5th Asia-Pacific Conference on Plasma Physics, 26 Sept-1Oct, 2021, Remote e-conference

Predicting the Solar Magnetic Cycle

Dibyendu Nandy[1,2]

[1] Center of Excellence in Space Sciences India, Indian Institute of Science Education and Research Kolkata, India [2] Department of Physical Sciences, Indian Institute of Science Education and Research Kolkata, India

e-mail (speaker): dnandi@iiserkol.ac.in

The dynamic activity of the Sun modulates the radiative, particulate and magnetic environment in the solar system creating space weather. Space weather critically impacts satellite operations and space-reliant technologies such as telecommunications, navigational networks, is hazardous to astronaut health and can impact electric power grids and air-traffic over polar routes. Slower long-term variations in solar radiative and wind output define space climate and the state of the heliosphere, forcing planetary atmospheres and climates.

It is now widely appreciated that solar activity variations that determine space weather and space climate originates due to a magnetohydrodynamic dynamo mechanism that relies on complex interactions between plasma flows and magnetic fields in the Sun's interior.[1] Understanding this dynamo mechanism is therefore of paramount importance. It is expected that this understanding would lead to more accurate predictions of the solar magnetic cycle; however, this has remained an outstanding challenge in solar physics.

While a wide variety of techniques have been utilized to predict the solar cycle, these have often resulted in divergent forecasts. An analysis of predictions for sunspot cycle 24 and the upcoming sunspot cycle 25 are critically assessed. The analysis shows that while predictions based on diverse techniques disagree across solar cycles 24–25, physics-based predictions for solar cycle 25 converge and indicates a weak to moderately weak sunspot cycle. [2]

In this review we discuss solar cycle predictions across solar cycles 24-25 and present the recent progress in understanding the physical basis of solar cycle predictability. [3]

In particular, we argue that the convergence in physics based predictions for Solar Cycle 25 is indicative of progress in the fundamental understanding of what drives solar cycle fluctuations over decadal timescales. We demonstrate that models based on the so called Babcock-Leighton mechanism for solar poloidal field generation are able to capture the essential variability of the sunspot cycle. We also argue that the dynamic memory of the solar dynamo is short and persists from one cycle to the next cycle only, and therefore, long-term multi-cycle forecasts are precluded by our current understanding.

Based on recent insights, resolutions to several outstanding questions in solar cycle predictions are discussed; these include: is it possible to predict the solar cycle, what is the best proxy for predictions, how early can we predict the solar cycle and how many solar cycles in to the future can we predict?

References

[1] R. Kumar *et al*, Astron. Astrophys. **623**, A54 (2019)
[2] P. Bhowmik *et al*, Nature Comm. **9**, 5209 (2018)
[3] D. Nandy, Solar Phys. **296**, 1 (2021)