INQUIRIES OF HEAVEN

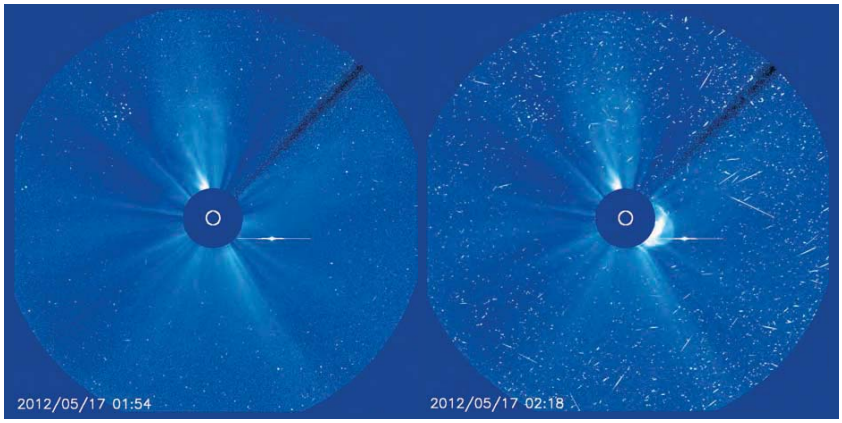
IAU 28TH GENERAL ASSEMBLY, BEIJING, CHINA, AUGUST 20 - 31, 2012 WEDNESDAY, AUGUST 29, 2012 DAY 8

A Tell-Tale Sign of a Wimpy Solar Cycle: the First GLE Event of Solar Cycle 24

Sudden spikes of energetic particle events from the Sun superposed occasionally on the cosmic ray background are known as ground level enhancement (GLE) events because these particles can be detected by neutron monitors and muon telescopes on the ground. These protons interact with air molecules and produce secondary neutrons and muons that are detected at the ground level. GLEs are the highest energy (~GeV) component of the normal solar energetic particle events accelerated by shock-driven ultra-fast (2000 km/s) coronal mass ejections (CMEs). Typically about 15 GLE events occur in a solar cycle (cycle 23 had 16 GLEs).

The current cycle 24 has produced only one GLE event so far on May 17, 2012, whereas cycle 23 had produced five of the 16 GLEs in the first 4.5 years. The Sun is already in its solar maximum phase, which means it did not produce any GLE event during its rise phase. Thus the cycle 24 seems to be extremely poor in producing GLE events so far.

The May 2012 GLE event was weaker than all the GLE-associated flares of solar cycle 23. There were eight other flares originating from the western hemisphere of the Sun in the longitude range 55-85 degrees favored for GLE origin, but none of them was associated with a GLE event. On the other hand the CME itself is very fast (2000 km/s) and formed a shock at a distance of 230 megameters above the surface based on the radio signatures. The GLE particles were released when the CME reached a height of about 930 megameters above the surface. This additional distance is needed for the shock to gain strength and accelerate protons to GeV energies. Images from the Solar Dynamics Observatory (SDO) revealed that the May 2012 CME overtook a hot plasma (> 6 MK) ejected some 40 minutes before. The preceding hot plasma implies the presence of particles that were already energized, making it easy for the shock to accelerate them to higher energies.



The coronal mass ejection (CME) on 2012 May 17 that produced the first Ground Level Enhancement (GLE) event of solar cycle 24. The images, separated by 24 minutes, show the fast CME above the southwest limb of the Sun. The white circle in the center is the size of the Sun and provides the scale to the images. The white streaks appearing all over the image on the right along with the CME are the energetic particles reaching the telescope and creating additional signal in the detector. [Images taken by the Solar and Heliospheric Observatory (SOHO) mission. Courtesy: ESA and NASA]

The lone GLE event is consistent with a weak cycle 24: the sunspot number peaked at 97 compared to 170 in cycle 23, indicating that cycle 24 is 40% weaker. The weakness of the cycle can be attributed to the weak polar magnetic field during the prolonged minimum between cycles 23 and 24. According to the Babcock-Leighton solar dynamo model, what goes in the polar region comes up as the sunspot activity. Thus a weaker input during cycle 23 must have resulted in the weaker sunspot activity in cycle 24. There have been suggestions that the solar activity might continue to decline over the next couple of cycles, approaching a global minimum in the middle of the 21st century. Such global minima were discovered by the American scientist John Eddy in 1976 who named the deepest such minimum, during the years 1645 to 1715, the Maunder minimum. ■

Nat Gopalswamy
Staff scientist at NASA's Goddard Space Flight Center (GSFC), and President of ICSU's Committee on Solar Terrestrial Physics (SCOSTEP) and IAU commission 49.