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1. NASA's Van Allen Probes Show How to Accelerate Electrons

One of the great, unanswered questions for space weather scientists is just what creates two gigantic donuts of radiation surrounding Earth, called the Van Allen radiation belts. Recent data from the Van Allen Probes -- two nearly identical spacecraft that launched in 2012 -- address this question.

The inner Van Allen radiation belt is fairly stable, but the outer one changes shape, size and composition in ways that scientists don't yet perfectly understand. Some of the particles within this belt zoom along at close to light speed, but just what accelerates these particles up to such velocities? Recent data from the Van Allen Probes suggests that it is a two-fold process: One mechanism gives the particles an initial boost and then a kind of electromagnetic wave called Whistlers does the final job to kick them up to such intense speeds.

"It is important to understand how this process happens," said Forrest Mozer, a space scientist at the University of California in Berkeley and the first author of the paper on these results that appeared online in Physical Review Letters on July 15, 2014, in conjunction with the July 18 print edition. "Not only do we think a similar process happens on the sun and around other planets, but these fast particles can damage the electronics in spacecraft and affect astronauts in space."

Over the last few decades, numerous theories about where these extremely energetic particles come from have been developed. They have largely fallen into two different possibilities. The first theory is that the particles drift in from much further out, some 400,000 miles or more, gathering energy along the way. The second theory is that some mechanism speeds up particles already inhabiting that area of space. After two years in space, the Van Allen Probes data has largely pointed to the latter.

Additionally, it has been shown that once particles attain reasonably large energies of 100 keV, they are moving at speeds in synch with giant electromagnetic waves that can speed the particles up even more – the same way a well-timed push on a swing can keep it moving higher and higher.
"This paper incorporates the Whistler waves theory previously embraced," said Shri Kanekal, the deputy mission scientist for the Van Allen Probes at NASA’s Goddard Space Flight Center in Greenbelt, Maryland. "But it provides a new explanation for how the particles get their initial push of energy."

This first mechanism is based on something called time domain structures, which Mozer and his colleagues have identified previously in the belts. They are very short duration pulses of electric field that run parallel to the magnetic fields that thread through the radiation belts. These magnetic field lines guide the movement of all the charged particles in the belts: The particles move along and gyrate around the lines as if they were tracing out the shape of a spring. During this early phase, the electric pulses push the particles faster forward in the direction parallel to the magnetic fields. This mechanism can increase the energies somewhat — though not as high as traditionally thought to be needed for the Whistler waves to have any effect. However, Mozer and his team showed, through both data from the Van Allen Probes and from simulations, that Whistlers can indeed affect particles at these lower energies.

Together the one-two punch is a mechanism that can effectively accelerate particles up to the intense speeds, which have for so long mysteriously appeared in the Van Allen belts.

"The Van Allen Probes have been able to monitor this acceleration process better than any other spacecraft because it was designed and placed in a special orbit for that purpose," said Mozer. "The mission has provided the first really strong confirmation of what's happening. This is the first time we can truly explain how the electrons are accelerated up to nearly the speed of light."

Such knowledge helps with the job of understanding the belts well enough to protect nearby spacecraft and astronauts.

Source: NASA

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Rosetta’s Lander Facing an Unexpected Comet Shape: A Double Nucleus

It appears that Rosetta’s comet has a double nucleus. A video from the spacecraft speeding towards Comet 67P/Churyumov-Gerasimenko shows what looks like two lobes touching each other, which could send a small wrinkle in the plans to land Philae on the comet’s surface later this year.

The Planetary Society’s Emily Lakdawalla said she can hardly wait to see more views of the comet.

"The nucleus of the comet is clearly a contact binary — two smaller (and unequally sized object) in close contact," she wrote, adding the nucleus measures 2.5 miles by 2.17 miles.

"Philippe Lamy is quoted as estimating that the two components would have come into contact at a relative speed of about 3 meters per second in order to stick together in this way ... This unusual shape could present a navigational challenge for the Philae lander team.

"The CNES release quotes Philae navigator Eric Jurado,“ she continued, “as saying that ‘navigation around such a body should not be much more complex than around a nucleus of irregular spherical type, but landing the Philae probe [scheduled for November 11], however, could be more difficult, as this form restricts potential landing zones.’”

Source: Universe Today
Johnstown has seen its share of outsiders move in to the area, but one outsider, one that traveled more than 150 million miles to get there, will celebrate its 90th year since its arrival.

A meteor, which scientists now believe came from the solar system's second-most-massive asteroid called Vesta, crashed through the Earth's atmosphere, splitting into a shower of meteorites, with pieces landing in Johnstown, Milliken, Mead and other surrounding communities.

A meteorite made headlines on July 6, 1924, when a funeral procession was interrupted by falling interstellar rocks. One of the meteorites, weighing around 20 pounds slammed two feet into the earth near Dilley Chapel in a hamlet called Elwell, which has since been incorporated into Johnstown.

"Hundreds of Lovelanders saw and heard something Sunday afternoon which they had never seen or heard before and perhaps never will again," the Reporter-Herald said in an article published July 7, 1924. "With the rumble of a distant battle and the flare of a star shell a meteor streaked across the sky."
"Anyone who saw it is of course passed away by now. But we have some accounts from some people who were children," said Ardis Briggs, volunteer with the Johnstown Historical Society. "Some people thought it was the end of the world because it smelled like sulfur and the loud sonic boom."

"The people at the funeral saw it fall and create a crater and went and dug it up," said Denver Museum of Nature and Science curator of geology James Hagadorn, describing the intense sounds and sights that the Lovelanders of 90 years ago must have experienced. "To me, that's a pretty cool event to witness."

The July 8, 1924 edition of the Fort Collins Express-Courier described it as "staccato cracks like the noise of a machine gun" as the "visitor" hurled through the atmosphere, breaking up an Elwell baseball game "in a stampede."

Vesta, the brightest asteroid in the solar system, was named after the mythological virgin Roman goddess of home and hearth. It is currently one of six celestial bodies humans have physical samples of and in 1807 became the fourth asteroid to be identified.

"Many meteorites come from the Earth or Moon, or from the origins of those bodies," Hagadorn said. "There are around 100 meteor chunks from Mars, which are pretty rare. ... Vesta meteorites are even more rare."

It's only been in the last couple of decades that it was determined that the Johnstown Meteorite must have been formed under similar conditions that Vesta is thought to have been created. As a protoplanet, with layers similar to that of Earth, the asteroid has been linked to the meteorite because of its unique composition.

"They did a very good job identifying the composition back in the day. What they didn't know was what that composition meant," Hagadorn said. "Interpreting that data has only happened in the last couple decades."

The specimen falls into the achondrite class of meteorites, which makes up only 8 percent of meteorite samples recovered in the world. Increasing the rarity of the famed Johnstown Meteorite is the fact that there were witnesses to the meteorites falling.

"It's a local pride and is a sighted fall. Most meteorites fall, but aren't seen. This was seen by possibly hundreds of people," Hagadorn said.

"Another thing about this meteorite is that it's really pretty. When you cut and polish meteorites, it's a window into its composition," Hagadorn said. "Imagine a granite countertop, but instead of grays and blacks, it has green, yellow-orange and olive colored crystals. That's a potent color combo."

While a hiker who happens upon something as visually striking as that would certainly harvest the rock, Hagadorn said most people who run across Vesta meteorites in the area probably wouldn't notice it.

"When a meteor falls to the earth, that sucker burns. It looks like it's covered in black scales, like a burnt crust," he said, referring to what is known as fusion crust. "Keep your eyes peeled. There are probably hundreds of pieces still out there today in the field."

Anyone who comes across something they suspect might be a meteorite is encouraged to send photos to jwhagadorn@dmns.org, where the museum staff can help identify it. The Denver Museum of Nature and Science was one of the first museums in North America to study meteorites.

Pieces of the meteorite can be seen on display at the Denver museum and at the Parish House Museum, 701 Charlotte St. in Johnstown.

Source: Loveland Reporter-Herald

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3. OCO-2 Takes the A-Train to Study Earth’s Atmosphere

Every day, above our planet, five Earth-observing satellites rush along like trains on the same “track,” flying minutes, and sometimes seconds, behind one another. They carry more than 15 scientific instruments in total, looking at many different aspects of our home planet. Called the Afternoon Constellation, or A-Train, these satellites work as a united, powerful tool for advancing our understanding of Earth’s surface and atmosphere.

The train is about to get longer. NASA’s Orbiting Carbon Observatory-2 (OCO-2), which launched July 2, will be the A-Train’s sixth member. Its mission is to measure atmospheric carbon dioxide, a greenhouse gas that makes up a greater percentage of our atmosphere today than it has in at least 800,000 years. It will produce data that will help scientists analyze data from the other A-Train instruments. In return, other satellites will help validate its vital data.

“The A-Train constellation is an ideal measurement system for us,” said Dave Crisp, the leader of the OCO-2 science team at NASA’s Jet Propulsion Laboratory in Pasadena, California. OCO-2 will fly along the same path as NASA satellites CALIPSO (Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation) and CloudSat, which monitor minute particles in the atmosphere called aerosols, and clouds, respectively. “We’ve lined up the ground tracks of OCO-2, CALIPSO and CloudSat almost perfectly, and we’re hoping to keep them well aligned for as long as possible during the missions, so we can do the science we want with measurements from all three satellites,” Crisp said.
OCO-2 measures carbon dioxide by observing its effect on sunlight. Sunlight is made up of waves of many lengths, or frequencies, some visible and others invisible. As sunlight passes through the atmosphere, carbon dioxide and other molecules absorb specific frequencies in the spectrum of light, leaving dark, narrow gaps in the spectrum. The more light that has been absorbed in a certain column of air, the more carbon dioxide is present there. In some cases, this may suggest that Earth's surface beneath that air contains a source of carbon dioxide, like a large industrial city. Less carbon dioxide implies a “sink,” which absorbs carbon dioxide, like a thick forest during the growing season.

The OCO-2 spacecraft carries a single instrument composed of three spectrometers that measure different regions of the spectrum of light. One of these spectrometers observes the spectrum of molecular oxygen, referred to as the A-band spectrometer. This is important because molecular oxygen is a relatively constant fraction of the atmosphere and can be used as a reference for measurements of other atmospheric gases, such as carbon dioxide. In addition to being critical for calibrating the carbon dioxide concentrations, it also tells scientists how much sunlight is absorbed or reflected by the aerosols and clouds, features that CALIPSO and CloudSat observe.

“If we combine the A-band spectrometer’s measurements with information on aerosols and clouds from CALIPSO and CloudSat, we can use that information to estimate the amount of absorption of sunlight by these airborne particles, which is something we cannot currently do,” said Dave Winker, principal investigator for the CALIPSO mission.

CloudSat and CALIPSO also help clarify OCO-2’s data. The observatory uses its A-band spectrometer to find out how far sunlight has traveled before it reaches the satellite (its optical path) -- vital information for finding sources and sinks. A tiny mistake in the path-length measurement can introduce serious errors in the satellite’s carbon dioxide measurements. Often clouds and aerosols in Earth’s atmosphere reflect some sunlight back toward space before it reaches the surface, shortening sunlight’s path and confusing the spectrometer about the distance to Earth. But CALIPSO and CloudSat’s data about the location and height of aerosols and clouds can verify OCO-2’s path-length measurements and determine what kept the sun from reaching Earth’s surface.

“To check OCO-2’s accuracy, we can compare it to CloudSat and CALIPSO. These measurements are synergistic,” Crisp said. Winker noted, “From OCO-2’s point of view, CALIPSO is going to be very important in validating their measurement by correcting for cloud and aerosol effects. That these two satellites are flying together is a key part of the mission.”

The A-Train’s other satellites support OCO-2’s work, too. MODIS (Moderate Resolution Imaging Spectroradiometer), an instrument on the Aqua satellite, tracks cloud cover. AIRS (Atmospheric Infrared Sounder), another Aqua instrument, measures air temperature and the amount of water content in the atmosphere. To accurately measure carbon dioxide, scientists must know all those details.

Source: NASA
The Night Sky

**Tuesday, July 15**
- Vega is the brightest star very high in the east.
- Far down to its lower right shines Altair, almost as bright.
- Look left of Altair by about a fist and a half at arm's length, and a little lower, for dim, compact Delphinus, the Dolphin. It's leaping in the lower edge of the Milky Way.

**Wednesday, July 16**
- If you have a dark enough sky, the Milky Way now forms a magnificent arch high across the whole eastern sky after nightfall is complete. It runs all the way from below Cassiopeia in the north-northeast, up and across Cygnus and the Summer Triangle in the east, and down past the spout of the Sagittarius Teapot in the south.

**Thursday, July 17**
- The Big Dipper, high in the northwest after dark, is beginning to turn around to "scoop up water" through the nights of summer and early fall.
- The waning Moon, nearly at last quarter, rises around 11 or midnight and climbs high in the early-morning hours.
- Far in its background is Uranus, magnitude 5.8. Locate it with binoculars or a wide-field telescope.

**Friday, July 18**
- Last-quarter Moon (exact at 10:08 p.m. Eastern Daylight Time). The Moon rises around midnight tonight, shining in Pisces.
- Early Saturday morning before dawn, the faint asteroid 611 Valeria will occult an 8.7-magnitude star in Pisces for observers along a track crossing northern Mexico, Texas, the Deep South (including the Atlanta area) and the Carolinas.

**Saturday, July 19**
- Mars is still slightly less than 3° (two finger widths at arm's length) from Spica, but they're sinking lower in the southwest at dusk.

Source: [Sky and Telescope](https://www.skyandtelescope.com/)

*Just as twilight ends in the evening this week, the planet Mars and bright star Spica do a celestial dance. Antares and Saturn are nearby.*

Source: [Space.com](https://www.space.com/)

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ISS Sighting Opportunities (from Denver)

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Sighting information for other cities can be found at [NASA’s Satellite Sighting Information](http://www.nasa.gov).

**NASA-TV Highlights**  
(all times Eastern Time Zone)

**Wednesday, July 16**
- 5:15 a.m. Coverage of the Rendezvous and Grapple of the Orbital Sciences/Cygnus Cargo Craft at the ISS (Grapple scheduled at 6:39 a.m. ET) (all channels)
- 8:30 a.m. Coverage of the Berthing of the Orbital Sciences/Cygnus Cargo Craft to the ISS (NTV-1 (Public), NTV-2 (Education))
- 1:30 p.m. ISS Expedition 41/42 Video B-Roll of Crew Training (all channels)
- 2 p.m. ISS Expedition 41/42 Crew News Conference (all channels)

**Thursday, July 17**
- 8:30 a.m. ISS Expedition 40 In-Flight Event with KDVR-TV, Denver (all channels)

**Friday, July 18**
- 1:30 p.m. “The Next Giant Leap” event at the Jet Propulsion Laboratory, Pasadena, Calif. (will include an in-flight event with ISS Expedition 40 Flight Engineer Reid Wiseman of NASA at 1:50 p.m. ET) (all channels)

Watch NASA TV online by going to the [NASA website](http://www.nasa.gov).  

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Space Calendar

- Jul 15 - Comet 296P/Garradd Closest Approach To Earth (1.314 AU)
- Jul 15 - Comet P/2008 QP20 (LINEAR-Hill) At Opposition (1.997 AU)
- Jul 15 - Asteroid 6268 Versailles Closest Approach To Earth (1.601 AU)
- Jul 15 - Asteroid 4151 Alanhale Closest Approach To Earth (2.512 AU)
- Jul 15 - Asteroid 37452 Spirit Closest Approach To Earth (3.118 AU)
- Jul 16 - Rosetta, Trajectory Correction Maneuver
- Jul 16 - Comet 157P/Tritton At Opposition (3.824 AU)
- Jul 16 - Asteroid 2013 AB4 Near-Earth Flyby (0.087 AU)
- Jul 16 - Asteroid 13188 Okinawa Closest Approach To Earth (1.187 AU)
- Jul 16 - Asteroid 99905 Jeffgossman Closest Approach To Earth (2.658 AU)
- Jul 16 - Asteroid 334 Chicago Closest Approach To Earth (2.797 AU)
- Jul 17 - Cassini, Orbital Trim Maneuver #385 (OTM-385)
- Jul 17 - Comet 210P/Christensen Closest Approach To Earth (1.044 AU)
- Jul 17 - Comet P/2014 L2 (NEOWISE) Perihelion (2.221 AU)
- Jul 17 - Comet 275P/Hermann At Opposition (4.146 AU)
- Jul 17 - Comet P/2011 VJ5 (Lemmon) At Opposition (4.175 AU)
- Jul 17 - Asteroid 2011 PU1 Near-Earth Flyby (0.020 AU)
- Jul 17 - Asteroid 2014 MV41 Near-Earth Flyby (0.027 AU)
- Jul 17 - Asteroid 3355 Onizuka Closest Approach To Earth (1.289 AU)
- Jul 17 - Asteroid 6001 Thales Closest Approach To Earth (1.687 AU)
- Jul 17 - Asteroid 9500 Camelot Closest Approach To Earth (2.018 AU)
- Jul 18 - Comet 175P/Hergenrother At Opposition (2.413 AU)
- Jul 18 - Comet P/2007 V2 (Hill) Closest Approach To Earth (2.687 AU)
- Jul 18 - Comet P/2010 H5 (Scotti) Closest Approach To Earth (6.146 AU)
- Jul 18 - Asteroid 2014 MJ6 Near-Earth Flyby (0.088 AU)
- Jul 18 - Asteroid 11066 Sigurd Closest Approach To Earth (0.789 AU)
- Jul 19 - Comet 287P/Christensen At Opposition (2.156 AU)

Source: JPL Space Calendar
Food for Thought

45 Years Ago: July 20, 1969: One Giant Leap For Mankind

Apollo 11’s historic mission to the lunar surface 45 years ago blazed a new trail for human exploration beyond our home planet. Now, NASA is looking to extended humanity’s presence in space, building the new SLS rocket and Orion capsule that will send astronauts beyond low Earth orbit, to an asteroid, and eventually to Mars.

July 1969. It’s a little over eight years since the flights of Gagarin and Shepard, followed quickly by President Kennedy's challenge to put a man on the moon before the decade is out.

It is only seven months since NASA's made a bold decision to send Apollo 8 all the way to the moon on the first manned flight of the massive Saturn V rocket.

Now, on the morning of July 16, Apollo 11 astronauts Neil Armstrong, Buzz Aldrin and Michael Collins sit atop another Saturn V at Launch Complex 39A at the Kennedy Space Center. The three-stage 363-foot rocket will use its 7.5 million pounds of thrust to propel them into space and into history. At 9:32 a.m. EDT, the engines fire and Apollo 11 clears the tower. About 12 minutes later, the crew is in Earth orbit.
After one and a half orbits, Apollo 11 gets a "go" for what mission controllers call "Translunar Injection" - in other words, it's time to head for the moon. Three days later the crew is in lunar orbit. A day after that, Armstrong and Aldrin climb into the lunar module *Eagle* and begin the descent, while Collins orbits in the command module *Columbia*.

Collins later writes that *Eagle* is "the weirdest looking contraption I have ever seen in the sky," but it will prove its worth.

When it comes time to set *Eagle* down in the Sea of Tranquility, Armstrong improvises, manually piloting the ship past an area littered with boulders. During the final seconds of descent, *Eagle's* computer is sounding alarms. It turns out to be a simple case of the computer trying to do too many things at once, but as Aldrin will later point out, "unfortunately it came up when we did not want to be trying to solve these particular problems."

When the lunar module lands at 4:18 p.m EDT, only 30 seconds of fuel remain. Armstrong radios "Houston, Tranquility Base here. The Eagle has landed." Mission control erupts in celebration as the tension breaks, and a controller tells the crew "You got a bunch of guys about to turn blue, we're breathing again."

Armstrong will later confirm that landing was his biggest concern, saying "the unknowns were rampant," and "there were just a thousand things to worry about."

At 10:56 p.m. EDT Armstrong is ready to plant the first human foot on another world. With more than half a billion people watching on television, he climbs down the ladder and proclaims: "That's one small step for a man, one giant leap for mankind."

Aldrin joins him shortly, and offers a simple but powerful description of the lunar surface: "magnificent desolation." They explore the surface for two and a half hours, collecting samples and taking photographs. They leave behind an American flag, a patch honoring the fallen Apollo 1 crew, and a plaque on one of *Eagle's* legs. It reads, "Here men from the planet Earth first set foot upon the moon. July 1969 A.D. We came in peace for all mankind."

Armstrong and Aldrin blast off and dock with Collins in *Columbia*. Collins later says that "for the first time," he "really felt that we were going to carry this thing off."

The crew splashes down off Hawaii on July 24. Kennedy's challenge has been met. Men from Earth have walked on the moon and returned safely home.

Source: NASA
A galaxy about 23 million light-years away is the site of impressive, ongoing, fireworks. Rather than paper, powder, and fire, this galactic light show involves a giant black hole, shock waves, and vast reservoirs of gas. This galactic fireworks display is taking place in NGC 4258 (also known as M106), a spiral galaxy like the Milky Way. This galaxy is famous, however, for something that our galaxy doesn’t have -- two extra spiral arms that glow in X-ray, optical, and radio light. These features, or anomalous arms, are not aligned with the plane of the galaxy, but instead intersect with it.

The anomalous arms are seen in this new composite image of NGC 4258, where X-rays from NASA’s Chandra X-ray Observatory are blue, radio data from the NSF’s Karl Jansky Very Large Array are purple, optical data from NASA’s Hubble Space Telescope are yellow and blue, and infrared data from NASA’s Spitzer Space Telescope are red.

Source: NASA