

The Reflector

Newsletter of the Peterborough Astronomical Association

Old Tool, New Use: GPS and the Terrestrial Reference Frame

ALEX H. KASPRAK

FLYING OVER 1300 kilometres above Earth, the Jason 2 satellite knows its distance from the ocean down to a matter of centimetres, allowing for the creation of detailed maps of the ocean's surface. This information is invaluable to oceanographers and climate scientists. By understanding the ocean's complex topography—its barely perceptible hills and troughs—these scientists can monitor the pace of sea level rise, unravel the intricacies of ocean currents, and project the effects of future climate change.

But these measurements would be useless if there were not some frame of reference to put them in context. A terrestrial reference frame, ratified by an international group of scientists, serves that purpose. "It's a lot like air," says JPL scientist Jan Weiss. "It's all around us and is vitally important, but people don't really think about it." Creating such a frame of reference is more of a challenge than you might think, though. No point on the surface of Earth is truly fixed.

To create a terrestrial reference frame, you need to know the distance between as many points as possible. Two methods help achieve that goal. Very-long baseline interferometry uses multiple



Artist's interpretation of the Jason 2 satellite. To do its job properly, satellites like Jason 2 require as accurate a terrestrial reference frame as possible. Image courtesy: NASA/JPL-Caltech.

radio antennas to monitor the signal from something very far away in space, like a quasar. The distance between the antennas can be calculated based on tiny changes in the time it takes the signal to reach them. Satellite laser ranging, the second method, bounces lasers off of satellites and measures the two-way travel time to calculate distance between ground stations.

Weiss and his colleagues would like to add a third method into the mix—GPS. At the moment, GPS

measurements are used only to tie together the points created by very long baseline interferometry and satellite laser ranging together, not to directly calculate a terrestrial reference frame.

"There hasn't been a whole lot of serious effort to include GPS directly," says Weiss. His goal is to show that GPS can be used to create a terrestrial reference frame on its own. "The thing about GPS that's different from very-long

see "GPS" on page 16

President's Message

Spring???

There's a rumour floating around that spring has arrived. If this is spring then one needs to question the whole global warming trend. I, like most of you, would like to get out there with my telescope and study the wonders of the night sky. I feel the cold weather is not good for the equipment and that's my excuse for not being out there. I'm anxious to try out a new 2" dielectric diagonal and 18mm Explore Scientific eyepiece. Hopefully that will happen soon.

I've received acknowledgement that some members have signed up to be judges at the annual Regional Science Fair at Trent University. The PAA has been well represented at this event and I look forward to another session. The Frank Hancock award will be presented to the best astronomy

related project and as usual there will be an award from John Crossen of the BHO.

The following is a repeat from my message a year ago, but still applies.

Looking ahead we need to focus on "Astronomy on the Hill" in May. You might ask "how can I help I don't have a telescope?" We need lots of help. You can help by manning the traffic control on Saturday night. Greeting people and letting them know what we are doing. On Sunday we could use help interfacing with the public and keeping an eye on equipment when a member needs a washroom break. There are many ways you can help. Come out and get involved.

Rodger Forsyth
PAA President

Letter from the Editor

We Can't Buy a Clear Night

Well, Mother Nature is playing hardball with us still. Snow still on the ground and clouds for Earth Hour. What more must we endure?

Can we look forward to a clear night for the total luna eclipse on April 15? If Mother Nature cooperates then all you have to do is stand outside between 1 a.m. and 4 a.m. to catch the best glimpse. John Crossen has the 411 on that.

Rick Stankiewicz has written up an article about his trip to Lowell Observatory in Flagstaff, Arizona. If you missed February's club meeting then catch up here.

John Chumak was in Alaska and he sent in these gorgeous Northern Light photos. Ah, to live north of 60. For us in the lower

part of the continent, this weak solar max is hard to take.

Phillip Chee
Editor, The Reflector



The Reflector

The Reflector is a publication of the Peterborough Astronomical Association (P.A.A.) Founded in 1970, the P.A.A. is your local group for astronomy in Peterborough and the Kawarthas.

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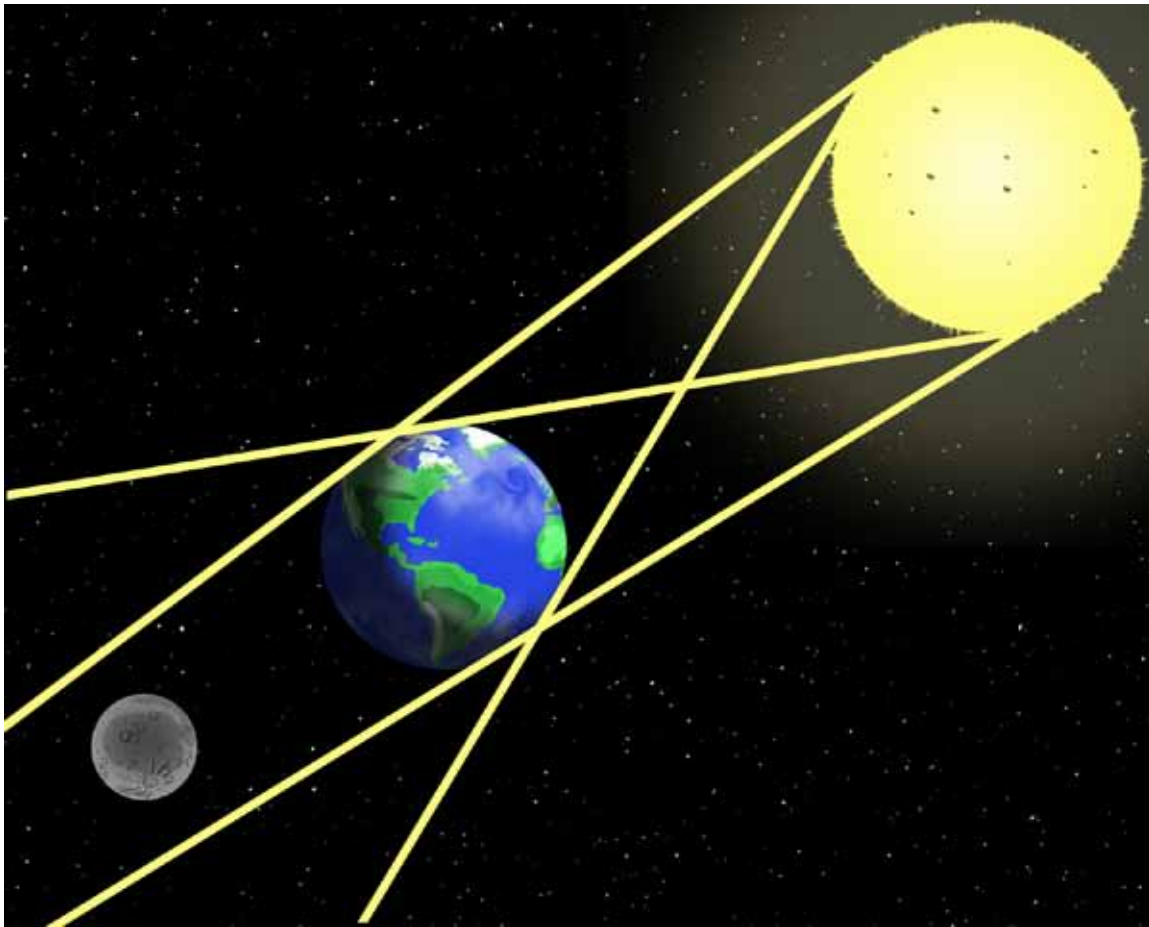
Rodger Forsyth, President

Peterborough Astronomical Association

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Mars Attacks the April Sky and the Moon Turns Red



Schematic of Lunar Eclipse. Everybody line up perfectly, smile and poof, we have a lunar eclipse. Drawing by Phil Medina.

JOHN CROSSEN

BIG NEWS FOR APRIL IS the total eclipse of the Moon on April 14-15. For those of us in Ontario the total eclipse begins shortly after 3:00 a.m. You may just want to go to bed early, set your alarm clock and step outside just before the birds start chirping.

The eclipse lasts for 76 minutes as the Moon glides into Earth's shadow, then out again about 4:00 a.m. At the 30 minute mark the Moon will take on a copper-red glow.

Planet buffs get a triple dip this Month. Jupiter is well up in the southern sky as darkness falls. Shortly thereafter (about 9:00) Mars joins the planetary parade rising

in the east southeast. You can't miss it because it's the only rusty red star-like object in the night sky and it's bright. Mars will be in the constellation Virgo very near the blue-white star Spica.

If you have the option of staying up late, Saturn will begin crawling up the eastern sky around midnight in the constellation Libra the Scales. Saturn will still have its rings tipped towards us, so it will be a stunning sight in even a small telescope. Binocular viewers will have to settle for an oblong glow—but at least you can say you saw it.

Constellation spotters will have a new batch of friends to meet starting with Virgo.

See "Corvus" on page 15

Lowell Observatory

RICK STANKIEWICZ

FOR THOSE OF YOU who missed my presentation at our February 7th meeting, I am submitting this abbreviated version to give you a sense of what you missed. What follows is my astro-tour to the famous Lowell Observatory complex (called Mars Hill) at Flagstaff, AZ that my wife and I took in September, 2013. This was one of the most historic astronomical facilities in North America and soon you will see why.

Time magazine included this observatory in its 100 most important places in the world (2011), along with the Great Wall of China and Machu Picchu. This was established by Percival Lowell (1855-1916) as a private non-profit facility since it opened in 1894. The mission is to study the solar system, planetary research and public outreach and they do an amazing job of all these. Percival Lowell also recognized light pollution as an issue long before others did and Flagstaff is now a leader in light pollution abatement to this day.

As we drove up the hill out of the city at an elevation of 7,250 ft (2,210 m) this sign lets you know you have arrived.



You have to enter through the Steel Visitor Center. There is a gift shop, some displays and you start all tours here too. One of the displays includes a 515 lb. (243 kg) chunk of meteorite that was quite impressive. The size of a few footballs, this “space rock” is 92% iron, 8% nickel with traces of gold, silver, platinum and diamonds. It came from the famous Canyon Diablo Crater, a.k.a. Barringer Crater or Meteor Crater, just 50 km east of Flagstaff (more about this another time).

When you leave the back of the visitor center there is a 42” (1.1 m) telescope. The Reflector is now an outdoor exhibit on the grounds. It was part of an 11 ton Alvan Clark & Sons telescope installed here in 1909. It had 4 secondary mirror combos for variable focal lengths (5.6 m “Newtonian focus” and 16 m, 24 m, 46 m “Cassegrain focus”). This allowed for spectroscopic work or Kodachrome images of planets. From 1909-1950 over 10,000 images were made of the universe. In 1922 the surface temperatures of Mars and Venus were made and after 1930, the accurate orbit of Pluto was plotted. Once a newer telescope replaced this one in 1969 it was not used much and was put on display outside in 2001.

Then on to the Slipher Rotunda Museum, which doubles as an exhibit hall and theatre, this beautiful old domed building was originally a library. It contains Percival Lowell’s first telescope (brass) that he got on his 15th birthday in 1870. It sure was nicer than any Tasco we might have had as a first telescope.

continued on next page

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Back in the day, Lowell was a vocal supporter of the theory that there was a civilization on Mars, as evident by “irrigation canals” that he saw while making detailed observations of the planet. There are samples of both Lowell’s sketches at the eyepiece of his large 24” refractor telescope and photographs taken around the same time and it is easy to see how he might have believed his observations were correct. This may have been his downfall though, because he was backing the wrong horse, but hindsight is always 20/20. Lowell’s logbook of Mars from October 19, 1894 showed he had the right idea and shows nicely features we recognize today like, Syrtis Major.

The search for a “Planet X” was started in earnest here around 1905 by Lowell. He may have almost found it if one compares his findings/calculations published in 1917 (a year after his death). He was definitely on the right track.

However, there are other displays which show other historical events and people that worked here, like Clyde Tombaugh, who in 1930 at 24 years old, became the first American to discover a planet (Pluto), the 9th in our solar system at the time and so it remained until 2006, when the International Astronomical Union decided otherwise. I don’t think the news has gotten to Flagstaff yet because they still talk like Pluto was discovered yesterday. There are newspaper clippings from March, 1930 announcing the discovery and there is nothing to suggest that it has since been “demoted”.

Clyde Tombaugh’s logbook of that fateful night making the photographic plates (late January, 1930), although Pluto was not “discovered” until 3 weeks later (February 18th) using the famous Zeiss Blink Comparator which is on display, with the plates showing Pluto that

See “Lowell” on page 12



March's PAA Meeting was a Smashing Success



GROUP WITH DR. PATTON AT SWISS CHALET. Members of the PAA Executive had the opportunity to meet Dr. Patton at dinner prior to his talk. The club paid for Dr. Patton's Quarter Chicken Dinner. Everyone else paid their own. L to R: Sean Dunne, Dr. Patton, Rodger Forsyth, John Crossen, Harold Briggs and Dean Shewring.

JOHN CROSSEN

HOW COULD IT BE anything less as our guest speaker, Dr. David Patton, slammed whole galaxies together before our eyes? Even massive black holes danced around each other prior to merging to form even larger black holes.

Part of what Dr. Patton was demonstrating (via computer simulations) was how galactic mergers, even near misses, can lead to new star formation as the gas within the two galaxies is perturbed and then coalesces to set off new star formation. It's star formation that can eventually lead to the birth of new solar systems.

Galactic merging is also an important function that leads to the growth of a galaxy. Large galaxies such as our Milky Way can be the end result of numerous smaller galaxies merging over billions of years. In our particular case we have yet to merge with the larger Andromeda Galaxy, but just wait a few billion years.

Dr. Patton is an Associate Professor in Trent University's Physics and Astronomy Department. His talk was a "101 version" of the work that he and a group of colleagues did during his sabbatical in 2012.

The question period at the conclusion of Dr. Patton's talk could have been endless. One answer just led to another question, so Dr. Patton has agreed to come back in a year with a talk on astrobiology. In addition to showcasing Dr. Patton's work the February meeting also honoured two PAA members for their contributions to the club.

First up was Pat Crebar who took over the job of treasurer and has opened the "Crebar Observatory" to club members on a regular basis. Since joining the PAA, Pat and her Mother, Jeanne, have scarcely missed a meeting or a club observing night.

Also honoured was Brett Hardy who has been an enthusiastic supporter of club

see "PAA Awards" on page 11

Jupiter's Great Red Spot is the real perfect storm



GREAT RED SPOT. Jupiter's Great Red Spot would give *Mary Poppins* and her parasol a merry ride with winds up to 432 km/h. Poor *Mary* would have to save *Mr. Banks* on the fly. Image by Gord Rife of Schomberg, Ontario.

JOHN CROSSEN

BAD WEATHER ON Earth usually runs its course in anywhere from a few hours to a few weeks. But Jupiter is home to a honkin' big storm that just won't quit. It's called the Great Red Spot or GRS and it'll blow the socks off of anything on Terra Firma.

Imagine a storm so huge you could sink about two and a half Earths into it.

Now wrap your brain around the fact that the wind on its outer regions is whirling around at nearly 432 km/h. Only the meanest, nastiest tornado on Earth can boast that kind of puffing power and with some exceptions, it's over in minutes. A hurricane might hit 160 km/h all of which sounds kind of puny compared to the GRS. Like a hurricane, the centre of the Great Red Spot is nearly inert—a calm zone.

The rotation of the GRS is caused by it having one belt of weather on top of it and another belt below it. They are moving in

opposite directions which cause the GRS (like rolling a marble between the palms of your hands) to spin. In this case the movement is anti-cyclonic or clockwise for us regular folks.

Giovanni Cassini is thought to have been the first to observe the GRS in the late 1600s, but scientists believe that it was already older than that. The problem was that telescopes had to get better than the little spyglass that Galileo first used on Jupiter in 1610. Cassini's improved telescope revealed more detail—including the GRS.

The Great Red Spot is an ever-changing thing of mystery. It changes size, colour, and at times almost vanishes. About 100 years ago, the storm covered over 40,000 km of Jupiter's surface. At that time it would have swallowed four Earths with ease. But it is currently about half of that size and seems to be shrinking. Some say that if this

see "[Great Red Spot](#)" on page 15

Alaskan



Hi Everyone,

I'm in Alaska leading a tour for the Aurora, will be here outside of Fairbanks through next Saturday.... Amazing part of the planet!!!

Absolutely Amazing Aurora Last Night 30 minutes outside Fairbanks, Alaska!!!! I took over 450 photos of it, I watched it dance and sway from 9:30pm until 4:00am!!! It got so Bright at times it turn the snow Green, to Red to Purple too! All images with a Canon 5D Mark II DSLR , Various ISO 800 to 3200, 24mm f/1.4 lens, 5 second to 15 second exposures.

I included some shots I took from my first clear night here!!!

Do you have this on your Bucket List?

Then consider joining me next year for my 2015 Aurora Photo Tour & Workshop!!!

My friend John Slonina operates

Slonina Nature Photography Tours, and I co-lead the tour and give the group instructions on how to photograph the Northern Lights & Night Sky...

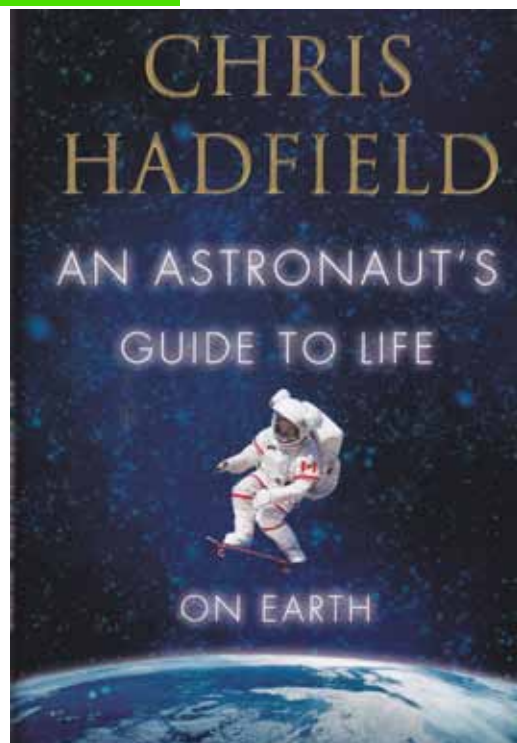
<http://www.sphotography.com/alaska-northern-light-aurora-photo-tour/>

John Chumack www.galacticimages.com

Aurora



BOOK REVIEW



CHRIS HADFIELD

RANDOM HOUSE CANADA, 2013

336 PAGES; ISBN 978-0345812704, \$32 HARDCOVER

RICK STANKIEWICZ

This book is so popular that I recently received two copies as Christmas presents and this was not just because my family knows me and my likes, but because this book is all the rage this season. Once I started to read it over the holidays I could not put it down. The subject of this book and the way it is written is a winning combination. If you ever wondered what it was like to be an astronaut, not to mention one of the most famous in our time, this autobiographical look at the career of Chris Hadfield will do it for you. His book is as personable as he is in real person (I know, because I met him several years ago). He is open and honest as he is detailed in the path he took through life to achieve his lofty goal of become a “successful” astronaut.

Not exactly a “tell all” book, but there are lots of stories relating to his and others experiences in the space program, it is written with humour and wit in everyday terms that anyone can relate to. However, the best parts of the book were the life lessons and perspective shared by Hadfield from liftoff to landing. The other cool aspect is that the book is current and will take you from his 9 dreams as a nine year-old after watching the Apollo 11 moon landing, right up to the point of his retirement as an astronaut last year.

There were many “words to live by” in this book and there was not a chapter that I did not highlight some for future reference and contemplation. This book was worth the read just to hunt out these gems of wisdom. Many we know already, but so few do we usually think about and if we did more often we would all be better people for it. One very poignant perspective shared is that there are usually three ways to view a situation, as a “minus one”, creating harm or trouble; as a “zero”, having neutral impact or not tipping the scales; as a “plus one”, where there is value added. Then he goes on to illustrate that many people want to be or think they are Plus One, but end up being viewed by others as Minus One. Often you are better off to just “aim to be a zero” and if you do your part well enough you may be a plus one in your own right. It all makes sense, but coming from Hadfield just seems to make perfect sense because he has the life lessons to prove it.

For me this was a great self-help book and made me reflect on my life through the experiences of others. This book also answered some questions I had about

See “Hadfield” on page 13

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PAA Awards



PAT RECEIVING AWARD. Pat Crebar receives a well-earned honour for her PAA work over the years. PAA President Rodger Forsyth does the presenting.

outreach activities as well as making Cedar Knoll Observatory a regular stop on the PAA's yearly observing list. Congratulations and thank you to both Brett and Pat for their outstanding service!

April's guest speaker will be Jim Kendrick of Kendrick Astro Instruments in Toronto.



BRETT RECEIVING AWARD. President Rodger Forsyth presents Brett Hardy with an award for his dedication and hard work on behalf of the PAA.

Jim's company is famous globally for its dew control systems that are used on telescopes and cameras. Jim will be bringing along some of his new gear aimed at the astro-imaging market and might even give us a preview of his work with Wayne Parker on POD Max. Be there or be square.

*continued from page 5***Lowell**

you can see for yourself almost as Tom-
baugh would have discovered it. Talk
about a piece of history, you can actually
live it!

Then there is the story behind Pluto's
name and the 11 year old girl from Eng-
land, Venetia Burney, who's submission
was chosen over many others and she
was not talking Disney characters ei-
ther, but rather a god of the underworld.
Coincidentally, the initials for Pluto are
"PL" which fits nicely as a tribute to Per-
cival Lowell.

It was here at Mars Hill in 1912, that
Melvin Slipher documented that the
great nebula in Andromeda (M31) was
moving toward us at 300 km/s and that
the Sombrero Galaxy was receding at
1,000 km/s. Edwin Hubble used much
of these findings to come up with his
"expanding universe" theory in 1929. It's
funny you don't find many references
to Edwin Hubble here, it's all about
Slipher. It was Carl Otto Lampland, May
5, 1923, who used the 42" Reflector to
discover a "temporary star" in M83, one
of the earliest recorded supernovas. At
Lowell they sure are proud of their own,
but for good reason.



Further up the hill from the museum
is the Percival Lowell Mausoleum erect-
ed in 1923, just outside the entrance to
the Clark Telescope, on a rise overlook-
ing Flagstaff. Next to the mausoleum is

the 24" (61cm) Clark Refractor Telescope
Dome. It was here that Lowell suspected
among others that there was a "Planet X"
beyond Neptune and he all but proved it
in his memoir published after his death,
so he did not live to see his vindica-
tion by Tombaugh in 1930. The scope is
still in use today for public education. I
never got to have a look because it was
too windy that night, as the dome is too
fragile. It is now under renovations until
2015, so I was lucky to have seen it at all.

Note the wooden dome construc-
tion with rivets (that originally had a
canvas skin), in 1899 the dome "floated"
on water until it leaked (note stains on
upper wall). Then in 1960, twenty-four
(1954) Ford truck tires were installed to
rotate the dome and they are still in use
today. You can see the ladder and kitch-
en "observing" chair and a rope used to
release a metal 6" fry pan covering the
lower finder scope, all examples of good
"old fashioned technology" or "practical
hi-tech" of the day.

In the opposite direction of the mu-
seum is the Abbot L. Lowell Astrograph
Dome, named for Lowell's brother,

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another benefactor of the facility. This houses the 13" (33cm) Pluto Planetary Telescope which was not used for viewing, but for photographing the night sky. It was this telescope which helped Tombaugh discover Pluto. Note the metal plate for holding the photographic plates. PAA member Brian McGaffney at the Nutwood Observatory has a 14" (36cm) astrograph that is not nearly as bulky as this one. I really got a sense of astronomical history standing here.

As we worked our way down the hill to the original home of the 42" Clark Reflector Telescope, but we were not allowed inside, as was the case with the 16" (41cm) McAllister Telescope Dome. This cassegrain scope is being used as a public scope while the Clark Telescope is being renovated, until sometime in 2015. Lastly is the Titan Monitoring Telescope, which is dedicated to studying and monitoring of Saturn's largest moon.

There is much research to this day occurring at and associated with the Lowell Observatory, like the Hendricks

Center for Planetary Studies, at Mars Hill, Anderson Mesa and Happy Jack where research is being done on the Sun, planets and comets. At these other locations in the area the public is not allowed like at Mars Hill. However, at Anderson Mesa, there are the 72", 42", 31" and Navy Precision Optical Interferometer and at Happy Jack, is the Discovery Channel Telescope-4.3m, \$50-million telescope that uses "active" versus "adaptive" optics.

The day tour ends with solar viewing at the visitor's center in the afternoon and for the same price of admission, a unique planetarium shows later that night in the museum, followed by a little bit of stargazing with telescopes run by staffers, at night.

I plan my trips around interesting things and I enjoy the experience so much more. I like to combine hobbies and travel and I am never bored. It gives a whole new appreciation for my hobby and history.

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Hadfield

being an astronaut, the space program and life on the International Space Station. Even if you have just a mild interest in such things you will not regret picking up this book.

Whether reflecting on a retirement, a career change or many aspects of life, "endings don't have to be emotionally wrenching if you believe you did a good job and you're prepared to let go." By the end of this book I believe the author had done a good job, but I was not prepared to let go, as I could have read on and on and to me, this is a sign of a good book. Another sign of a good book is that after reading it, I felt better for having done so.

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The Sky this Month

Mercury vanishes from pre-dawn skies by mid-month and reaches superior conjunction on the 26th.

Venus is in the eastern morning sky. The waning crescent Moon passes north 4° on the 25th.

Mars is in opposition on the 8th rising near sunset and up all night long.

Jupiter is moving eastward in the western evening sky in Gemini. Sets after midnight.

Saturn rising late in the evening and retrograding in Libra.

Total Lunar Eclipse on the 15th. Penumbral stage begins 12:53 am with greatest eclipse beginning 3:45 am lasting about 79 minutes.

Lyrid Meteors peak 2 am on the 22nd.

Moon Phases

First Quarter	4:31 AM	April 7
Full Moon	3:42 AM	April 15
Last Quarter	3:52 AM	April 22
New Moon	2:14 AM	April 29

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Corvus

The mythical goddess of fertility will be in the south-southeast. Mars is her house guest this year. Be sure you visit them before summer sweeps the lovely couple into the sunset.

Libra the Scales is a lesser known spring constellation. Perhaps it's the fact that Libra is quite dim so it is difficult to find unless you have a dark rural sky to work with. Also, Libra resembles an old-fashioned balance scale, not the modern digital kind you find in your bathroom or at the gym. Google it up if you're under 25.

Three other constellations grace the night sky just beneath Virgo. The four stars that make up Corvus the crow will take a bit of imagination to figure out. I usually tell people to look for the square kite-like grouping of stars just below and to the

right of Spica. Imagine the stars as the four points of the Crow. The lowest is the Crow's beak. The two above it represent his wing-tips and the highest is the tip of his tail.

Next to Corvus is Crater the Goblet. Crater is a little easier to deal with because it really looks like a goblet. So it doesn't require a goblet of wine to find it.

Running along the horizon just below Corvus and Crater is Hydra the Snake. Hydra stretches from Virgo all the way to Cancer the Crab. If you'd like a star chart that will help you find these creatures of the night, pick up a copy of *SkyNews* at Chapters in Peterborough. The illustrations are excellent as are the easy-to-read star charts. Plus there are articles about the planets and upcoming celestial events that you'll want to stay up for.

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Great Red Spot

continues the GRS will eventually become circular by 2040 instead of its current oval shape. Will it eventually grow bigger again? We really haven't observed it long enough to know if this is a cyclical thing or if it will just puny up and go away.

Infrared images reveal that the GRS is colder than the surrounding cloud cover and stands about 8 kilometres above it. But the biggest mystery is what causes it to be red and what are the processes behind it changing colours? Some years it is a vibrant red while other years it fades to salmon pink and almost white.

The most popular theory is that the storm protrudes deep into Jupiter's cloud layer and dredges up gases rich with complex organic molecules, red phosphorus, or other sulfur compounds. When these elements are exposed to sunlight, they turn red. Then, with the passage of time, they drop back into the cloud layer and the GRS dims.

Anyone who has observed Jupiter for a few years will be well aware of the Great Red Spots capricious nature. So in addition to watching the dance of Jupiter's moons each clear night, we can also look to find the GRS. This year it's fairly easy to spot if your timing is good. But you'd better hurry because Jupiter will be sinking into the western sunset by the end of April.



KW Telescope
P E R C E P T O R

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GPS

baseline interferometry and satellite laser ranging is that you don't need complex and expensive infrastructure and can deploy many stations all around the world."

Feeding GPS data directly into the calculation of a terrestrial reference frame could lead to an even more accurate and cost effective way to reference points geospatially. This could be good news for missions like Jason 2. Slight errors in the terrestrial reference frame can create significant errors where precise measurements are required. GPS stations could prove to be a vital and untapped resource in the quest to create the most accurate terrestrial reference frame possible. "The thing about GPS," says Weiss, "is that you are just so data rich when compared to these other techniques." You can learn more about NASA's efforts to create an accurate terrestrial reference frame here: <http://space-geodesy.nasa.gov/>.

Kids can learn all about GPS by visiting <http://spaceplace.nasa.gov/gps> and watching a fun animation about finding pizza here: <http://spaceplace.nasa.gov/gps-pizza>.



Peterborough Local 590

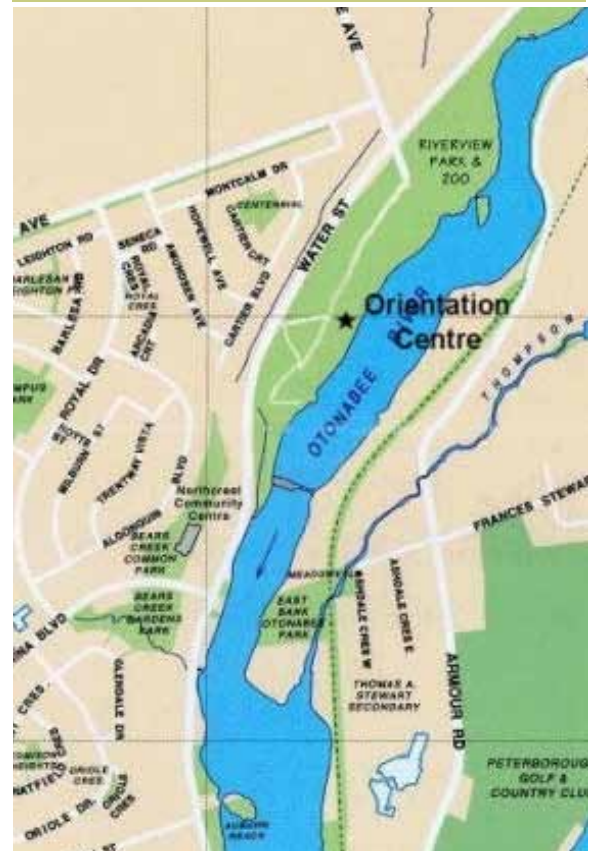


Articles

Submissions for *The Reflector* must be received by the date listed below. E-mail submissions are preferred (Microsoft Word, OpenDoc, ASCII and most common graphic formats are acceptable). If your article contains photos or graphics, please provide a separate file for each. Typed or hand-written submissions are acceptable provided they are legible (and not too long.) Copyrighted materials will not be published without written permission from the copyright holder. Submissions may be edited for grammar, brevity, or clarity. Submissions will be published at the editor's sole discretion. Depending on the volume of submissions, some articles may be published at a later date. Please submit any articles, thoughts, or ideas to:

phillip.chee@gmail.com

Next submission deadline:
April 25, 2014



Meetings

The Peterborough Astronomical Association meets every first Friday of each month, except July and August, at the **Peterborough Zoo Orientation Centre** (Next to the PUC Water Treatment Plant) at 7 p.m. P.A.A. general announcements will begin each meeting with the guest speaker starting at 7:30 p.m.