



A little science...A touch of fiction...A lot of adventure...

News from the Den

It's JULY! If you're a sports junky you are in heaven this month - it's the Yellow Jersey, the Venus Rosewater Dish, the Challenge Cup, the Claret Jug, the Club World Cup Trophy. If you have to ask what events these outstanding athletic achievements stand for - you're not a sports nerd. But it doesn't mean you can't enjoy the cycling, tennis, golf and football (soccer for all my heathen American readers). Beat the heat or cold and watch elite athletes compete for these prizes.

But, it's also time for US Independence Day. With the oohs and ahhs for the greens, reds and all so elusive blues, eclipsed by the nova-like, sparkling whites of the overarching fireworks on the night of 4 July. The first fireworks to celebrate US independence were launched on July 4th, 1777; one year after the signing of the Declaration of Independence. But, how are these amazing pyrotechnics produced? How has scientific advances over the last 1200 years made them safer, more complex, more spectacular? It all starts with 'black powder', invented by Chinese alchemists in 800 CE. A secret blend of potassium nitrate, charcoal and sulphur. Stuff this blend into a paper container, add a fuse, touch a match, and BOOM!

What happens inside the container to create the explosion? The sulphur melts first, flows over the potassium nitrate and charcoal catching them on fire, producing gases and energy (lots of energy - remember $E=mc^2$? A tiny bit of mass can produce a ginormous amount of energy). Place a small hole in the container in the correct spot and the produced gases from the burning components are funneled in a specific direction. *Voila* - the container is propelled skyward by the escaping gases and you have fireworks.

Today, modern firework designers use a mix of virtual modeling, engineered launching brackets (this is not your neighbors who try this at home), and computer circuits which map and time all the launches, using varying fuse lengths. Another advance is what we ooh and ahh over - it's all about color.

In the 1830's Italian firework makers began using potassium chlorate instead of potassium nitrate which increased the burning temperature by 300°C to 2000°C. This increase in temperature allowed them to add other chemical salts (which burn at higher temperatures) to the black powder mix. Strontium and lithium for deep reds, calcium for bright oranges, sodium which glitters yellow, and barium to burn a radiating green. However, with the addition of these salts, the firework makers created a host of problems. Fallout from strontium-red is carcinogenic. Barium is also toxic to biological life. Time for alternatives. In 2015, 5-amino-1H-tetrazole (the explosive compound found in automobile airbags) was substituted for strontium for red bursts. Green fireworks now contain boron carbide instead of barium to make the greens.

It is the most sought after color that is most difficult to achieve. The holy grail in all fireworks is the *perfect blue*. It must be bright enough to stand out against the black sky and not fade to white as it cools. So when you see a brilliantly dazzling blue explosion, tip your hat to the chemist who created the correct mixture-using the perfect combination of fuse length and copper gas. Since a gas is already in

the mix, this increases the total gas output on ignition. That is why blue fireworks tend to explode higher in the sky than others. ([BOOM!](#))

Latest science news - a new eye on the sky

On 23 July 1928 a baby girl was born to immigrant parents in Philadelphia Pennsylvania. Her name was Vera Florence Copper. Her father was born in Lithuania and immigrated to the US with his parents. He anglicized his name to Pete Cooper from Pesach Kobchefski and married Rose Applebalm (a Ukrainian immigrant). Both parents were employed at Bell Telephone as electrical engineers.

After a move to Washington DC, ten-year old Vera developed an interest in astronomy, even building her own telescope. With her new device, she began tracking meteors in the night skies. She attended Vassar College and studied under Maria Mitchell (discoverer of Comet 1848 VI). After graduating in 1948, she was refused entry to Princeton due to gender policy and she declined an offer from Harvard when she married Robert Rubin, then a graduate physics student at Cornell. At Cornell, she studied galactic dynamics under Martha Carpenter. Her physics course work was taught by several Nobel laureates - Hans Bethe and Richard Feynman. From the data she compiled during her graduate studies, she laid the groundwork for the existence of the supergalactic plane (the ecliptic about which all galaxies rotate within the universe) and noted deviations in Hubble flow (a calculation based on Hubble's Law which predicts how all galaxies should move). Her career spanned decades and numerous institutions. Most notable were Georgetown University, Carnegie Institute in Washington, Palomar Observatory, and her most important post was at the Vatican Observatory.

Dr. Vera Rubin was the first to note unusual motions of galaxies - stemming from her work on the Andromeda Galaxy and the discovery of the Rubin-Ford effect and rotational curves. This work all culminated in the amazing discovery that the outmost parts of galaxies move as fast as those closest to the galactic center. At the speeds of rotation she observed - galaxies should fly apart as the spin. (Think about spinning a baseball on the end of a rope above your head. The baseball is pulled away from you with higher and higher force as the rate of spin increases due to angular momentum). She calculated that the cumulative force of gravity of all the stars within the galaxy was not enough to hold a galaxy together. Conclusion: a large amount of unseen mass must be exerting a force upon the spinning galaxy. Up to ten times more mass than the galaxy contained would be needed to maintain galactic stability. She her observational data confirmed the existence of DARK MATTER.

We now know that the universe is made up of: 68% dark energy, 27% Vera Rubin's dark matter and less than 5% ordinary matter (the stuff we see and interact with makes up only this tiny part of the entire universe).

This month on top of Cerro Pachón in the Chilean Atacama Desert, the Vera C. Rubin observatory opened its eyes onto the universe. This gigantic video camera can produce a 3200-megapixel image every 3 seconds (your smartphone has about 12-megapixels). Each night of observation the 3-ton camera (which is about the size of a car) will gather 20 terabytes of optical data (176 trillion bits) in a 1000 images. As it scans the skies of the southern hemisphere, this observatory and its immense video camera will spin at high-speeds, estimates are it will discover over 90,000 near-Earth objects; create a detailed map of the Milky Way and its internal structure; map more than 20 billion galaxies and measure distortions in their shape which will tell astronomers about dark energy's impact on the universe's expansion; and witness more than 10 million supernovae.

Dr. Rubin's scientific discoveries were not easily won. At every turn, she had to battle against gender-bias. Fight for every minute of telescope time against her male colleagues. While at the Palomar Observatory in 1965, she was told her time on their telescope would be limited since they did not have a woman's restroom. This was a common 'out' used by observatories to refuse women access. Religion even stood in her way, during her time at Georgetown University, she was barred from meeting with her advisor in his office as women were not allowed in that area of the Catholic university.

Her scientific achievements and accomplishments tell us none of these barriers kept her from her research.

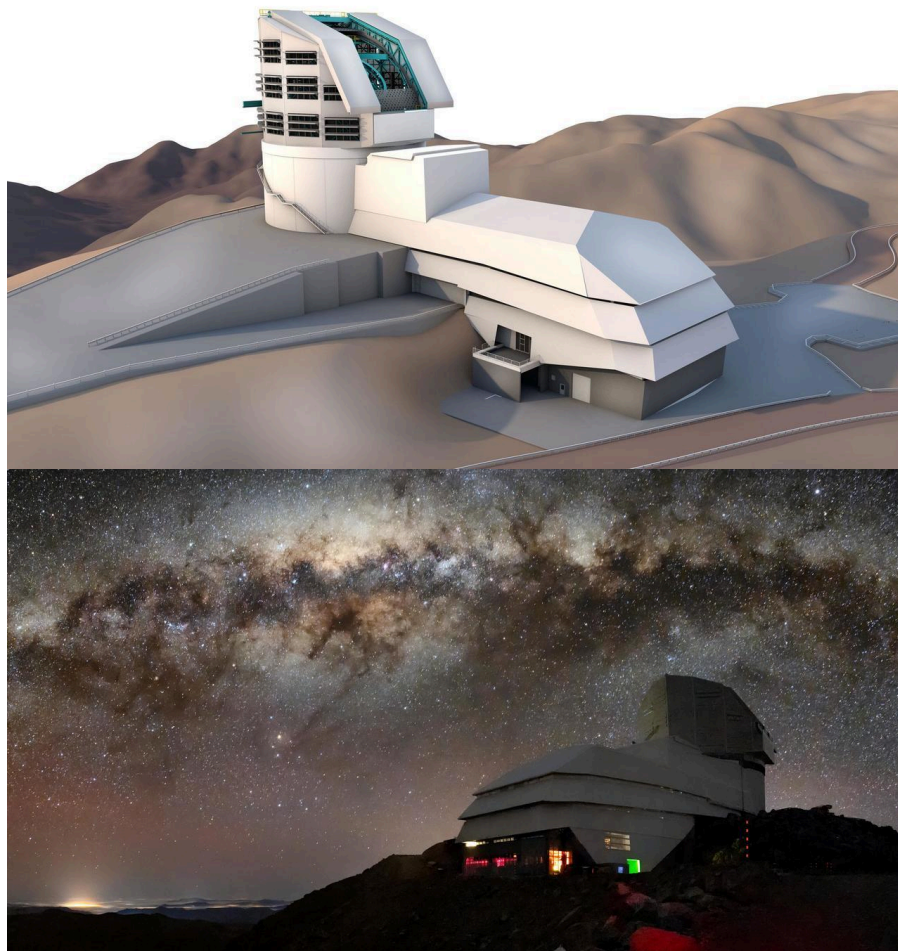
Besides laying the groundwork for the understanding of our universe, Dr. Rubin was an advocate for women in science stemming from the gross discrimination she experienced throughout her career. She also was a champion for science literacy. On her election to the National Academy of Science. She stated it was 'the saddest day of her life' - being selected to the ranks where so few women were highlighted.

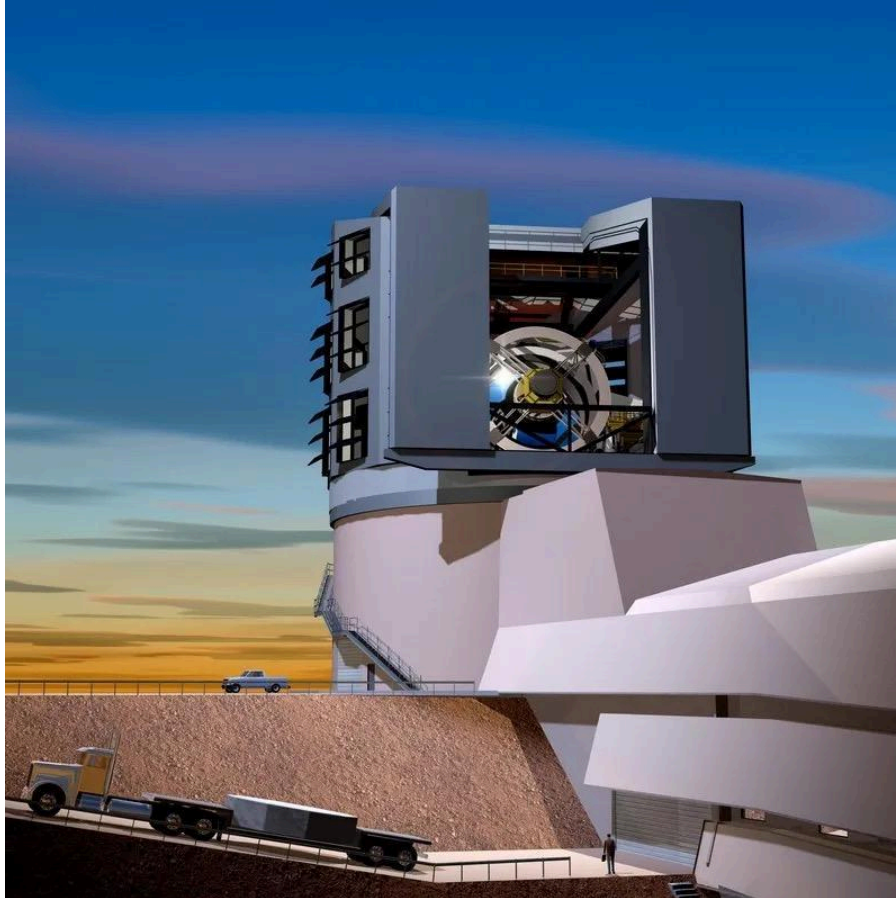
Hats off to Dr. Rubin and to the foundation she laid for the amazing work which will now be accomplished at the Vera C. Rubin Observatory in Chile!

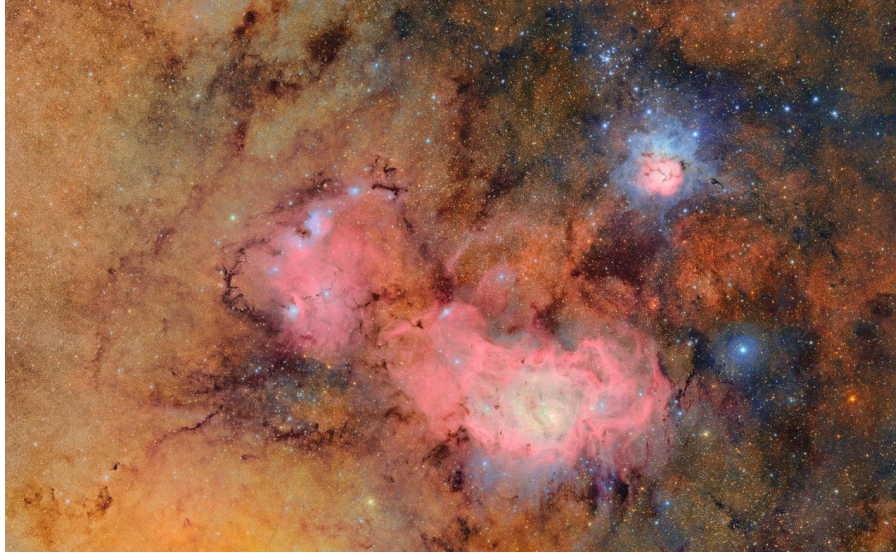
Rubin Quotation

"Don't let anyone keep you down for silly reasons such as who you are, And don't worry about prizes and fame. The real prize is finding something new out there."

Photos of the month







First Photo above: this aerodynamic design for the observatory looks more like a James Bond villain's lair than an astronomy observatory. The high winds across the top of Cerro Pachón can disrupt observational data, so the building was designed to minimize air turbulence. Credit: Science, vol. 388, issue 6753, p. 1259.

Second Photo above: The observatory and its target - the overarching Milky Way Galaxy. [The Observatory/Milky Way](#). Credit: Rubin Observatory/NSF/AURA/B

Third Photo above: The Mount Assembly with the 8.4-meter Simonyi Survey Telescope within the observatory. It will spin at high speeds on a three-dimensional gimbal - taking an image every 5 seconds. Credit: Rubin Marzo 2024 N°48.jpg

Fourth Photo above: The world's largest video camera is the 3-ton LSST Camera in the Rubin Observatory. Credit: Rubin observatory/gallery ([Photo Gallery](#))

Fifth Photo above: The first image after the Rubin 'eye' was opened to the skies of the Southern Hemisphere. Image of the Trifid and Laggon nebulae. The 5-gigapixel image combines 678 exposures taken in just 7.2 hours of observing time, and was composed from about two trillion pixels of data in total. Credit: Credit: NSF–DOE Vera C. Rubin Observatory

Science Book of the Month - *Vera C. Rubin, a Life*

This amazing biography by Jacqueline Mitton and Simon Mitton shares the amazing life of Dr. Rubin. Chosen as a *Physics Today* Best Book of the Year in 2021 it sheds light on how the observations which define the illusive dark matter were gathered and the struggles Dr Rubin went through to make them. It also extolls the support and encouragement this amazing astronomer gave to other women and advocacy for science literacy. ([VeraC.Rubin](#))

Minutiae

If you missed our announcement - we have a new publisher! Spectrum-books, London will reissue my books and publish all new Nexus Series volumes. Thanks to Andrew and his staff.

May your summer days be bright - your winter days be easy - enjoy some BBQ with friends - celebrate each other.

Just a reminder for our readers - we always provide the reference to the information shared - it's usually in a link. Make sure you click on the link if you're interested in learning more about the subject.

AI is never used in the design, construction or editing of our newsletters.

We'll be back next month with another installment. Be well, be kind. CA



Keep being curious,

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