Auroral display dazzles millions around the globe

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The aurora borealis and aurora australis (commonly known as the northern lights and southern lights, respectively) visible Friday, Saturday and Sunday nights brought forth enormous widespread interest in the astronomical phenomenon. Millions have followed news reports, watched videos and shared their own images of the display on social media.

Aurora are generated through the complex interaction between charged particles emitted by the Sun and Earth's magnetic fields. These particles, mostly electrons and protons, are captured in Earth's magnetic field, which resembles a giant version of that surrounding a common bar magnet, and rain down on the upper atmosphere. The particles then collide with and excite atoms and molecules in the atmosphere, which in turn release various colors of light, ultimately producing the dazzling displays so many have seen.

For those living in higher latitudes in Canada, Norway and Siberia on Earth's Northern Hemisphere and the southern parts of Australia, New Zealand, Chile, Argentina and South Africa, aurora are a somewhat more common occurrence. Charged particles from the Sun are constantly bombarding Earth in the form of the solar wind and thus faint aurorae are often present in the regions surrounding the poles.

The most common color of aurora is green, which occurs when oxygen atoms in the thermosphere (60–120 miles above the sea level) are hit and then emit light. The rare red occurs when oxygen is hit at even higher altitudes, while the pink often seen is produced by emissions from nitrogen molecules at lower heights.

The particle wind from the Sun, however, is not constant. Scientific study of the Sun began with Galileo, who made the first detailed observations in 1612 of sunspots on its surface using a telescope and mapped their motion across its disk. The presence of an 11-year "solar cycle" in which sunspot numbers rise and fall was first identified in 1843 through the work of German astronomer Heinrich Schwabe and Swiss astronomer Johann Rudolph Wolfe.

Exactly how actions in the Sun's atmosphere could affect the Earth's aurora awaited developments in physics to explain both these events themselves. In 1896, Dutch physicist Pieter Zeeman showed that magnetic fields could change and split the distinct colors of light emitted by a hot gas as viewed through a spectroscope, which separates colors. In 1908, American astronomer George Ellery Hale observed this splitting in the light emitted by sunspots, showing magnetic fields up to thousands of times higher than that at the Earth's surface were present within them. Over the 20th century, studies of radio propagation in Earth's atmosphere made it clear that solar flares resulted in the Sun's emitting energetic particles, which produced changes in radio communication.

Sunspots are heralds of these far more energetic events, solar flares. A solar flare is thought to be the result of a collapse or snapping of magnetic fields on the Sun, which produces a colossally intense burst of radiation and throws out electrons, protons and heavier ions, the lightest of these, the electrons, having some accelerated to near the speed of light.

Solar flares are often, but not always, associated with coronal mass ejections (CMEs). This second type of energetic event involves the ejection of vast clouds of plasma and their related magnetic field from the Sun's atmosphere. The ejections are already many times the size of Earth at their occurrence and grow to tens of millions of miles in size by the time they reach our distance from the Sun.

Only in the space age, on December 14, 1971, would the Orbiting Solar Observatory 7 spacecraft actually image a CME leaving the Sun, something which happens at a small scale almost daily. Today there is a whole fleet of spacecraft which observe the Sun and the resultant "space weather," including the flagship Solar Dynamics Observatory and the venerable Solar and Heliospheric Observatory.

The relatively new Parker Solar Probe takes images of the Sun's atmosphere from within the solar atmosphere itself, a region which the spacecraft survives only through truly ingenious engineering and flight planning.

And while solar flares and CMEs are common, they mostly head into empty space. On occasion, however, they do hit Earth and cause a shock to the planet's magnetic field known as a geomagnetic storm.

The aurora on Friday and Saturday were caused by five successive CMEs that erupted from the Sun, three of which hit Earth. They induced a geomagnetic storm strong enough to produce aurora visible in the northern hemisphere, as far south as Puerto Rico. A sixth CME was expected to make an oblique impact on Earth Sunday but had not yet registered as of this writing.

Perhaps most significantly about the weekend's aurora, however, was the mass social character of the event. In the past, photographs of the aurora were mostly taken by professionals with specialized cameras and lenses. Today, many if not most of the nearly 7 billion smartphones in use can take a 5-second exposure revealing the green, pink and red (and sometimes blue) hues.

They elicited a certain wonder in the natural world and connection with other humans. Workers and young people in the United States and Russia were witness to the same aurora, despite the drive by the respective ruling elites to vilify the other country.

The effects of geomagnetic storms are, however, not always benign. On September 1, 1859, British astronomers Richard Carrington and Richard Hodgson made the first observations of a solar flare, when a brilliant white spot appeared on a sunspot as they observed it and changed its appearance and location within the sunspot over a five-minute period. Just 17.6 hours later, the most brilliant auroral display historically recorded began, reaching almost to the Equator.

Those aurorae, however, were accompanied by widespread failures of telegraph lines, the most advanced form of communication at the time. Operators received shocks, telegraph pylons sparked, and some lines even caught fire.

More recently, a geomagnetic storm on March 13, 1989 knocked out the Hydro-Quebec power grid, shutting off power for millions of Canadians on a day when the temperature low for that day was 23 degrees Fahrenheit (-5 Celsius). That same storm also threatened to take down the power grid for the 150 million inhabitants of the US Northeast.

And on July 23, 2012, an eruption on the Sun was observed that was comparable to the Carrington event. It ultimately missed Earth, and studies in 2013 estimated that if it had hit, the economic cost to the United States alone would have been between $600 billion and $2.4 trillion. A study from China predicted that it would have taken four to 10 years to recover from the disaster.

Such issues are, in the final analysis, not scientific but social and political questions. The dangers of such storms to world power grids has been known for decades, but the cost of updating the grids has, for the bourgeoisie, always been cost-prohibitive. Moreover, a truly scientific plan for generating electricity would involve power generation and distribution that knows no national boundaries, because the dangers posed by natural phenomena know no such artificial lines. As with all problems of modern society, capitalism is the main barrier of genuine progress.