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The Reflector

Newsletter of the Peterborough Astronomical Association

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

Dr. Ethan Siegel

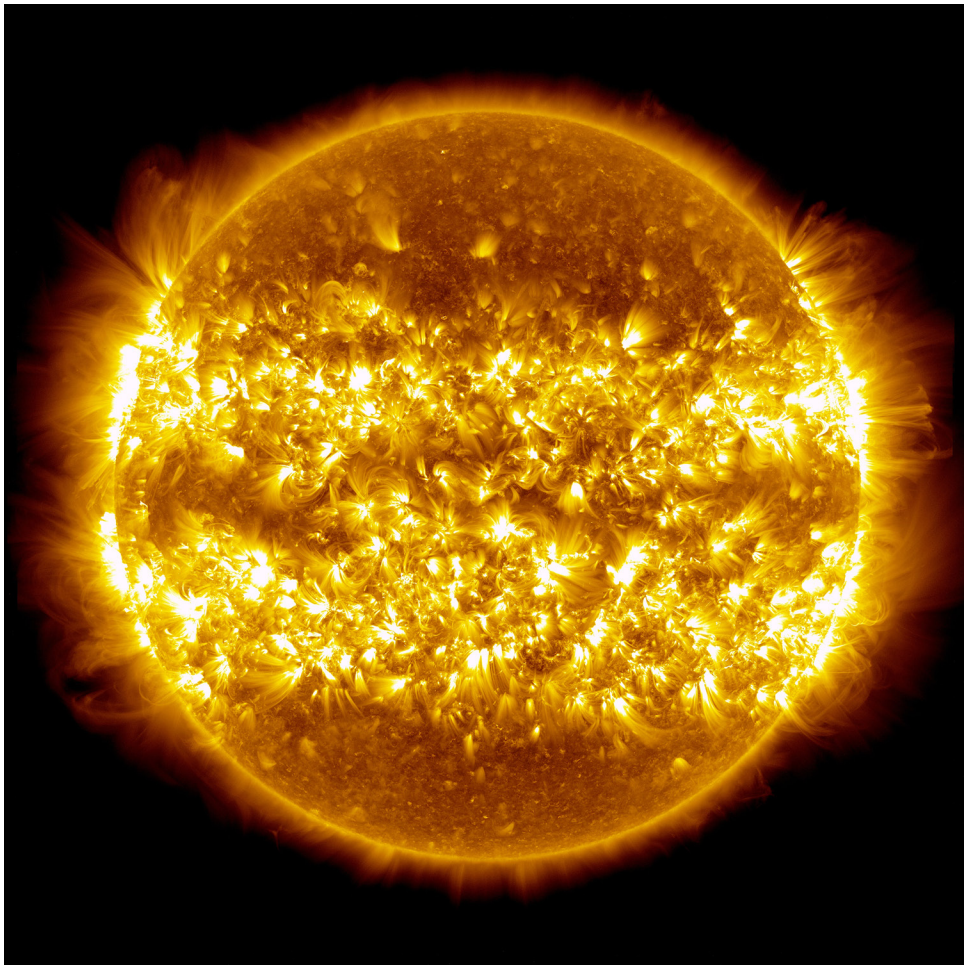

Image credit: composite of 25 images of the sun, showing solar outburst/activity over a 365 day period; NASA / Solar Dynamics Observatory / Atmospheric Imaging Assembly / S. Wiessinger; post-processing by E. Siegel.

Here on Earth, the Sun provides us with the vast majority of our energy, striking the top of the atmosphere with up to 1,000 watts of power per square meter, albeit highly dependent on the sunlight's angle-of-incidence. But remember that the Sun is a whopping 150 million kilometres away, and sends an equal amount of radiation in all directions; the Earth-facing direction is nothing special. Even considering sunspots, solar flares, and long-and-short term variations in solar irradiance, the Sun's energy output is always constant to about one-part-in-1,000. All told, our parent star consistently outputs an estimated 4×1026 watts of power; one second of the Sun's emissions could power all the world's energy needs for over 700,000 years.

That's a literally astronomical amount of energy, and it comes about thanks to the hugeness of the Sun. With a radius of 700,000 kilometres, it would take 109 Earths, lined up from end-to-end, just to go across the diameter of the Sun once. Unlike our Earth, however, the Sun is made up of around 70% hydrogen by mass, and it's the individual protons or — the nuclei of hydrogen atoms — that fuse together, eventually becoming helium-4 and releasing a tremendous amount of energy. All told, for every four protons that wind up becoming helium-4, a tiny bit of mass — just 0.7% of the original amount — gets converted into energy by $E=mc^2$, and that's where the Sun's power originates.

You'd be correct in thinking that fusing $\sim 4 \times 1038$ protons-per-second gives off a tremendous amount of energy, but remember that nuclear fusion occurs in a huge region of the Sun: about the innermost quarter (in radius) is where 99% of it is actively taking

see "The Sun" on page 16

President's Message

Spring Has Finally Arrived

It seems we have finally seen the last of winter's wrath. There have been a few warm days but there has also been lots of rain with the perpetual cloudy skies. Saturday April 19th I did get out to the SkyShed for the first time and enjoyed some great viewing. Jupiter, Mars, M42 and the beautiful M37.Let's hope the skies are clear for our next publicised event.

The PAA was well represented at the Science Fair at Trent University. Trish McCloskey, Sean Dunne, David Mills and I were judges. There were nine astronomy related projects this year, a record, which made judging them a tad more challenging. I presented the Frank Hancock Award and a one year family membership to the PAA and Trish presented the Buckhorn Observatory Award on behalf of John Crossen. Turned out that the two of us were called upon to hand out many awards and Sean landed the job as official photographer for the proceedings. I thank the members for their continued support.

We have an update on the use of Green Laser Pointers in this issue. I encourage everyone who owns one to read this article.

On May 10th and 11th we will host our 9th annual "Astronomy on the Hill" weekend on Armour Hill and the Peterborough Museum and Archives. We need your help. If you have a telescope, bring it along, if not we need volunteers to watch equipment, direct traffic and mingle with the public answering questions etc. Please come out and support your club. This is a great weekend for families to get out and participate in live astronomy events.

Rodger Forsyth
PAA President

Letter from the Editor

April Showers Bring May Astronomers

I can't remember such a lingering spring where the thermometer refuses to rise above room temperature. I just hope May atones for our lousy winter observing season. We can look forward to the eta-Aquariid meteors on the 6th and a possible new meteor shower on the 24th radiating from Camelopardis.

This week is the only chance you'll get to our annual astronomy display at the Peterborough Public Library. Dean Shewring organized this year's theme on auroras.

John Crossen delivers the usual sparkling wit with a number of articles Saturn, spacecraft launches to the asteroids, exoplanets an astronauts. What great variety of topics for your reading enjoyment.

Rick Stankiewicz is enjoying his excursion to Australia and sent it a couple of photos of the Milky Way and Magellanic Clouds as seen from Down Under.

Until next month.

Phillip Chee
Editor, The Reflector

PETERBOROUGH ASTRONOMICAL ASSOCIATION

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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Some Pointers About Green Laser Pointers

Over the last decade, the ethereal glow of a Green Laser Pointer (GLP) has become a familiar sight at astronomy education and public outreach events. From star parties for beginners to sky-at-night tours around astronomical installations these instruments have become valuable tools.

With the beam of a Green Laser Pointer an astronomy educator can direct an audience to a specific object — planet, meteor-shower radiant, star, asterism, constellation, or nebula. That makes the Green Laser Pointer one of the best tools in an astronomer's instrument case – but only if used responsibly.

Green Laser Pointers are tools not toys; and their misuse can lead to serious harm. It is estimated that the beam from a 5 mW GLP when flashed in the eyes is 26,000 times the surface luminescence of the Sun.

Small wonder then that under the Canadian Aeronautics Act, conviction for laser flashing an aircraft carries maximum penalties of a five-year prison term, and a $100,000 fine. We suggest that you visit this website for further details: www.tc.gc.ca/eng/civilaviation/standards/aerodromeairnav-standards-ais-directed-bright-light-menu-1068.htm.

In keeping with the PAA's commitment to safe astronomy education we ask that our members observe the following guidelines when using a GLP:

1. Ensure that the GLP is operated only by designated, responsible adults, preferably PAA members who are familiar with the potential hazards of laser light. During public events, it is best to assign one or more members to help GLP operators spot oncoming air traffic;
2. Take special care not to shine a GLP in the direction of any person, vehicle, aircraft, or wildlife;
3. Never point a GLP at a glass window or anything with a shiny surface. The reflected beam can be just as dangerous.
4. Avoid using a GLP near an airport or airport runway approach. We suggest a that GLP not be used within 10 km of any airport;
5. Use the minimum power to do the job: if a 5 mW laser is bright enough, why use a stronger one?
6. Be aware that distraction and distress can be experienced by anyone illuminated by green laser light, even if the level is well below that which would cause physiological damage;
7. Use good sense in storing your GLP. Don't leave lasers accessible to children. Consider removing the batteries when you are done using a GLP.

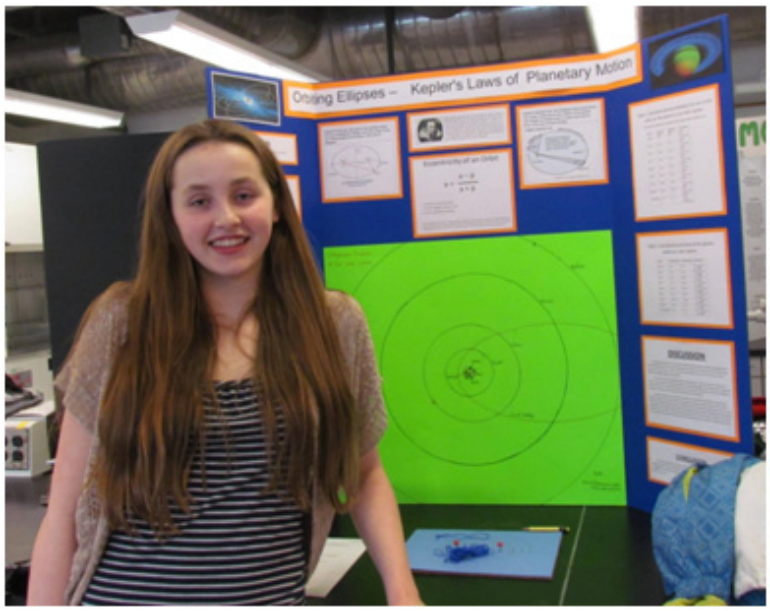
By following these guidelines you will reduce the chance of an unfortunate incident involving a Green Laser Pointer while leading public astronomical activities.

John Crossen / Rodger Forsyth

Peterborough Regional Science Fair

The 45th Annual Peterborough Regional Science Fair was held at Trent University on April 8th.

This year's Science Fair turned out to be one the biggest yet with approximately 250 students presenting 210 projects or so. There were nine astronomy related projects, which Rodger thinks is a record. This made judging a challenge and interestingly enough the best projects came from the junior level at the fair. The PAA was well represented as we had four judges there and awards were handed out in three categories.



First place for the Frank Hancock Award went to Isaac and James Chandra of Rhema Christian School for "Mission 2 Mars".

These two brothers took first place last year for their project "Big Planet Bigger Planet".

Their depth of knowledge and relaxed style of presentation was truly amazing and they attracted quite an audience.

continued on next page

Continued from previous page

Second place for The Frank Hancock Award went to Carling Stever of James Strath School for "Orbiting Ellipses—Kepler's Laws of Planetary motion".

The Buckhorn Observatory Prize for Best Astronomy Project went to Shaylene Kathiravelu for "Life on Mars" and to Joshua Lee for "What is Luna? Our Beautiful moon".

There were so many interesting astronomy projects we could have stayed all day.

But the presentations were due and it was time for our PAA representatives to perform on stage. And perform they did.

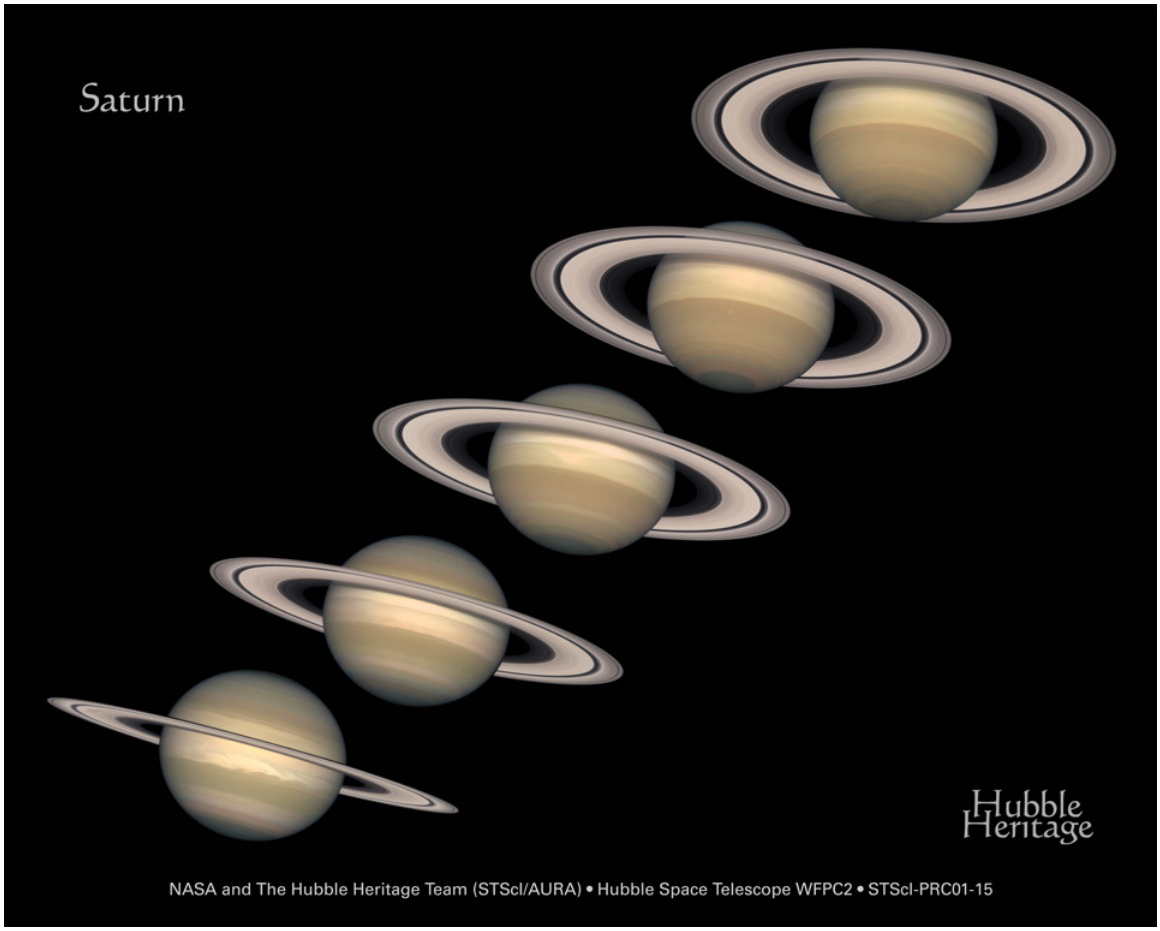
—Sean Dunne, reporter and photographer.

Rodger Forsyth with Isaac and James Chandra.

Rodger Forsyth with Carling Stever.

Trish McCloskey with Joshua Lee.

Saturn is At its Biggest and Brightest in May



Saturn. At 760 times the size of Earth, Saturn is one big beauty. Like Jupiter, the planet is composed mostly hydrogen and helium gas. Its rings are made of billions of chunks of highly reflective ice. Astronomers think they may be the remains of ancient ice moons that came too close to the planet. Depending on where Earth and Saturn are in their orbits around the Sun we see the rings from different angles. Hubble/NASA photo.

John Crossen

The most beautiful planet in our solar system is in full bloom this May 10. It will be at opposition (at the end of a straight line starting at the Sun, halving Earth and culminating at Saturn). Because of this it will rise as the Sun sets and be visible until the following sunrise on the 10th. Thanks to its "Earth friendly" tilt in 2014, Saturn will give us the best view of its rings since 2005. I recommend viewing Saturn sometime after 10:00 p.m. as it will have risen out of the "pollution soup" close to the horizon and will be in clearer air.

You can see the rings at 30 power with a small telescope. Binocular viewers will only see is football-shaped elliptical object. Here's a hint, Saturn will be the brightest object in the constellation Libra, the Balance Scales.

Mars is also a member of May's planetary parade. It rises before Saturn and can be found in the constellation Virgo which is just in front of Libra. Mars is a tough planet to pick out any detail on with a good telescope. But on a clear, steady night the surface details are visible if you take your time viewing the Red Planet at high power. Binocular and naked eye observers will have to settle for finding the ancient god of War.

Also on the planetary agenda is another of my favourites, Jupiter. The huge (1,000

see "Saturn" on page 15

Peterborough Public Library Lobby Display
AURORAS: Wonders of the Night Sky

Dean Shewring

A PAA display could be found in the lobby case of the Peterborough Public Library from Monday, April 28th to Monday, May 5th this year. Titled "AURORAS: Wonders of the Night Sky", it featured several beautiful aurora photos from amateur astronomers across Canada as well as from prominent local PAA members. Aurora posters from NASA, donated books and calendars, and articles and photos from *SkyNews* were also part of the library lobby display. The display is timed to highlight the improved chances of seeing aurora during the spring of the year and to promote the PAA's May 10 and 11, 2014 Astronomy Weekend activities.

Thanks should go to John Crossen and Rick Stankiewicz for supplying exciting material from their aurora photo collections. Thanks also to *SkyNews* for their up-to-date information on auroras in Canada. Finally, thanks to Stan Nowicki and Boyd Wood for helping me install the display at the library. I do hope people found our efforts both enjoyable and informative.

Photos: Dean Shewring

PHOTO GALLERY

Big Bird

This image is one I took on April 6th during an outing with members of the Brisbane Astronomical Society (BAS) at a private viewing area near Wyallah, 2 hours west of Brisbane over the Dividing Range (S 28°16.08'.8'' and E152°11.49'.8'').

This image shows the "Emu" from Aborigine folklore. See if you can make out the profile of the "big bird" with the head facing to the upper right side of the frame and is formed by the "Coal Sack" Nebula (below the Southern Cross) and the body runs to the lower left of the frame through the Milky Way. These views are almost naked eye viewing and are truely unbelievable from a northern hemisphere perpsective. It is opportunities like this that are making this trip one of a lifetime.

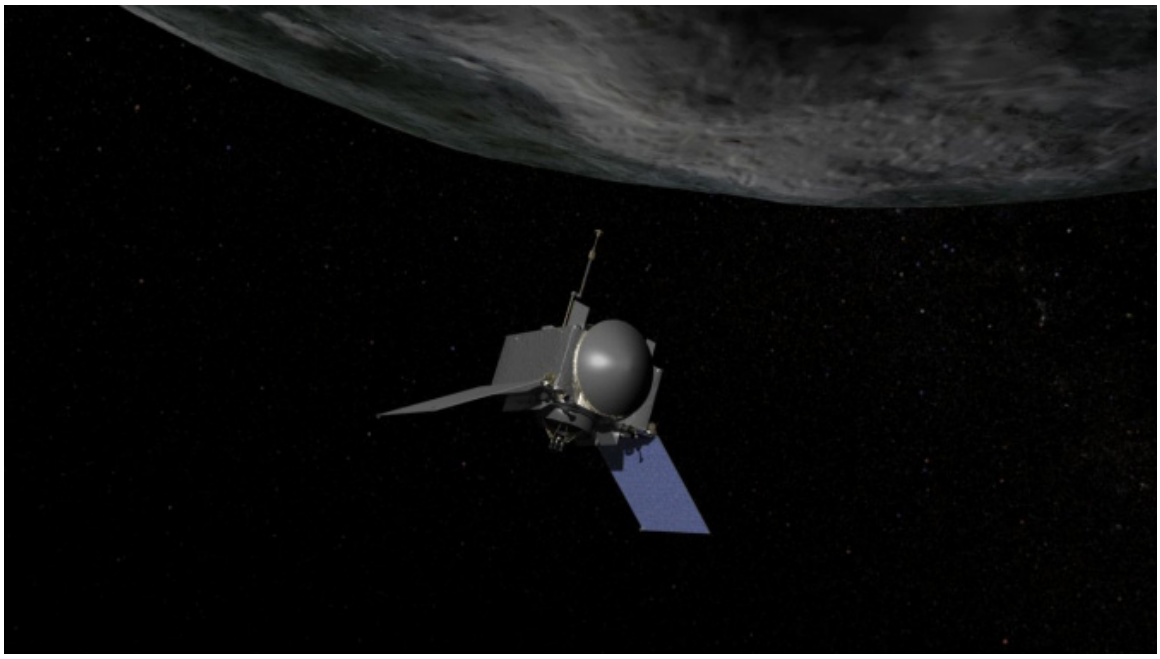
To take this image I used a Canon modified 50D and Sigma 10-20mm lens at 10mm; ISO 2000, f/4.5, exposure, 90 seconds. This was tripod mounted on an iOpteron "SkyTracker" drive. Single frame exposure and no processing at all.

Magellanic Clouds

This image shows just how easy it is to see our closest neighbouring galaxies, the Large and Small Magellanic Clouds. On March 22nd I was in New South Wales, near Lismore on a clear night in the country and this image captures what I was able to see at almost naked eye. The LMC is the upper portion of the image and shows an irregular galaxy in the cnstellation of Dorado, 170,000 lyr from us and the smaller fainter SMC is to the lower left in the constellation of Tucana, 200,000 lyr away. Note the bright spot to the lower left of the SMC, this is 47 Tucanae. This globular cluster is brighter than M13 that we are familar with in the north and is in fact the second brightest cluster next to Omega Centauri. Compared to what we are used to seeing in the northern hemisphere, the objects that I saw and imaged were “light years ahead” of what we can see at home. The Andromeda Galaxy pales in comparison to the LMC and SMC for naked eye captures.

This image was taken with a Canon 50D modified camera and Sigma 10-20mm lens at ISO 2000, f/4.5, for about 90 seconds, on a tripod mounted iOpteron SkyTracker.

NASA Heads to an Asteroid in 2016



OSIRIS IN ORBIT. Those who wish to have their names etched on a microchip and receive a downloadable certificate of participation in the project must do so prior to September 30, 2014. For more about the OSIRIS-Rex mission, visit: http://www.nasa.gov/osiris-rex.

JOHN CROSSEN

Why spend a gazillion dollars to go to an asteroid when tons of them rain down on Earth every year in the form of meteors? At the risk of sounding like a broccoli commercial, it's all about freshness. Asteroids are the building blocks of our solar system. So scientists want to study them in their pristine condition.

The meteors that land on Earth have been exposed to our atmosphere. Worse yet, their journey to Earth's surface will superheat them thanks to friction with our atmosphere. And once they strike Earth they are exposed to numerous contaminating elements ... sometimes for thousands of years.

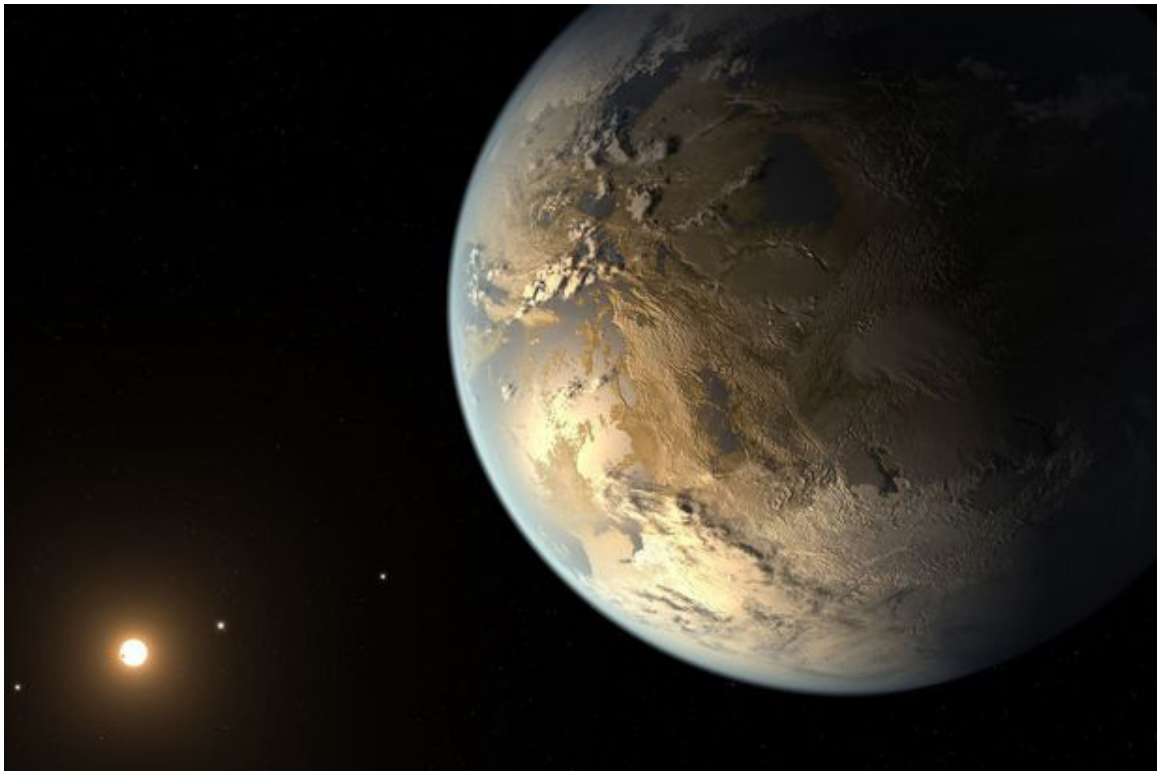
Then there's the shock of impact to consider. Slamming into Earth at seven times the speed of a bullet could alter their internal composition. Even meteors found in Antarctica have been exposed to water in the form of ice and snow. But in airless space they are uncontaminated by Earthly elements.

Another force behind NASA's small asteroid trek could be the fact that there are currently plans on the drawing board to capture a large asteroid near Earth and draw it in so that it can be mined and explored like a mini-planet. Thus Mohamed not only goes to the mountain but brings it back home. But that's down the road a bit.

The NASA team at the Marshall Spaceflight Centre in Huntsville, Alabama will head up the mission. In April they were given the go-ahead on the first U.S. mission to land, collect samples and return from an asteroid. (Prior to this JAXA the Japanese Space Agency launched and brought back Hayabusa with samples

See "Osiris" on page 15

Newest exoplanet was made for Canadians



The art of Kepler. Kepler has been credited with discovering over 964 exoplanets and more are sure to turn up as more data is analyzed. The current total exoplanet count is 1,706. This includes all the dedicated instruments and techniques used to find them. Shown here is an artist's concept of what Kepler 186f might look like.

John Crossen

The Kepler Space Telescope was retired because of two malfunctioning gyros. But the long list of exoplanet candidates it identified is still being culled by scientists. And they're finding some nifty stuff.

Their latest discovery is a rocky little world known as Kepler-186f. Veteran planet hunters like Geoff Marcy at the University of California are very excited because Kepler-186f is just 10 percent larger than Earth. Plus, it orbits in what is known as the Goldilocks Zone. This means it is not so close to its home star that you'd roast. Nor is it so far away that you'd be frozen solid. In other words it could be just right for life.

Kepler 186f orbits a red dwarf star or M class star. So its version of our Sun is smaller and cooler than dear old Sol. But to even things up, Kepler 186f orbits closer to its home star. By orbiting closer, it travels a shorter distance and has a shorter year—just 130 days compared to our 365. Hum, that would make me about 140 years old if I was an inhabitant of Kepler 186f. I'll stick to Earth.

Kepler 186f is located in the constellation Cygnus and is nearly 500 light years from Earth. Given that one light year is slightly less than 10 trillion kilometers, we probably won't be visiting it soon. And if we could we probably should pack for winter weather. That's because scientists estimate that Kepler 186f orbits on the outer edge of the Goldilocks Zone. So while its rivers and lakes may contain

see "Kepler" on page 13

Looking for thrills, lots of "me" time and constant change?

Astronauts back from Space. After a 5-month stay in the microgravity of Earth Orbit the astronauts and cosmonauts are unfit to stand or walk. Commander Chris Hadfield (far left) took nearly 3 weeks to get back to being his "old self." This despite plenty of daily exercise to keep fit while in orbit. Imagine what shape the astronauts would be in after a 1 year trip to Mars! Their first step on Mars would be a face plant.

John Crossen

We take the Sun for granted. It rises every day and sets every night—end of story. Hang on, there's a lot more to know about Earth's outer-space heater. Let's start with some simple facts that a lot of people don't know.

For starters, the Sun is a star. You'd be surprised how many guests at my observatory are amazed to learn that the only difference between the Sun and one of the 100 billion stars in our galaxy is distance. While the other "twinkling suns" are light years away, our Sun is just 143 million kilometres from Earth. By cosmic standards, we're neighbours. Still, it takes sunlight about 8 minutes to traverse that distance. So the sunlight that warms your face is already 8 minutes old. And light isn't slow.

Through empty space light zips along at about 300 thousand kilometres per second. That's right, per second! In the snap of a finger light will travel around the Earth 7.5 times. But let's get back to the Sun, it's full of surprises.

The Sun is 1 million times larger than Earth and nearly 110 times Earth's diameter across. To buy a pair of pants that would fit around the Sun, you'd have to specify a 4,730,005 kilometre waist band!

Astronomers have calculated that the Sun accounts for 99.86% of our solar system's total mass. So if you squeezed all 8 planets, the 3 dwarf planets, their moons and the asteroid belt into one big clump, the Sun would have just about the same mass. In fact they'd all fit inside the Sun.

Big though the Sun seems in comparison to puny Earth, it is still classified as a yellow dwarf star. That's a bit of a misnomer because the light the Sun gives off is white and astronomers really

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classify old Sol as a G2V series star. This denotes a star with about a 6,000 degree Celsius surface temperature.

So how hot is the dwarf next door? True to its G2V classification, the surface temperature of the Sun pumps the thermometer up to about 6,000 degrees Celsius. But the core of the Sun is where the real heat is—15 million degrees Celsius of it. That's unimaginably hot. So what's up?

The Sun's energy output is the result of nuclear fusion. It's a process in which hydrogen atoms are heated and compressed to the point that 99% of the hydrogen mass fuses into helium and 1% escapes as pure energy. It's the same process as the hydrogen bomb. In just one second the Sun produces enough energy to power the entire United States for 9 million years — and we're still polluting our planet with fossil fuels!

The Sun is a middle-aged star with a life expectancy of about 10 billion years. As it ages it will expand from a yellow dwarf into a red giant and engulf all the rocky inner planets. So our source of light and life will eventually be our end. But cheer up and look on the sunny side. That's 2 billion years away.

to 'The Sky this Month'

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Kepler

flowing water, they would probably be frozen over most of the year. Remind you of someplace familiar?

To quote Marcy, "The planet probably basks in an orange-red glow from its star and is most likely cooler than Earth, with an average temperature slightly above freezing, similar to dawn or dusk on a spring day."

Kepler 186f doesn't orbit on its own. The planet has four running mates who are about the same size but are either too far out or too near the home star to be candidates as Earth Twins.

Lead researcher Elisa Quintana at NASA's Ames Research Center said she considers the planet to be more of an "Earth cousin" than a twin because it circles a star that is smaller and dimmer than our sun.

Currently scientists don't have enough data to say whether Earth's doppelganger has an atmosphere, but if it does; it probably contains a lot of carbon dioxide. So take a really deep breath before you take off your space helmet.

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The Sky this Month

Mercury reappears in the evening sky and is brightest during first half of the month. Passes between the Pleiades and Hyades on the 7th and 8th. Reaches greates elongation east (23°) on the 25th.

Venus is in the eastern morning sky low in the twilight. The waning crescent Moon passes north 2° on the 25th.

Mars is past its opposition and is well placed in the evening sky. Retrograd motion ends on the 21st.

Jupiter is low in the western evening sky in Gemini. Sets near midnight.

Saturn at opposition on May 10 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.

η-Aquariid Meteors peak 3 am on the 6th.

New Meteor Shower? peaking 3 am on the 24th. Predicted to radiate from Camelopardis this is debris from the recent Comet 209P/LINEAR.

Moon Phases

First Quarter	11:15 PM	May 6
Full Moon	3:16 PM	May 14
Last Quarter	8:59 PM	May 21
New Moon	2:40 PM	May 28

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Saturn

times bigger than Earth) gas giant is best viewed just an hour after sunset. That way it will be high enough to avoid Earth's image-destroying atmosphere near the horizon. You will find Jupiter in the constellation Gemini or just look for the brightest object in the western sky. Jupiter should remain visible until around midnight.

Both telescope and binocular viewers should be able to see the four Galilean Moons orbiting the planet. As usual the telescope will reveal the most detail, especially the contrasting weather bands that encircle old Jove.

Early risers who wonder what that bright object is in the East will be looking at Venus. About an hour and a half before the Sun comes up it will be dazzlingly bright like an aircraft landing light. Those with a telescope will be treated to the sight of a ¾ orb glowing like a light bulb. The reason Venus is so bright is that it is completely enshrouded in a curtain of reflective clouds. But these aren't ordinary clouds. They are composed of sulphuric acid. So when it rains, it hurts.

Mercury has made the transition from the morning sky to the evening. It will be visible in the western sky about 45 minutes past sunset. It will be near the star cluster known as the Pleiades, but far brighter. Binoculars will give you a good gander at both.

If you're interested in learning more about backyard astronomy, pick up a copy of Terence Dickinson's book *NightWatch*. It features excellent star charts, lots of info about the planets and more, all beautifully illustrated. Amazon has *NightWatch* for around $20. It's a small price to pay for a book that's virtually the bible for us backyard bug swatters.

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Osiris

from asteroid Itokawa.) Over the next few years the Huntsville team will build the spacecraft, flight instruments and ground system, as well as the launch support facilities.

The object of their affection is a small asteroid named Bennu. The mission's moniker is a tribute to NASA's acronym department — OSIRIS-Rex. That's short for Origins Spectral Interpretation Resource Identification Security. To me it sounds like a hybrid between the Egyptian God of the afterlife and a dinosaur. Perhaps rocket scientists think differently than you and me.

The expected launch date will be in 2016 and rendezvous with Bennu in 2018. After spending a year on the asteroid doing studies with its five onboard labs, it should return to Earth with a 60-gram sample from Bennu in 2023.

Once the sample is returned to Earth scientists will be able to perform more complex studies that will tell them more about the composition of the early solar system and water that made life possible on Earth. A sidebar to this is the fact that the mission will also allow scientists the opportunity to learn more about Near Earth Objects (NEOS) that could collide with us in the future.

Until we meet again by the backyard telescope keep your outdoor lights aimed and dimmed down. You'll save energy, money and our starry Kawartha night sky.

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KW Telescope
PERCEPTOR

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The Sun

place. So there might be 4 × 1026 watts of power put out, but that's spread out over 2.2 × 1025 cubic metres, meaning the Sun's energy output per-unit-volume is just 18 W / m^3. Compare this to the average human being, whose basal metabolic rate is equivalent to around 100 watts, yet takes up just 0.06 cubic metres of space. In other words, you emit 100 times as much energy-per-unit-volume as the sun! It's only because the sun is so large and massive that its power is so great.

It's this slow process, releasing huge amounts of energy per reaction over an incredibly large volume, that has powered life on our world throughout its entire history. It may not appear so impressive if you look at just a tiny region, but — at least for our Sun — that huge size really adds up!
Check out these "10 Need-to-Know Things About the Sun": http://solarsystem.nasa.gov/planets/profile.cfm?Object=Sun.
Kids can learn more about an intriguing solar mystery at NASA's Space Place: http://spaceplace.nasa.gov/sun-corona.

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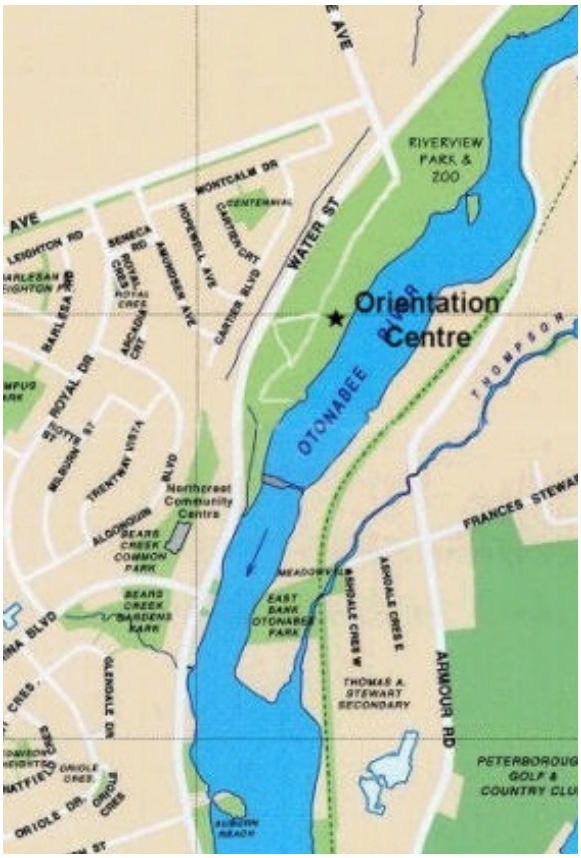
Articles

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 photso 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:
May 26, 2014



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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 annoucements will begin each meeting with the guest speaker starting at 7:30 p.m.