NOVA

NEWSLETTER OF THE VANCOUVER CENTRE RASC
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General Assembly Vancouver 2020 Update

by Hayley Miller

It's hard to believe we are three months away from hosting this year's GA! The GA Organizing Committee has worked hard to ensure this GA is green, inclusive, and First Nations and youth focussed. The GA is a good time to meet new members, reconnect with old ones, and support the space and astronomy community here in BC and across Canada.

We have a diverse line up of speakers such as Bob McDonald and Jess McIvor, public events such as our Youth Outreach/Novice Astronomers of All Ages Day and workshops such as Beginner's Astro Imaging.

We are now recruiting volunteers and reaching out to Girl Guides, high school students and university students. Volunteers are needed to help register and greet guests, sell merchandise, and stand by to float wherever they are needed.

We are pleased to announce that free excursions on Monday, June 8th have been added to the GA. We are offering a guided bird watching tour in North Vancouver in the morning followed by a tour at Triumf at UBC in early afternoon and a late afternoon behind-the-scenes tour at Science World (which will include a IMAX film of the Apollo 11 mission).

RASC GA 2020 VANCOUVER

Coquitlam Executive Inn Hotel rooms are booking up and ticket sales in general have been good!

GA T-shirts will be available for purchase on Eventbrite in the next few weeks.

More details of the GA can be found on our website: ga2020.rasc-vancouver.com ✸

MARCH 12 — SFU	APRIL 9 — SFU	MAY 14 — SFU
Alan McConnachie of the Dominion Astrophysical Observatory: Into the future with the CFHT!. Room SWH10041.	Speaker TBA. Watch Meetup for details. Room SWH10041.	Vancouver Centre member Bill Burnyeat will speak. See Meetup for details. Room SWH10041.

International Women's Day Girl Guide Event

by Hayley Miller

For the first time in its history, The RASC Vancouver Centre participated in International Woman's Day.

Six female volunteers—Suzanna Nagy, Hayley Miller, Jennifer Kirkey, Marina Miller, Meredith Miller, and Janelle Berry—joined Girl Guides BC of all ages and their adult Guiders in a hands-on career adventure at the downtown campus of Vancouver Community College.

Participants explored cool careers, met female role models, participated in interesting activities, connected with new friends, and more...

We set up The Jim Bernath Meteorite Collection and talked about everything from old meteorites that wiped out dinosaurs to current space news like the new tiny moon that has been orbiting the Earth for the last three years.

We also took this opportunity to talk about volunteering at our upcoming G.A. for our Youth Outreach/Novice Astronomer of all Ages Day on Sunday, June 7 and managed to sign up a few space enthusiasts.

Overall it was a fun day for everyone that came out. ✸

Photos by Haley Miller

President's Message

by Gordon Farrell

Well, we are now just three months away from hosting the 2020 RASC General Assembly and preparations are getting into high gear. Our GA committee, led by Haley Miller, has been working hard to get the speakers, venues, accommodations, sponsors, and merchandise in place for June 5th. We have a terrific lineup of speakers, including planetary scientist and astrophysicist Sara Seager and science journalist and broadcaster Bob McDonald. For a full list of speakers, see https://ga2020.rasc-vancouver.com/speakers/

This will also be a green GA, with incentives ranging from encouraging people to bring their own mugs to wooden name tags for attendees. Most events will take place at the Executive Plaza Hotel Metro Vancouver in Coquitlam (at the corner of Lougheed Highway and North Road) with the exception of the Helen Sawyer Hogg lecture, which will be at SFU. A big "thank you" to the entire GA commit-

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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.

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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

rasc-vancouver.com
astronomy.meetup.com/131/
www.facebook.com/RASC.Van
www.instagram.com/rascvancouver/
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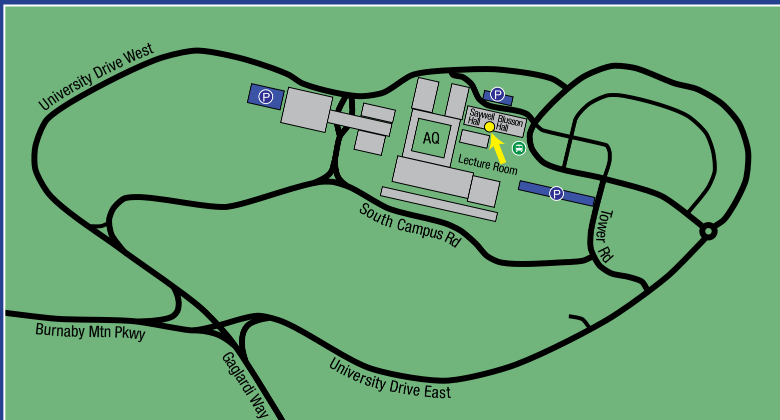
Map to Meeting Site



Our Jan-Apr 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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tee for all of their hard work in pulling this all together in such a short amount of time.

Registration is open now so please visit https://ga2020.rasc-vancouver.com/ and sign up. We look forward to seeing everyone there!

The GA will also include participation from local First Nations, acknowledging that the GA will take place on their ancestral, traditional and unceded territory, in particular the Tsleil-Waututh, Kwikwetlem, Squamish and Musqueam nations. A project that our webmaster, Ken Jackson has been pursuing related to First Nations is a version of our RASC planisphere that depicts their traditional picture of the night sky. There are already Ojibwe, D(L)akota, and Cree planispheres available but nothing for our local First Nations on the BC coast. Efforts to fill the gap have stalled, so if there are any First Nations members of RASC-Vancouver Centre that would be willing to help out (or know someone who could help) please reach out to ga2020+firstnations@rasc-vancouver.com so we can share those stories with the public and help preserve them for future generations. ✸

A test of how the wooden GA nametags might look

Our pre-lecture dinner with last month's Paul Sykes speaker, Mary Beth Laychak (centre, in green)

Photos by Jennifer Kirkey and Ian McLennan

Can We See the Whole Universe

by Andrew Krysa

Most astronomers, cosmologists and physicists are pretty much in agreement today that the age of the universe is 13.8 billion years, give or take a few tens of millions of years. We see today that all the galaxies and clusters and superclusters of galaxies are all receding from us. In fact, the further away the galaxy is the faster it is receding from us. The whole universe—including space itself—is expanding. This picture we take for granted today has not always been how astronomers have viewed our cosmos. A little over a hundred years ago, most scientists and astronomers still believed that the universe was static and had existed for all eternity. A visit to Markarian Fine Optics, a telescope store in Burnaby, reveals a fascinating insight into this history. The owner of the store has an astronomy book published in 1895—on display for customers to look at but not for sale—which for its time contained the latest up-to-date information on our cosmos. Browsing through the book reveals insights into the view of our universe at that time. Pluto had yet to be discovered, Einstein's papers on special and general relativity hadn't been published yet so people didn't even know the force that made the sun and stars shine and people believed that our galaxy, the Milky Way, was all that there was and that the whole universe was essentially our galaxy. A section of the book talks about "nebulae" or clouds of dust supposedly residing in our own galaxy and mentions the Andromeda "nebula," then believed to be one of these local dust clouds. We now know this "nebula" as the Andromeda Galaxy, a galaxy in its own right, a spiral galaxy much like our own Milky Way but slightly larger and 2.3 million light years away. We also now know of hundreds of millions of other galaxies beyond our Milky Way laid out through the universe in large filaments or tendrils of clusters and superclusters, each containing millions of these galaxies. We know that our own Milky Way is a galaxy residing in our Local Group with the Andromeda Galaxy and many smaller satellite galaxies, which itself is part of the Virgo supercluster of galaxies. This 55 million light year radius Virgo supercluster (which is actually a lobe of a much larger supercluster called Laniaka), containing a hundred or so galaxy groups and clusters, lies within one of the

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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

May
9 – Astronomy Day at SFU

June
5 - 7 – RASC General Assembly in Vancouver

August
15 – Perseid Meteor Shower Watch at Aldergrove Regional Park
15 - 23 – Merritt Star Quest
15 - 23 – Mt. Kobau Star Party

October
16 - 18 – Manning Park Dark Sky Festival

December
10 – AGM

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universe's enormous filaments called the Pisces-Cetus Supercluster complex, about a billion light years long and a hundred and fifty million light years wide. So how did we come to know in a little over a century that our humble view of the universe was wrong and what happened to change this view? And how can we be sure this modern view of our universe is fully correct? Is our concept of the size of the universe still too small? The universe has been expanding for 13.8 billion years and because nothing can travel faster than the speed of light the most distant things we can see in the galaxy (and therefore the oldest, too) are more than 13 billion years old. But is the universe all that we can actually see or has a part of it expanded beyond our ability to see it, forever invisible to us because of the limiting factor of the speed of light?

One seemingly unlikely pioneer began changing our view of the universe in the early 20th century. As early as 1881, the Harvard Observatory in Massachusetts was hiring women as "computers" to help study and catalogue the growing number of glass plate photographs the observatory was producing. Women were not allowed in the actual observatory at the time and they were paid much less than men so it was more economical to have a large team of women. The women had the mundane job of measuring the brightness, position and colour of stars and classifying the stars by comparing the glass plate photographs to known catalogues. Even though they were under-appreciated, a number of these women later became famous for discoveries as astronomers in their own right. One of these (at the time) unappreciated "computers" was named Henrietta Swan Leavitt, a graduate of Radcliffe College who was hired by Harvard College Observatory in 1908. She discovered something remarkable in 1912. From studying the photographic plates, she discovered something special about a type of star called a Cepheid variable. Cepheid variable stars, which can be the size and brightness of our sun or slightly more massive, hotter and brighter, pulsate regularly and vary in diameter and brightness with a well-defined stable period. Leavitt studied 25 of these Cepheid variable stars in the Small Magellanic Cloud (a nearby satellite dwarf galaxy of the Milky Way but then believed to be a dust cloud within the Milky Way). She correctly assumed that these stars were all about the same distance away from us and so could be compared with one another in brightness. She measured the time between the stars' ups and downs in brightness and then determined that the brighter the Cepheid got at its brightest point, the longer its period between its ups and downs were. This was remarkable because if one knew the period of the brightening and dimming of the Cepheid variables then one could infer their intrinsic brightness. Leavitt's data states that a given length of period has a unique brightness associated with it—a Cepheid with a specific period would be exactly the same brightness as any other Cepheid in the universe with that same period. Cepheid variables are abundant in our universe and if you find one you can determine the distance to it because brightness drops off by the square of the distance (a light from two metres away looks one quarter as bright as a light one metre away; a star four light years away would seem only 6.25% as bright as the same star one light year away). Leavitt had discovered a standard light house distance marker for our universe. Henrietta Leavitt became almost completely deaf after a severe illness but became head of the photographic photometry department at the Harvard College Observatory. She was considered in 1926 for a Nobel Prize, the committee not realizing she had died in 1921. The work that Henrietta Leavitt did helped pave the way for more groundbreaking research by other similarly brilliant people.

A few years after Henrietta Leavitt used her 299 photographic plates to construct her brightness/period scale for Cepheid variables, Dr. Harlow Shapely began using the 60-inch telescope at the Mount Wilson observatory in California to search for Cepheids in globular clusters in our own Milky Way. Globular clusters are spherical, densely-packed conglomerations of tens or hundreds of thousands of stars which are always magnificent to look at through even the smallest of telescopes. These globular clusters are thought to be some of the most ancient structures containing some of the oldest stars in the universe. Some clusters can be up to thirteen billion years old or nearly the age of the universe. Shapely discovered a large number of Cepheids in these globular clusters. He used Henrietta's law to determine the distances to all the globular clusters he saw. In 1918, Shapely discovered that they were between 50,000 to 220,000 light years away. By mapping out a three-dimensional distribution of the locations and distances of the globular clusters, Shapely correctly realized that they were arranged in a spherical halo orbiting around the centre of the galaxy. Then by placing and locating where our position inside this giant halo was, he guessed fairly accurately that our sun was 50,000 light years from the galactic centre (we are about 30,000 light years from the centre). Shapely was also able to correctly determine the galactic centre of our galaxy to be located looking towards the constellation of Sagittarius. He incorrectly estimated the size of the Milky Way however to be about 300,000 light years across (the disc of the milky Way is about 100,000 light years across) so he believed that these globular clusters were actually still inside the Milky Way galaxy. In 1920, Shapely and Herbert D. Curtis participated in a great debate in Washington D.C. over how big the universe was. Shapely still believed that the Milky Way was all there was to the universe, even though the 300,000 light year diameter he estimated was shockingly large for most people to imagine at the time. Curtis' opinion was that the universe was made up of many galaxies as big as our own and that the spiral shaped nebulae astronomers saw in their telescopes were actually other galaxies and that they, as well as globular clusters, lie outside our galaxy as "Island Universes." Dr. Harlow Shapely became the director of the Harvard College Observatory in 1921 after the passing of the former director, Edward Charles Pickering, who had hired Henrietta Leavitt as a computer years earlier.

The famous astronomer Edwin Hubble himself had said that Henrietta Leavitt should have won the Nobel Prize; however, Hubble being somewhat of an opportunist and never having been nominated himself, may have wanted to share in the spotlight. Hubble has become a household name while only a few astronomy-savvy individuals know of Leavitt. Hubble was able to use his own measurements of Cepheid variable stars and Leavitt's period-luminosity law to determine that Cepheid variables in the then-named "Andromeda Nebula" and other similar nebulae were far too distant to be located in our Milky Way galaxy. In 1919, Hubble was hired to work at the Mount Wilson Observatory with its new 100-inch reflecting telescope, completed in 1917

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(then the largest in the world) in California. One night in 1923, he was comparing several photographs of Andromeda over several nights and discovered a Cepheid variable. Over several months, Hubble determined that the Cepheid varied in brightness with a period of 31.45 days, meaning it was 7000 times brighter than the sun using Leavitt's law. Comparing the Cepheid's apparent brightness (how bright it actually looks from Earth) with its actual brightness, he determined it was 900,000 light years away. Since the Milky Way had already been measured by Dr. Harlow Shapely to be 300,000 light years across (incorrect but still a very good estimate for the time) this was well out of our galaxy. Later it was found that there were two types of Cepheid variable stars, the kind that Henrietta had discovered and a Type II brighter Cepheid variable. Hubble thought he was looking at a classic Cepheid but because he was looking at a Type II Cepheid, which is more than twice as bright, it was found that Andromeda was over 2,000,0000 light years away. The Andromeda Nebula, long thought to be a cloud of dust or similar material inside our galaxy, was discovered to actually be our neighbour spiral Andromeda Galaxy, much like our own Milky Way spiral galaxy. The Large and Small Magellanic Clouds, which look like two spectacular white blotches in the night sky from the southern hemisphere, were found to be two irregularly-shaped mini galaxies, about a tenth the size of our Milky Way, gravitationally interacting with the Milky Way and both about a tenth the distance the Andromeda galaxy is away from us. Hubble measured the distance to several other Cepheid variable stars in other nebulae and discovered that these nebulae were actually other small satellite galaxies of either the Andromeda Galaxy or our Milky Way (in fact Messier 32 or M32, a satellite galaxy of the Andromeda Galaxy, can clearly be seen beside Andromeda in the same amateur telescope eyepiece view) and the two collections of miniature galaxies around Andromeda and our Milky Way form the two lobes of our Local Group of galaxies.

Hubble went on to do much more than just measure the distances to our nearest galactic neighbours. He actually made one of the most astounding discoveries of all about our universe. He discovered that most of the galaxies we can see are moving away from each other and the further away they are from each other, the faster they are moving. The furthest galaxies we can see from us today, that are actually from when galaxies first started forming about a billion years after the Big Bang, are receding from us at speeds approaching that of light. How do we know all of this? For many years before Hubble, scientists had been looking at the spectrum of radiation coming from other stars. Electromagnetic radiation includes the visible light that we can see and the light not visible to our eye—infrared, ultraviolet, gamma rays, x-rays, radio waves and microwaves—but these are all the exact same phenomena vibrating at different wavelengths. All these different wavelengths in the whole electromagnetic spectrum are really just different energies of light. We can see just a tiny portion of the range of different frequencies that surround us, called visible light, and the rest we are blind to. Isaac Newton was the first to use a clear prism to split a ray of this visible light coming from the sun into its component rainbow of colours called the visible spectrum. More than a century later, scientists noticed that the visible spectrum had characteristic vertical black bands along it at very precise places. These absorption lines, as they were called, will appear if an element is placed between a light source and the observer. These elements could be in the outer layers of a star or in a dust cloud between a star and us. Each particular element has its own characteristic absorption lines along a continuous spectrum so we always know that hydrogen has its own signature absorption line on a light spectrum as does oxygen, carbon, sulphur and so on. We know that the universe is all made of the same "stuff" or the same elements because when we see the light from stars split into a spectrum we can see these absorption lines and they are exactly the same as elements on the Earth. Helium was actually discovered by looking at the absorption lines in the spectrum of the sun. Scientists could see a pattern of absorption lines they had not encountered before and reasoned it was a new element and called it helium before helium was finally discovered physically on Earth.

These absorption lines in the spectra of visible light would show us the truth about galaxy motion. In 1912, scientist Vesto Slipher began observing the spectra of light coming from various far away spiral nebulae (which we now know to be separate galaxies outside the Milky Way) and found that the spectra had the same absorption lines as nearby stars so they must be made of the same elements we are all familiar with. However he also discovered that all the absorption lines were shifted all together along the spectrum by a certain amount in wavelength. This phenomenon was by this time understood as the Doppler Effect. Light waves we detect from an object if it is moving away from us will be stretched and they will be compressed if the light source is moving towards us. The same thing happens with sound waves. When an ambulance is moving towards you, the sound waves are compressed and at a higher frequency so the pitch of the siren is higher. As the ambulance passes by and moves away behind you, the siren's pitch sounds lower as the waves coming to your ears are now stretched and are a lower wavelength. Similarly with light, as an object moves away from us it appears more shifted to a lower frequency and so appears more towards the red end of the visible spectrum. As an object approaches us, the emitted light is compressed and so becomes a higher frequency and appears more shifted to the blue end of the visible spectrum. We say red-shifted objects are moving away from us and blue-shifted objects are moving towards us. The more an object has its spectral lines shifted towards the red end of the visible spectrum the faster it is moving away and the more the absorption lines are shifted to the blue end of its visible spectrum the faster the object is moving towards us. Slipher observed that the absorption lines in the light spectra emitted from most of the spiral nebulae were almost all red shifted. The nebulae were emitting light of longer and longer wavelengths as if they were moving away from us.

Hubble was able to take the distance measurements he made using Cepheids (and by then type 1a supernovae, a new astronomical distance calculator) to the spiral nebulae in 1929 which were by then known to be separate galaxies thanks to his distance measurements, and compare them with Slipher's measurements of the speeds at which these galaxies were moving away. With the help of a Mount Wilson staff member, he plotted this information on a graph and was able to show an incredible linear relationship between a galaxy's distance from us and the speed it is receding from us which is now called Hubble's Law. This law shows that the further a galaxy is away from us the faster it is moving away from us. The universe is expanding. The great revelation which Hubble finally revealed to us was that the universe was not eternally unchanging and ended the static universe theory for good.

Now comes a big key to our puzzle of just how big the observable universe is and whether the observable universe—all that we can see with our most powerful telescopes—is all that there is. The most redshifted light we can detect in the observable universe suggests that light has reached us from galaxies that are over 13 billion years old. The first light was emitted when the density and temperature of the early universe became low enough. Electrons and protons from the hydrogen plasma of the early hot universe could now bind themselves together

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to form atoms so that photons could travel freely. The newly formed atoms did not scatter radiation like the plasma did so for the first time the universe turned from opaque to transparent. This bursting forth of light is forever imprinted in the famous Cosmic Microwave Background Radiation and happened about 380,000 years after the Big Bang, or almost 13.8 billion years ago. Because this is the oldest light we have detected, that also gives us a measurement for the age of the Universe itself.

But over the last 13.8 billion years, the universe has been continually expanding—and at first it did so very rapidly. This is where things become very counterintuitive and "weird." It is now believed that the universe and its initial extremely dense state that led to the Big Bang expansion could have popped out of empty space. This happens in quantum physics all the time. Particles and their antiparticles pop in and out of the empty vacuum all the time for such incredibly short periods of time (trillionths of a second) that we can hardly detect them. Empty space is not really empty space at the quantum level which is at a level several orders smaller than the size of an atom. The current understanding of what is called the vacuum state or the quantum vacuum actually contains fleeting electromagnetic waves and a seething "froth" of unimaginably short-lived particle formation and destruction. This vacuum state is associated with a zero-point energy which actually has measurable effects. The false vacuum energy would behave something like Einstein's famous cosmological constant. Einstein considered this his biggest blunder after creating and inserting it into his equations as a counter-effect to gravity that would keep the universe static—however it now seems that dark energy behaves exactly how Einstein predicted the cosmological constant should behave so he may have been right after all. The false vacuum energy would act like an energy permeating all of space, causing the expansion of the universe right after the Big Bang to speed up faster and faster. In turn, what would become our observable universe would start expanding faster than the speed of light. Einstein stated in general relativity that nothing can travel faster than the speed of light and this is true of objects travelling through space. But general relativity says nothing about space itself being able to expand faster than the speed of light. And as space itself expands faster than light speed it takes the objects that are at rest within it apart from one another at faster than light speeds. And it seems the universe could have expanded during this brief inflationary period by a factor of 1028. This is an incredible amount but it could have taken just a fraction of a second (an incredibly short 10-36 seconds). So parts of the universe that relative to us could have expanded faster than the speed of light have not had enough time for their light to reach us so we can't see them. This is the part of the universe that would be unobservable to us.

But what about the observable universe, the part we can see? How far can we see? You might think that in a universe limited by the speed of light that would be 13.8 billion light years multiplied by the speed of light. However we can see so much further than that for two unintuitive reasons. First, the objects that are just at the edge of sight of each other, like us and a galaxy 13 billion light years away, are receding relative to each other at almost the speed of light (we know that thanks to Hubble's Law). They are now double the distance from each other that you would expect—each is moving at nearly the speed of light so the distance between the two objects would be 13 billion light years times two. Secondly, space itself is also expanding. So the "fabric of space" itself between the two objects is actually stretching at nearly the speed of light, stretching the light along with it. Part of the redshift we see in the light from distant objects is due to

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My First LPA (Light Pollution Abatement) Report by Leigh Cummings

I greet you, fellow members, from my new chair. Even though I'm retired, it seems I've been burning the midnight oil of late just trying to bring myself up to speed on our local issues.

Only a hermit living alone in a cave for the past several years could claim to be unaware of the impacts that various forms of pollution are having on our planet. Global warming caused by CO_2 and methane emissions are constantly in the news, as is our struggle to control plastics entering our environments. Every once in awhile, we see a story about light pollution. This usually happens when someone complains about light trespass affecting their life. Sometimes this increases the dialogue about lighting by-laws and sometimes it even results in some changes. There has also been documentaries about the loss of our night sky and the impact this has on astronomy and our cultural well-being. But what about the impact artificial light has on our ecology as a whole?

Various biologists have studied the impact of artificial light on individual species and reported the impacts on that species. It is only relatively recently that ecologists have undertaken studies on how artificial light is affecting entire ecosystems. Experiments have been underway using different forms of lighting in an otherwise dark environment to see what spectrums and intensities affect the balance of the natural processes. We have seen on the news the effect that brightly lit cities have on migratory birds, but how often do we see news stories about the effect lights have on the insect population that the birds and other predators depend on for food? New studies in the UK have indicated that insect populations are in steep decline. This has always been attributed to the use of pesticides and, while this is certainly true, light pollution is also a major contributor to the decline.

Another area coming under increasing scrutiny is the effect light pollution has on waterways and shoreline ecologies. There have been studies done in South Africa, Wales, and California, as well as some coastal communities in B.C., to try to determine the impact shoreline lighting has on the life in these bodies of water. These studies are beginning to show that light shining into the water (especially blue light that penetrates the deepest) changes the behaviour of both the animal life as well as the plant life at night. When the shoreline is lit 24 hours a day, the type of plant life that will grow, as well as the location of shellfish that attach themselves to rocks or pilings, changes dramatically. Also the fish prey/predator balance shifts due to the change in the nocturnal movement of plankton. These studies indicate that we have to start thinking about how we can mitigate the impact our shoreline developments have on the marine environment.

One opportunity will be to start with our parks: city, provincial and national. We must make them a nocturnal oasis for nature to be "natural" both at night as well as during the day. I will be reaching out to the park administrations in all our levels of government in hopes of helping them and the park operators choose lighting that meets standards more in alignment with a healthy nocturnal ecosystem, as well as meeting the safety concerns for the people visiting the park. We are lucky that most of the provincial and national parks are relatively wild and should be easy to conform if we bring nocturnal ecology into the future planning of these parks.

Unlike some of the other forms of pollution that will take a large shift in our economy to effectively make meaningful changes, light pollution should be easier. Light that is not doing what it is supposed to do, or shining where it is not needed, is a waste. It makes economic sense to not waste. As individuals, we can make better choices for our outdoor home lighting. We can also do the simplest of things by flicking a switch when light is not needed. Following these simple steps can have a trickle-up effect on our governments. After all, we usually end up with governments that reflect the society they govern.

Let us leave our sky darker than we found it. ✸

Are the Weather Gods Mad at Us?

by J. Karl Miller

It's been raining here for all of January—one day of no rain. February was not much better. From my astronomical point of view, it was the pits. I haven't taken part in one of SFU's Starry Night events since well before Christmas; Since October, most of the time the event had to be cancelled, mostly because of bad weather.

The Moon, Mars and Venus together four years ago

Every now and then there was a break in the clouds, allowing for a short glimpse of the evening and night sky. In late January, the Moon and Venus appeared very close to each other. The picture above shows a similar situation exactly 4 years ago on February 1st. At that time, Mars was also near the Moon, but not this time. I looked at the recent event a couple of months ago, through some holes in the clouds, but before I could get my camera ready, the Moon and Venus were covered up again. Let me emphasize that the apparent closeness of these two planets to the Moon is strictly a perspective effect, caused by the particular position of our Earth in its orbit around the Sun. The actual distances are in the millions of kilometres.

The Tarantula Nebula

Another way to do some "armchair" astronomy is to take some pictures of the sky, preferably as seen from other latitudes. To this end I use one of the remote-controlled telescopes at slooh.com, with locations on the Canary Islands and Chile. Here's a black-and-white image of the Tarantula Nebula.

I quote an excerpt from Wikipedia:

"The Tarantula Nebula has an apparent magnitude of 8. Considering its distance of about 49 kiloparsecs (160,000 light-years), this is an extremely luminous non-stellar object. Its luminosity is so great that if it were as close to Earth as the Orion Nebula, the Tarantula Nebula would cast visible shadows. In fact it is the most active star-

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burst region known in the Local Group of galaxies. It is also one of the largest H II regions in the Local Group with an estimated diameter around 200 to 570 parsecs, and also because of its very large size, it is sometimes described as the largest although other H II regions such as NGC 604 which is in the Triangulum Galaxy could be larger."

One parsec is the distance at which the radius of the Earth's orbit around the Sun is seen at an angle of one arc second—that distance is 3.26 light years. That means that even from the nearest star (4 light years away) the Earth's orbital radius has an angle of less than one arc second.

Let the weather gods do their thing. If you have a roof over your head, and a safe place to live, you can evade them anyway. ✸

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the object receding from us but also is due to the stretching of space in between the two objects. This would just about double again the distance two observable objects are from each other. Taking all this into account, astronomers have worked out that the galaxies right on the edge of the observable universe, whose light has taken 13.8 billion years to reach us, must now be 46.5 billion light years away. It is possible that, somewhere, a few of our calculations are not quite right but for now that is our best measurement for the radius of the observable universe. Doubling it, of course, gives us a diameter of 93 billion light years.

Where things get really complex is when we try to think about the universe beyond that which is observable, or the "whole" Universe. Depending on which theory of the shape of the universe you prefer, the whole universe could actually be finite or infinite. Recently, data analyzed at the University of Oxford by computer algorithms about objects in the observable universe looking for meaningful patterns came up with a new estimate of the "whole" universe being at least 250 times larger than the observable universe.

The truth though is that we are not completely sure if the universe has a finite size or whether it is infinite. We can see galaxies extending out from us in all directions with no evidence of diminishing. With the sophisticated, powerful telescopes we have today we can see about as far as nature allows us to see because of the limiting constraint of the speed of light. We cannot see past this point because stars and galaxies have not always existed and have been evolving over time and the universe has been expanding with time so light from other parts of the unobservable universe has simply not had time to reach us yet. If the universe and space everywhere continues to expand faster and faster as it has been doing the last few billion years then the light beyond our current observable universe may never reach us.

In just over a hundred years, our picture of our universe has evolved from a quaint belief that our Milky Way galaxy with a few hundred billion stars was all that existed. In that century, many astronomers, physicists and cosmologists contributed to expanding our view of the universe. We now estimate the size of the universe we can detect to be a staggering 93 billion light years in diameter with trillions upon trillions of galaxies. Many discoveries and advances have been made and other theories remain controversial and disputed about what the entire actual size of the universe might be. One thing cosmologists seem to agree on today is if somehow you could stop and freeze the "whole" universe, that which we can see and that beyond which we can not see, and somehow could step back and miraculously "see" or perceive all of creation you would see far more than people a hundred years ago would have ever imagined. You would detect galaxies and galaxy clusters and superclusters and filaments of superclusters containing trillions of galaxies extending far out beyond from what we can see today. But how far, no one knows. ✸

International Women's Day

Photos by Marina Miller

Members' Gallery

Occultation of Mars

by Andrew Krysa

I took this image of the Moon with Mars about 20 minutes after it poked out from behind the dark side the morning of the occultation before sunrise on Feb. 18th. The picture was taken at Sunset Beach, downtown Vancouver.

Moon and Venus

by Howard Trottier

The Moon and Venus above the dome of the Trottier Observatory at SFU's Burnaby campus on the evening of Jan. 28th.

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