

IIT-Kanpur team develops new way to predict solar cycles ✓

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The sun is a giant magnetic ball that goes through roughly 11-year cycles of activity that drive solar flares and space weather that can disrupt satellites and power grids on the earth. But predicting the strength and timing of these cycles has been difficult because scientists can't see the magnetic fields deep inside the sun, where the activity originates.

In a January 20 study in

Astrophysical Journal Letters, PhD student Soumyadeep Chatterjee and assistant professor Gopal Hazra at IIT-Kanpur reported reconstructing the invisible magnetic fields inside the sun using 30 years of data collected from the surface.

For decades, solar physicists have used computer simulations called dynamo models to understand how the sun generates its magnetic field. Traditionally, these models relied on simplified theoretical rules

to represent sunspots. For example, previous models often treated sunspots as simple, symmetrical circular patches even though real sunspots are messy and irregular. But such simplifications often led to inaccurate predictions.

The duo, instead of relying on theoretical shapes, fed their 3D computer model real observations of the sun's surface field. They used data recorded between 1996 and 2025 by satellites like SOHO and the

Solar Dynamics Observatory. By forcing the model to align with observations from the surface, they could estimate what the magnetic fields deep inside the sun must be doing.

The data-driven model could reproduce the 'butterfly diagram', a chart visualising how sunspots migrate from the sun's high latitudes towards the equator over a cycle.

It also revealed the behaviour of the toroidal magnetic field within the

sun's convection zone. This field wraps around the sun like a doughnut and is the primary driver of sunspots. The researchers found their simulated internal field matched the actual intensity of cycles 23, 24, and 25.

They also tested the model's predictive capability by stopping the data feed at various points to see if it could forecast what happened next. It could accurately predict the peak amplitude of a cycle up to

three years in advance. So by monitoring the surface magnetic fields today, scientists can get a reliable warning of how active the sun will be later.

"Our findings on one hand strengthen our physics understanding of the generation of solar magnetic fields and on the other... predict when the sun will be active, violent, and very dangerous for spaceborne technological assets and communications," Dr. Hazra told *The Hindu*.