“Rogue” sunspots spoil chances for long-term space weather forecasting

Melinda Nagy

The Sun’s spots and the eruptions associated with them wax and wane cyclically, with a period of roughly 11 years. The intensity of these solar cycles, however, is extremely variable. There were periods in the past, known as grand minima, when virtually no sunspots appeared on the Sun for several decades. In contrast, in the second half of the past century we were witness to a series of very strong cycles, known as the Modern Maximum. The Modern Maximum abruptly came to a halt with the ongoing solar cycle where activity only reached much lower levels.

Forecasting these large cycle-to-cycle variations is the Holy Grail of solar dynamo theory, the discipline studying the ultimate origin of solar activity. Recent years have seen significant advances in our understanding of the factors driving these variations. Disappointingly, however, these advances have also pointed that there inherent limits to the predictability of the behaviour of the dynamo, due to the fact that the emergence of individual sunspots is a haphazard process obeying statistical regularities only. A group of researchers associated with the Max Planck Institute for Solar System Research (MPS) in Göttingen, led by Senior EPSD Prize winner Manfred Schüssler and working in collaboration with Jie Jiang (Beijing Astronomical Observatory) found that certain large sunspots, emerging at the wrong place at wrong time may even deflect the whole further course of history, bringing major changes in solar activity. This indeed, may have been the cause of the abrupt end of the Modern Maximum.

Leading a team of researchers from Eötvös University, Budapest (ELTE) and the University of Montreal, Melinda Nagy (ELTE) has now reported at the ESPM-15 meeting even more extreme effects of large active regions that, by sheer chance, happen to disobey the overall statistical regularities of the sunspot cycle. In a dynamo model designed to carefully mimic the actual behaviour of the Sun they found that some of these “rogue” sunspots are capable of completely suppressing the solar cycle, thereby inducing a Grand Minimum. As Kristóf Petrovay, head of the ELTE group explains, the enormous amount of magnetic flux contained in these spots is ultimately transported to the Sun’s polar areas where it can offset the global magnetic dipole field, leaving no seed field for the dynamo to amplify in the following solar cycles.

These results seem to indicate that the possibilities forecasting solar activity, especially on the long term, may be limited, especially as far major, abrupt changes are concerned. Events like the onset of a Grand Minimum or an unusually strong “freak” solar cycle (like the cycle that peaked in 1957) may prove to be impossible to predict more than a few years ahead -much to the chagrin of solar and space researchers.