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Sunny Devastation: The Carrington Event of 1859

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Sunny Devastation

The Carrington Event of 1859

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As luck would have it, the largest solar storm in recorded history was the first one ever observed, and it was spotted accidentally. The year was 1859, and famed British astronomer Richard Christopher Carrington happened to be tracking sunspots, dark areas on the sun's surface. Suddenly, two blindingly radiant white lights — more intense than any previously observed solar activity — appeared above the sunspots. Within five minutes, the extreme white lights had disappeared, and all seemed to be normal.

The effects of the massive solar storm, named the Carrington Event, did not reach the Earth until the next day. However, most effects of this huge solar event were mild, the largest of which was that people living as far south as the Caribbean islands experienced an aurora's magnificent display of swirling colors. Meanwhile, telegraph lines sparked, shocking operators and setting office papers on fire.

The Carrington Event, like most solar storms, can be broken down into two major components: a solar flare and a coronal mass ejection (CME). This first component is caused by explosive activity on sunspots, which are concentrated in active regions of magnetic activity on the sun's surface. The first emission of a solar flare consists of low-energy x-rays and ultraviolet radiation. In the second part of the solar flare, a radiation storm of high-energy waves and a small amount of charged particles — mainly protons and electrons — are released.

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However, most of the magnetic radiation released by a solar flare does not escape the sun's gravitational pull. Instead, gravity bends the magnetic currents and many of the released particles back towards the sun's surface. Sometimes the magnetic currents cannot handle the pressure caused by the bending, so they snap, releasing into space billions of charged particles. These discharges are theorized to be the origin coronal mass ejections, though not all scientists currently subscribe to this theory. If a CME is not directed at Earth, our planet is not significantly affected. However, if Earth is in the CME's pathway, such as it was during the Carrington Event, devastating effects can occur.

While the types of emissions released by solar storms have not changed since 1859, technology has changed drastically. Because of technological advancements, a Carrington Event-sized solar storm today would be much more harmful than it was 150+ years ago. The worst effects of the 1859 Carrington Event were a few shocked telegraph operators and some people waking up in the middle of the night to an abnormally bright and colorful sky. One might assume that since the largest solar storm ever recorded did not cause any catastrophes, then we do not need to worry about solar storms. Unfortunately, this is not the case. Even though the Carrington Event was more of a scientific marvel than a natural disaster, this is only because of the specific context of the storm. In 1859, there were not extensive power grids and electrical wires, any satellites orbiting the Earth, or any astronauts aboard the not-yet-existent International Space Station. With today's reliance on certain technological systems, we have much more to lose.

Each stage of the solar storm has the ability to damage humans in a different way. The first solar emissions to hit the Earth are the soft, low-energy x-ray waves and ultraviolet radiation. When these waves reach our planet, they ionize and expand the ionosphere, the top layer of our atmosphere, which reflects radio waves and makes radio communication possible. Thus when the ionosphere is disrupted, so too is radio communication. Since radios were not invented until 1895, this was not an issue during the 1859 Carrington Event. Contemporary society, however, would find such a disruption more devastating, as many mediums of communication, such as cell phones and television, would be interrupted by such a disturbance. Additionally, when the

ionosphere expands, it sometimes extends far enough to reach orbiting satellites, giving them more drag. This can cause the affected satellites to fall back to Earth sooner than they typically would.

Minutes to hours after the solar flare's first particles hit, the second part of the emissions reach Earth. These higher-energy waves and small amount of charged particles are not numerous enough to penetrate Earth's atmosphere. However, if astronauts at the International Space Station are doing work outside in their space suits, they are vulnerable to the incoming radiation. If these emissions arrive only a few minutes after the solar flare is detected, astronauts may not have enough time to retreat into the safety of the shielded space station. Instead, they may receive a

damaging dose of radiation, which would have a significant impact on their DNA.

The CME stage of the solar storm is the most harmful to people on Earth because CMEs occupy a larger area and carry more charged particles than solar flares. Additionally, during the three to five days it takes a CME to reach Earth, the number of particles in the CME actually increases. As the particle cloud hurtles towards our planet, the accompanying shock wave constantly creates more of the dangerously charged particles. When the CME finally hits, it creates a geomagnetic storm that disturbs Earth's magnetic field and causes a positive-charged change in the electrical field.

Satellites hit by a CME can be damaged in two possible ways. First, the charged particles that bombard the satellite can penetrate the device and damage it internally, because free protons and electrons are extremely reactive. Secondly, the satellite can become electrically charged via the induced electrical field, making it vulnerable to high currents and eventual electrical discharge. Damage to these satellites would cause long-term dysfunction of GPS and other communication systems such as cell phones and credit card transactions. These systems would be offline until the necessary satellites could be repaired or replaced, which could take months.

Many people have become so reliant on these technologies that having a stretch of months or years without them would severely limit global communication and transportation. The fallout would have negative effects on international economy; for example, transporting goods between countries would be much more difficult without GPS, and paying for these goods would be more complicated as the money could not just be wired as per usual. Additionally, one estimate calculates the possible damage to satellites to cost between $30 billion and $70 billion. Since many satellite programs are publicly funded, this would be a huge cost to various governments and, by extension, to taxpayers. There would also be a significant burden on the average citizen who is unable to, for instance, use a cell phone to call for an ambulance when an emergency occurs outside the home.

The other major concern about CMEs is how they could damage power grids worldwide. The induced electrical field that solar storms create can overload high-voltage transmission lines and transformers, essentially causing them to fry. With our current, highly interconnected electrical grid configuration, a solar storm as large as the Carrington Event could destroy so many transformers and power lines that it would take years for power to be fully restored. The costs of repairing such a widespread power failure could be trillions of dollars.

To create effective mitigation and preparation strategies for solar storms, we must first know the likelihood of another Carrington Event-sized storm occurring, an extremely divisive subject among specialists. One prominent researcher, Pete Riley, predicted in 2012 that there was as high as a 12 percent chance that another Carrington Event-sized solar storm would occur in the next ten years. This seems to be the most quoted statistic in the field right now, but some specialists question the mathematics behind the calculation. Much of the uncertainty derives from the fact that we have only known about the existence of solar storms for about 150 years, so we do not have much evidence gathered from direct observation. Additionally, one of the major techniques currently being used to research historical solar storms is studying solar particles preserved in ice cores, but many scientists argue that this method is inaccurate or, at least, not well-tested.

We cannot prevent solar storms from occurring, but we can prepare for them by developing mitigation strategies. It would help to be able to predict when solar storms will occur, but we currently do not know enough about how these storms are caused to be able to do so. Instead, it is best to focus on reducing the amount of possible satellite and power grid destruction that could occur, as these are the two largest threats of solar storms. Since we cannot protect the satellites in orbit from radiation, drag, or induced electrical currents, the most effective strategy to combat the possible destruction of satellites is to have replacement satellites already built and on standby for if solar storms destroy the active satellites. In terms of the power grid, steps should be taken to prepare for the induced electrical field, such as by adding more ground resistors to the most high-risk transformers.

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The magnitude of the Carrington Event of 1859 may have been a solar weather anomaly, or it may be a sign of what to expect in the future. Regardless, the gravity of the risk must not be underestimated by the minor effects of the Carrington Event; although that 1859 solar storm did not cause much damage, the technological systems in place today could be detrimentally affected by a comparable solar storm. The risk of solar storms must be acknowledged, from the radio communication disruption and potential radiation poisoning of astronauts, to the destruction of satellites and power grids by CMEs. Furthermore, steps must be taken to protect the technological systems in place for that day in the future when a mammoth solar storm could strike again.