. It was a remarkable and very special time... "you had to be there" to fully understand what could be described as "a rapture."

That year, counting from December of 1968 to December of 1969, NASA pulled off five successful Apollo missions. Apollo 8 had "saved 1968" (a terrible, tumultuous year, especially in the USA) by orbiting the Moon for the first time and for 20 hours. What followed was the Apollo 9 and Apollo 10 missions to test and verify that the LEM was fully operational for the ultimate mission. Apollo 11 had the first real shot at a landing but it was not guaranteed and it was certainly dangerous. And indeed they pulled it off. To add glory to what had already been accomplished, Apollo 12 got the second landing in... and this was "before the decade was out," the goal that President John F. Kennedy had set in the early 1960s. The Moon landing in 1969 certainly captured the world's imagination and kick-started a new era of discovery.

Today, some 50 years later, only 4 of the 12 Moon walkers are still with us. We still have with us Buzz Aldrin (AP11), David Scott (AP15), Charles Duke (AP16) Harrison Schmitt (AP17). Sadly we have lost all of the men of AP 12 and AP 14.

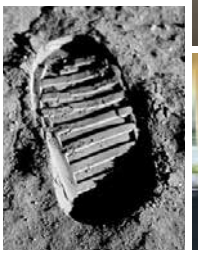
Apollo 11 lifted off from Launch Pad 39A at NASA's Kennedy Space Center on the coast of Florida at 9:32 a.m. ET on July 16, 1969. Four days later, as Collins orbited the Moon in the command module, Armstrong and Aldrin landed Apollo 11's lunar module, *Eagle*, on the Moon's Sea of Tranquility. Armstrong became the first person to step on the surface. Aldrin joined him about 20 minutes later.

NASA plans to return to the Moon and there is some pressure from U.S. Vice-President Mike Pence to move up its launch year to 2024. Some experts are calling the timeline unrealistic. What we have seen over the last 40 years or so is the robotic missions and many remote sensing missions too numerous to mention here. A great deal has been learned from these missions, combined with some of the lunar rocks from the Apollo missions and now the lunar rocks found in Antarctica and in a number of deserts here on Earth. Lately, China, Israel and India have made attempts to soft land and the challenge is still there—getting safely to the surface of the Moon is not easy.

Canada is making an effort, too, and is participating in the Lunar Gateway, a platform from which humans can travel to the Moon, an asteroid or Mars. As well, we have a Canadian researcher involved in efforts to create artificial gravity allowing future astronauts to spend more time and go further in space. Numerous Canadian astronauts and scientists found particular inspiration in the landing's legacy. Sudbury, Ontario is another lesser-known way that Canada played a role in the lunar landings as well. Here, the Apollo astronauts had training in geology in the late 1960s and into the early 1970s.

I took the time this August to go to Seattle's Museum of Flight to take in the "Destination Moon" exhibit before it moved on to Cincinnati, Ohio in September, 2019. It was well worth the time and effort. Indeed the exhibits were impressive and awe-inspiring. Shown was everything from the small piece of wood from the Wright Brothers' airplane, the *Wright Flyer*, flown at Kitty Hawk in 1903 and carried to the surface of the Moon in the lunar module, *Eagle*, all the way to the massive 19-foot-tall F-1 that lifted the Saturn Vs off the Earth. Along with the Apollo 11 Command module, there was was a lunar rock sample from Apollo 12 and Buzz Aldrin's helmet and gloves. ✸

Apollo 11 Anniversary Gallery



Terrestrial photos by Hayey Miller; others by NASA