Sushant S. Mahajan

Solar Astrophysicist • Data Scientist • AI for Science
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EDUCATION

Ph.D. in Astronomy, Georgia State University, USA 2019
Thesis: *Observational Constraints on the Solar Dynamo and the Hunt for Precursors to Solar Flares*
Advisor: Petrus C. Martens

Master of Science, Physics, Georgia State University, USA 2014–2017

Master of Technology, Engineering Physics, Indian Institute of Technology (BHU), India 2014
Thesis: *The Effect of Torsional Oscillations on the Solar Cycle*
Advisors: Dibyendu Nandi and B. N. Dwivedi

PROFESSIONAL HISTORY

Research Scientist, W. W. Hansen Experimental Physics Laboratory, Stanford University 2024–present

Postdoctoral Fellow, W. W. Hansen Experimental Physics Laboratory, Stanford University 2022–2024

Solar Physics Postdoctoral Fellow, Institute for Astronomy, University of Hawai'i 2019–2022

Visiting Research Assistant, Catholic University of America 2018–2019

Graduate Teaching Assistant, Georgia State University 2014–2018

Summer Research Fellow, NASA Advanced Supercomputing Division, Ames Research Center 2016

Summer Research Fellow, Center of Excellence in Space Sciences, India 2013–2014

Solar Physics REU, Montana State University 2012

Summer Research Intern, IISER Kolkata 2011

RESEARCH THEMES

Agentic AI and custom LLM applications for heliophysics research, data analysis and scientific discovery (AskJSOC portal).

Time-series analysis, AI/ML for rare-event forecasting, and data-driven simulations for solar and heliophysics applications.

Solar dynamo physics, large-scale solar flows, torsional oscillations, meridional circulation, helioseismology and magnetic field evolution.

Scientific software, large observational datasets, and computational workflows for reproducible physics research.

Data Commons server development and data management for NASA/SDO mission data.

AWARDS & HONORS

Stanford University Libraries Data Sharing Prize, Stanford Solar Observatories Group 2026

Recipient, NASA Silver Group Achievement Award, JSOC Flood Recovery Team 2025

Editor's Choice, *Solar Physics* for "The Sun's Large-Scale Flows I: Measurements of Differential Rotation & Torsional Oscillation" 2024

Best Young Presenter Award, IAU Symposium 340, Jaipur, India 2018

Best Young Scientist Poster Award, IAU Symposium 335, University of Exeter, UK 2017

Highlighted in the VarSITI newsletter young scientists section 2017

Honorary Mention, Best Student Poster, Solar Physics Division meeting, Boulder 2016

Second Century Initiative Fellowship, Georgia State University 2014–2018

GATE Fellowship for M.Tech. thesis at IIT (BHU) 2013–2014

Best Idea Award, Technex festival, IIT (BHU) 2011

INVITED TALKS & RECENT ORAL PRESENTATIONS

"Beyond 60 Degrees: High-Quality HMI Polar Magnetograms for the Solar Community," COFFIES annual meeting, Stanford University, CA 2026

"How much magnetic flux and energy do active regions carry away from the solar interior?" Flux Emergence Workshop, San Diego, CA 2025

"Unveiling the Solar Poles: Addressing Projection Artifacts and Revealing Circumpolar Features in HMI Magnetograms," AAS/SPD 246, Anchorage, AK 2025

"Explaining Empirical Relationships in Sunspot Number & Area Time Series Using Poynting Theorem," TESS meeting, Dallas, TX 2024

"Unveiling the Sun: Exploring the Wonders of Solar Astrophysics," KIPAC public lecture, Stanford University 2023

"The Influence of Active Regions on Plasma Flows Inside the Sun," UCAR/HAO colloquium 2023

"Removal of Active Region Inflows Reveals a Weak Global Trend in Near-Surface Meridional Flow," AGU Fall Meeting 2022

"Removal of Active Region Inflows Reveals Solar Cycle Scale Trends in Meridional Flow," TESS meeting 2022

"Parameterization of Inflows around Active Regions," AGU Fall Meeting 2022

"Inflows Around Active Regions Explain Solar Cycle Scale Variations in Photospheric Meridional Flow During Cycle 24," SPD/AAS 2021

"Explaining Empirical Relationships Found in Sunspot Number and Area Time Series with a Simplified Dynamo Model," AGU Fall Meeting 2020

"Observational Constraints on the Solar Dynamo," SPD/AAS 2019

"Spying on the Heart of the Solar Dynamo," NASA Goddard Heliophysics Seminar and SCOSTEP

meeting 2018

"Torsional Oscillations: a Tool to Map Magnetic Field Amplification inside the Sun," IAU Symposium 340 2018

RECENT POSTER PRESENTATIONS

"High Latitude Solar Magnetic Feature Interpolation Studies," SHINE Workshop student poster 2025

"The Sun's Global Flows: Differential Rotation and Meridional Flow," SHINE meeting 2024

"The Sun's Global Flows I: Differential Rotation and Torsional Oscillation," AGU Fall Meeting 2022

"Removal of Active Region Inflows Reveals Solar Cycle Scale Trends in Meridional Flow," SHINE Workshop 2022

"Inflows Around Active Regions do not Contribute to the Photospheric Torsional Oscillation Pattern," SHINE Workshop 2021

"Using Torsional Oscillations to Forecast Solar Activity," IAU Symposium 335 2017

MEDIA & PUBLIC COMMUNICATION

KRON4 interview on the Northern Lights May 2024

NBC Bay Area appearance on the Northern Lights May 2024

ABC7 Bay Area appearance on the Northern Lights May 2024

Quoted in *San Francisco Chronicle* on California aurora visibility May 2024

Quoted in *San Francisco Chronicle* on solar maximum and renewed aurora prospects Nov 2024

Stanford Report, "Four Questions with a Scientist" on the 2024 total solar eclipse Mar 2024

Quoted in Lucile Packard Children's Hospital article on leap year science Feb 2024

PUBLIC OUTREACH & SERVICE

Volunteer at KIPAC public solar eclipse viewing events, Stanford University 2022–present

Volunteer for "KIPAC + Friends" Community Day public science fair, Stanford University 2025

Judge, Maui County Regional Science and Engineering Fair, Hawai'i 2020–2021

Lecturer, HI STAR outreach program, Institute for Astronomy, University of Hawai'i 2020–2021

Volunteer, Hard Labor Creek Observatory open house nights, Georgia 2015–2018

Volunteer, Urban Life Observatory, Georgia State University, Georgia 2014–2018

Presented "Know Thy Sun" at Charlie Elliott Wildlife Center astronomy club, Georgia 2018

Telescope controller, Stars over Yellowstone Night, Montana 2012

CONFERENCE SESSION ORGANIZATION

Co-convener, AGU26 session proposal "Solar Connectivity: Linking Interior Dynamics to Magnetic Variability and Heliospheric Evolution for Solar Cycles in the Past, Present, and Future" 2026

Co-organizer/chair, SHINE session "Understanding Variations in Sun's Global Flows," Juneau, AK 2024

Co-organizer/chair, SHINE Session 1 / WG1 "Where in the solar interior lies the seat of the dynamo?," Stowe, VT 2023

Co-organizer/chair, SPD session "Unveiling the Solar Poles" / "SPD: Unveiling the Polar Poles," Anchorage, AK, with Lisa Upton and Shea Hess Webber 2025

MENTORING

Project mentor for Kevin Brooks, a PhD candidate at New Mexico State University 2025–present

Project mentor, Ignited Fellowship, KIPAC Research Fellow – Surface Flux Transport Simulations 2026

Advised Ansh Malviya on statistical analysis of solar flares 2023

Mentored Prabhanjan Kulkarni on AI powered solar flare forecasting models 2020–2021

AstroPAL mentor for graduate students at Georgia State University 2016–2018

Advised William Keith Douglas Jr. on solar filament analysis; work contributed to a co-authored paper 2016

MANUSCRIPTS IN PROGRESS

"Subsurface Dynamics of Solar Active Regions: Insights from Local Helioseismology," for Frontiers Research Topic *Reviews in Astronomy and Space Sciences Vol. 2* 2026

"Beyond 60 Degrees: High-Quality HMI Polar Magnetograms for the Solar Community," 2026

"How much magnetic flux and energy do active regions carry away from the solar interior?" 2026

DATA MANAGEMENT & WEB DEVELOPMENT

Prepared and published the SWAN-SF benchmark dataset that has been used in thousands of AI projects 2020

Responsible for producing new electric and velocity field based metadata parameters from SDO/HMI data 2024–present

Responsible for developing an agentic AI-powered JSOC Data commons server that allows the public to query and visualize SDO data in natural language 2026–present

REFEREED PUBLICATIONS, DATASETS, WHITE PAPERS & PROCEEDINGS

Ding, B., Zhao, J., Chen, R., Waidele, M., **Mahajan, S. S.**, and Vesa, O.
Characterizing the Observational Properties of the Sun's High-latitude $m = 1$ Inertial Mode. Astrophysical Journal 2025

Dash, S., DeRosa, M. L., Dikpati, M., Sun, X., **Mahajan, S. S.**, Liu, Y., and Hoeksema, J. T.
Ensemble Kalman Filter Data Assimilation into the Surface Flux Transport Model to Infer Surface Flows: An Observing System Simulation Experiment. Astrophysical Journal 2024

Mahajan, S. S., Upton, L. A., Antia, H. M., Basu, S., DeRosa, M. L., Hess Webber, S. A., et al.
The Sun's Large-Scale Flows I: Measurements of Differential Rotation & Torsional Oscillation. Solar Physics 299, 38 2024

Mahajan, S. S., Sun, X., and Zhao, J.
Removal of Active Region Inflows Reveals a Weak Solar Cycle Scale Trend in the Near-Surface Meridional Flow. Astrophysical Journal 950, 63 2023

Pal, S., Bhowmik, P., **Mahajan, S. S.**, and Nandy, D.
Impact of Anomalous Active Regions on the Large-Scale Magnetic Field of the Sun. Astrophysical Journal 953, 51 2023

Hess Webber, S. A., **Mahajan, S. S.**, Koufos, A., Chatterjee, S., Leka, K. D., Sadykov, V., et al.
You Get What You Pay for: Scientific Engineering Challenges for Successful Distributed Multi-Satellite Missions in Solar and Heliophysics. Bulletin of the American Astronomical Society 55(3), 168 2023

Hathaway, D. H., Upton, L. A., and **Mahajan, S. S.**
Variations in Differential Rotation and Meridional Flow within the Sun's Surface Shear Layer 1996–2022. Frontiers in Astronomy and Space Sciences 2022

Mahajan, S. S., Hathaway, D. H., Munoz-Jaramillo, A., and Martens, P. C.
Improved Measurements of the Sun's Meridional Flow and Torsional Oscillation from Correlation Tracking on MDI & HMI Magnetograms. Astrophysical Journal 917, 100 2021

Ahmadzadeh, A., Aydin, B., Georgoulis, M. K., Kempton, D. J., **Mahajan, S. S.**, and Angryk, R. A.
How to Train Your Flare Prediction Model: Revisiting Robust Sampling of Rare Events. Astrophysical Journal Supplement Series 254, 23 2021

Angryk, R. A., Martens, P. C., Aydin, B., Kempton, D., **Mahajan, S. S.**, Basodi, S., et al.
Multivariate Time Series Dataset for Space Weather Data Analytics. Scientific Data 7, 227 2020

Hazra, S., **Mahajan, S. S.**, Douglas Jr., W. K., and Martens, P. C.
Hemispheric Preference and Cyclic Variation of Filament Chirality from 2000 to 2016. Astrophysical Journal 865, 108 2018

Mandal, B. P. and **Mahajan, S. S.**
Complex Classical Mechanics of a QES (Quasi Exactly Solvable) Potential. Communications in Theoretical Physics 2014

Ahmadzadeh, A., Hostetter, M., Aydin, B., Georgoulis, M. K., Kempton, D. J., **Mahajan, S. S.**, and Angryk, R. A.
Challenges with extreme class-imbalance and temporal coherence: A study on solar flare data. IEEE conference proceedings 2019

Ahmadzadeh, A., Aydin, B., Kempton, D. J., Hostetter, M., Angryk, R. A., Georgoulis, M. K., and **Mahajan, S. S.**
Rare-Event Time Series Prediction: A Case Study of Solar Flare Forecasting. IEEE conference proceedings 2019

Filali Boubrahimi, S., Aydin, B., Kempton, D., **Mahajan, S. S.**, and Angryk, R. A.
Filling the Gaps in Solar Big Data: Interpolation of Solar Filament Event Instances. Proceedings of the 6th International Conference on Big Data and Cloud Computing 2016

COMPUTATIONAL SKILLS

Machine learning for time-series and rare-event prediction using Python and MATLAB tooling.

Proficient in using OpenAI Codex and Claude Code agentic coding tools in sandbox environments with cloud and local LLM providers.

Proficient in developing custom AI agents and skills for data commons, visualization and data dissemination.

Proficient in developing RAG based AI agents and LLM-wiki in Google's OKF format for knowledge management and retrieval.

High proficiency languages: Python, MATLAB, Fortran, bash.

Parallel computing and optimization with OpenMP, MPI, C++, FORTRAN and CUDA-aware workflows.

Scientific data analysis and visualization with Python, MATLAB, and ParaView.