Photo by Bit Cloud on Unsplash | Norway)

The Aurora Australis was visible over the whole country on May 11, 2024. This was a rare event, but with solar activity ramping up we may see more. **Guest writer Mike Stone** *explores the science of aurorae.*

What is an aurora?

Simply, an aurora is an ever-shifting display of coloured ribbons, curtains, rays, and spots in the night sky; in Aotearoa, the whole sky seems to be ablaze. This phenomenon tends to occur close to the poles – near the South Pole, it is known as Aurora Australis and near the North Pole as Aurora Borealis. In Aotearoa NZ the spectacle is more commonly observed in the south of the South Island.

Mātauranga Māori

Māori in the far south of the country have observed the aurora for hundreds of years. Ngāi Tahu calls the aurora Ngā Kurakura o Hine nui o te po, i.e. the rainbow or glowing lights of the goddess of darkness.[1]

The people of Wanganui called the spectacle Tahunui-a-rangi and interpreted the lights as the campfires of ancestors reflected in the sky. These ancestors had sailed southward in their waka and settled on a land of ice. Auroral displays let today's people know they will one day return.[2]

Being the southern-most part of Aotearoa, Stewart Island is an excellent place from which to see the southern lights – the Aurora Australis. The island's Māori name, Rakiura, translates as 'glowing skies'.[3]

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The solar cause

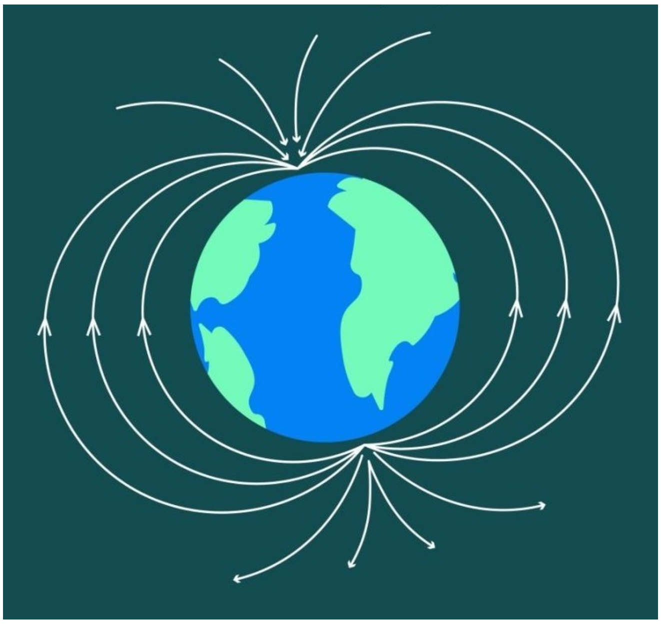
The sun is a huge ball of burning gases, mostly hydrogen, in the form of plasma, a heated gaseous mixture of hydrogen ions (bare protons) and electrons. These moving charged particles generate magnetic fields, which can become concentrated in areas called sunspots.

Sunspots are active, sending electromagnetic radiation into space as solar flares or as larger Coronal Mass Ejections (CMEs). The high-energy electrons and protons in CMEs travel outward from the sun at speeds of 250 – 3,000 km/s, taking from 15h to several days to arrive here.[4,5]

The sun is also constantly sending a stream of plasma towards the earth, called the solar wind, which varies in strength and speed.

The sun's activity (solar flares, sunspots and CMEs) increases and decreases over an 11-year period called the solar cycle. This cycle corresponds to times when the sun's polarity flips – its North Pole becoming the South Pole, and vice versa. In 2025, about halfway through this cycle, we expect a solar cycle maximum, when the sun produces about three CMEs every day (compared with about one CME every five days near solar minima).[6,7] So the solar cycle affects solar activity and, consequently, the intensity and frequency of auroral displays.

Its effect on Earth



Lines of Earth's magnetic field [Valerya Milovanova / Windy.app]

The effects of CMEs are hard to predict as the physics is complex. Even when we see an eruption on the sun, it's not clear if or when it will hit earth, or how strong the effects might be. It is only when the eruption arrives at monitoring satellites (e.g. DSCOVR) that we can gauge the strength of an impending geomagnetic storm. This may give us only 15-60 minutes' notice.[6]

A screenshot from a 2005 NASA animation showing the position of aurora near the North Pole

The movement of fluid in the earth's outer core creates a magnetic field around the Earth. The magnetosphere protects us from many types of solar radiation. When a CME arrives, it collides with Earth's protective magnetic field, triggering a series of complex interactions in the atmosphere.

The thermosphere is the layer of the atmosphere at 85 to 1,000 km above the planet. The lower thermosphere is mostly N_2 and O_2, but in the upper thermosphere atomic oxygen (O) is the dominant gas, created by light energy splitting the oxygens in O_3. This atmospheric layer protects us by absorbing a large amount of X-rays and UV radiation from the sun, so can get very hot (up to 2,000° C). This region is also called the ionosphere, as here the energetic solar radiation knocks electrons off molecules and atoms, turning them into ions.

The CME bombardment temporarily weakens Earth's magnetosphere, which enables charged solar particles to penetrate deep into the atmosphere at the poles. This excites molecules of gas, triggering vibrant, multi-coloured auroras at high latitudes.[8] Solar winds create most aurora seen near the poles, while CMEs lead to the occasional and more powerful aurorae that can be seen further from the poles.

Observing aurora

The protons and electrons in the CME collide with gas particles in the upper atmosphere, but it is the electrons that cause the greatest effect.[9] The atoms or molecules are excited by these collisions, and their electrons gain energy. The light creates the aurora that we see.

The colour depends on the particles that are being impacted and their altitude. Light emitted by excited oxygen atoms at lower altitudes (<240km) gives a yellow/green aurora, the most commonly seen colour. At higher altitudes, the oxygen concentration is lower and the O atoms emit red light. Excited molecules of N_2 emit purple light at higher altitudes and blue at lower.

All these colours are visible to the naked eye if the aurora is bright enough. However, they show up with more intensity in the camera lens. The colour sensors in our eyes (the cones) do not work very well in the dark – we tend to see in black and white. Cameras have the benefit of long exposure, so they spend more time collecting light to produce an image. As a result, they detect more colour in dimmer conditions.[11]

Aurora australis 6:20pm, 11 May, Owhiro Bay, Wellington. [Jeff Ng]

To find aurora

Unfortunately, the southern lights are not very predictable and you may get less than an hour's notice! To view an aurora, go to a place away from city lights and with few obstructions (e.g. a hill or beach) and look south from 10pm-2am. It will be best on a moonless night.[10]

As the southern lights are found around the South Pole, it makes sense that the further south you go in Aotearoa NZ the more likely you are to see the lights. Looking south and close to the horizon, expert Ian Griffin from Otago Museum says he sees a couple of aurora every week, on average.

The May event

The solar disk on May 11 showing the large sunspot AR3664. [Solar Dynamics Observatory, NASA]

From May 10 to May 12 (UT) Earth's magnetic field experienced a prolonged disturbance. It started when 4-6 CMEs slammed into our planet's magnetosphere one after the other at about 5am on May 11 NZT. These geomagnetic storms were launched by solar flares from a single, massive sunspot, named AR3664, which is more than 15 times wider than Earth (and visible with eclipse glasses). Most of these flares were X-class — the most powerful type of surface explosions the sun can produce.[8] On May 15 the same sunspot sent out another X-class eruption, but as it was no longer directly facing Earth it had little impact.[6,12]

Ocean Networks Canada detected a temporary weakening of Earth's magnetosphere from undersea sensors at depths of 2.7km.[13]

Another effect of this bombardments was vibrant, multicoloured auroras visible at latitudes much farther from Earth's polar regions than normal.[8] This geomagnetic storm also resulted in some minor power grid disruptions, radio blackouts and temporary interference to GPS and Starlink satellites.[6,8]

However, the effect in May 2024 was not the biggest we could expect; it was a one-in-twenty-year event, not a one-in-100-year event, according to Professor Craig Rodger from Otago University. He says that in 1921, a larger geomagnetic storm resulted in aurora being seen in Samoa.

By studying the sun's magnetic activity and developing forecasting models, we can better predict and prepare for such future events to protect people and technology – satellites can be put into safe mode to reduce damage and astronauts can delay their spacewalks.[14]

As the solar maximum is approaching, there is a good chance that we will experience more large disturbances over the next 18 months.[6,8] Keep an eye out (alerts for southern NZ are found here.)

Resources useful for the classroom

Videos: It missed us by 9 days
Catching the aurora
Comparative magnetospheres
An episode of the Secrets of the Universe
This NASA activity guide has some aurora activities
A citizen science project, Aurorasaurus

References/endnotes

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Aurora australis 02:21am, 12 May, Loch Cameron, Twizel [Mike White]