**More solar storms brewing after last week’s aurorae as Sun ‘wakes up’**

On Friday night, people from across the world were treated to a rare spectacle: vivid aurorae hanging like curtains of light in the sky. They appeared even in places where aurorae aren’t usually visible. For instance, people at the Indian Astronomical Observatory spotted an aurora over Hanle in Ladakh — far away from places near the poles, where they are a more common sight.

“I haven’t seen anything like this in the last 20 years,” says Dibyendu Nandi, a space physicist at the Indian Institute of Scientific Education and Research (IISER), Kolkata.

Beautiful though the aurorae are, the events on the Sun that produce them can trigger blackouts on the earth, knock out satellites in space, endanger the lives of astronauts, and affect space weather throughout the Solar System. Studying, understanding, and, in future, predicting them is thus a key goal of solar physics research.

Approaching the peak

Aurorae like these are created when some violent events on the Sun’s surface throw up a mass of charged particles into space. A geomagnetic storm happens on the earth when these particles become trapped in the planet’s magnetic field and interact with atoms in the upper atmosphere. These interactions finally produce aurorae.

These storms are rare, occurring around once every few decades. The last time charged particles from the Sun blew into the earth with similar energy and intensity was in 2003. And both events happened as the Sun was nearing the peak of its solar cycle — an 11-year period during which the star’s magnetic field flips.

The peak is when the flip actually happens, creating magnetically active patches on the star’s surface called sunspots. These sunspots grow and shrink as solar cycles begin and end. The charged particles that struck the earth on May 10 are rooted in events at these sunspots. “This is definitely a sign that the Sun is ‘waking up’ and is becoming more active, especially compared to the last solar cycle,” Jonathon Eastwood, a space physicist at Imperial College London, the U.K., said.

In the last solar cycle, which spanned the 2010s, no sunspot gave rise to a geomagnetic storm that matched the intensity of that on Friday.

Since early May, scientists have been monitoring the sunspot AR 3664. It was growing in size: by May 7, it was 16-times as wide as the earth and brimming with magnetic energy.

The supercharged magnetic fields in such sunspots sometimes disconnect and reconnect in fractions of a second, releasing a great burst of energy that sends plumes of charged particles called coronal mass ejections (CMEs) into space. On May 10, three CMEs struck the earth.

CMEs happen together with solar flares — powerful flashes of radiation — and all these active events are collected under the term ‘solar storms’.

Surging currents

Magnetic fields deflect charged particles, but the earth’s couldn’t prevent many of the particles from slipping through to locations close to the planet’s magnetic poles. Here, their interactions with oxygen atoms in the upper atmosphere produced vivid red light, and with oxygen, and nitrogen in the lower atmosphere producing green and purple light, respectively. Thus, the world had its aurorae.

On May 10, a few space-weather forecasters — including the Center of Excellence in Space Sciences India (CESSI) at IISER Kolkata — warned of potential power disruptions.

The fluctuations in the earth’s magnetic field during a geomagnetic storm can send currents surging through cables, like what happened in Sweden and South Africa in 2003.

“These storms can also affect satellites in orbit on which our communication and GPS navigation networks depend,” Dr. Nandi, who also heads CESSI, said.

CESSI is the only Indian institute that provides timely updates on space weather.

Early warnings matter

This is not the worst geomagnetic storm to have ever struck the earth. In 1859, the Sun spouted a strong solar flare and triggered a super-geomagnetic storm on the earth, the most powerful in history. Telegraph wires either caught fire or were able to operate without a power supply (because they drew on the current surges produced by the storm).

Dr. Nandi said such storms — which CESSI would have categorised as ‘extreme’ — are likely to occur once every few centuries. The May 10 geomagnetic storm was ‘severe’ on CESSI’s scale, and caused only minor power grid irregularities and GPS disruptions.

In high-latitude countries such as New Zealand, power grid operators switched off local circuits to prevent outages. According to Dr. Nandi, these are some ways by which early warnings from space-weather forecasters made a difference.

He also said the solar storm that struck the earth had weakened by May 12, but that it may be too early to say the storms are subsiding altogether. For example, CESSI flagged moderate storms on May 13 as a result of an earth-bound CME that erupted on May 11.

Waiting for Aditya

Space scientists have long wanted to anticipate a solar storm before it even begins brewing. Currently, the best they can do is catch a CME and/or flares as soon as they happen.Many spacecraft that monitor the Sun for these events are parked in the L1 point in space, about 1.5 million km in the earth-Sun direction, from where they have an uninterrupted view of the star. One of these spacecraft is Aditya-L1 of the Indian Space Research Organisation (ISRO), which reached L1 in March this year.

The principal investigator of its primary instrument, the Visible Emission Line Coronagraph (VELC), told The Hindu it is still being calibrated, so it hasn’t chimed in on the events since May 10.

Of the other instruments: ISRO said on May 14 the ASPEX payload had “captured the enhancement of the alpha particle and proton flux of the solar wind” as signatures of the solar storm. It also said the SoLEXS and HEL1OS payloads had detected “the multiple X- and M-class flares … during the last few days”. The Chandrayaan-2 orbiter around the moon also reportedly detected “signatures” of the emissions from the Sun.