Understanding the solar activity and exploring the scope of space weather prediction

Thesis submitted in fulfilment
for the Award of
DOCTOR OF PHILOSOPHY
in
PHYSICS

by
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It is certified that the work contained in the thesis titled **Understanding the solar activity and exploring the scope of space weather prediction** by **Mr. Akash Biswas**, Roll Number **20171506**, has been carried out under my supervision and that this work has not been submitted elsewhere for a degree.

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I, **Mr. Akash Biswas**, certify that the work embodied in this thesis is my own bona-fide work and carried out by me under the supervision of **Dr. Bidya Binay Karak** from January 2021 to December 2023 at the **Department of Physics**, Indian Institute of Technology (BHU), Varanasi. The matter embodied in this thesis has not been submitted for the award of any other degree/diploma. I declare that I have faithfully acknowledged and given credits to the research workers whenever and wherever their works have been cited in my work in this thesis. I further declare that I have not wilfully copied any others' work, paragraphs, text, data, results, etc., reported in journals, books, magazines, reports dissertations, theses, etc., or available at websites and have not included them in this thesis and have not cited as my own work.

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List of Publications

1. Pawan Kumar, **Akash Biswas**, and Bidya Binay Karak. Physical link of the polar field buildup with the Waldmeier effect broadens the scope of early solar cycle prediction: Cycle 25 is likely to be slightly stronger than Cycle 24. Mon. Not. R. Astron. Soc., 513 (1):L112–L116, June 2022a. doi:10.1093/mnrasl/slac043.

2. * **Akash Biswas**, Bidya Binay Karak, and Robert Cameron. Toroidal Flux Loss due to Flux Emergence Explains why Solar Cycles Rise Differently but De- cay in a Similar Way. Phys. Rev. Lett., 129(24):241102, December 2022. doi:10.1103/PhysRevLett.129.241102.

3. ** **Akash Biswas**, Bidya Binay Karak, Ilya Usoskin, and Eckhard Weisshaar. Long-Term Modulation of Solar Cycles. Space Sci. Rev., 219(3):19, April 2023. doi:10.1007/s11214-023-00968-w.

4. § Elena M. Golubeva, **Akash Biswas**, Anna I. Khlystova, Pawan Kumar, and Bidya Binay Karak. Probing the variations in the timing of the Sun's polar magnetic field reversals through observations and surface flux transport simulations. Mon. Not. R. Astron. Soc., July 2023. doi:10.1093/mnras/stad2254.

5. † **Akash Biswas**, Bidya Binay Karak, and Pawan Kumar. Exploring the reliability of polar field rise rate as a precursor for an early prediction of solar cycle. Mon. Not. R. Astron. Soc., 526(3):3994–4003, December 2023a. doi:10.1093/mnras/stad2966

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*Presented in Chapter 2
**Presented in Chapter 3
§Presented in Chapter 4
†Presented in Chapter 5

6. ‡ **Akash Biswas**, and N. Gopalswamy. Forecasting the geoeffectiveness of CMEs using Artificial Neural Network aided by forward modelling. (Under Preparation)

‡Presented in Chapter 6

Conferences / Presentations

1. **Poster presentation** titled **'Exploring the predictability of the solar cycle from the polar field rise rate: Results from observations and simulations'** in the **International Astronomical Union Symposium 365,** held in Yerevan, Armenia.

2. **Oral presentation** titled **'The role of nonlinear toroidal flux loss due to flux emergence in the long-term evolution of the solar cycle'** in the **International Astronomical Union Symposium 365**, held in Yerevan, Armenia.

3. **Poster presentation** titled **'Explaining why all solar cycles rise differently by decay in the same way'** in March 2023, at the 41st Annual meeting of the **Astronomical Society of India (ASI)** hosted by the Indian Institute of Technology Indore.

4. **Invited talk** (young researcher participant) titled **'Toroidal flux loss due to flux emergence explains why all solar cycles decay in the same way'** in June 2022, at the **"Solar and Stellar Dynamo: A New Era"** workshop organized by the **International Space Science Institute (ISSI)** in Bern, Switzerland.

5. **Oral presentation** titled **'Scope of an early prediction of solar cycle: Linking the Waldmeier effect with the polar field rise rate'** in June 2022 at the meeting of the **International Space Science Institute (ISSI) Team 474** led by Prof. K. Petrovay in Bern, Switzerland.

6. **Poster presentation** titled **'Toroidal flux loss due to flux emergence explains why all solar cycles decay in the same way'** in March 2022, at the 40th Annual meeting of

the **Astronomical Society of India (ASI)** hosted by the Indian Institute of Technology Roorkee.

Dedicated to my Parents.

Acknowledgements

"The only way you can get out of this darkness, to a better life, is by studying very hard." often said my mother (Maa) whenever our small village used to get plunged into darkness due to frequent power shortages. As I try to begin the impossible task of acknowledging some of the countless people who contributed towards my journey, I must start with Maa, who laid the foundation for it. Her perseverance, patience, and passion towards my academic journey all the way back from nursery school to my PhD have been a source of inspiration and guiding light for me. While growing up, we always had much fewer resources than what was needed, but we never felt 'poor' as my father (Baba) always managed to provide more than what he could, with a wide smile shining on his face, hiding the back-breaking hard work he had to do in the farmlands. Whatever little I could achieve so far is all due to their sheer perseverance, zeal and neverending love and support.

Working with Dr. Bidya Binay Karak has been the greatest pleasure of my academic journey so far. Apart from the scientific brilliance, his kindness, understanding and wonderfully straightforward approach towards mentorship are what instilled a lot of confidence and self-belief in me. The time during my PhD has been a highly uncertain and difficult one, but the constant support and guidance of Dr. Karak made it a lot easier.

I gratefully thank Dr. N. Gopalswamy for giving me the wonderful opportunity to work with his group at NASA/GSFC. It has been a great learning experience.

A special thanks to Prof. Dipankar Banerjee, Dr. Robert Cameron, Prof Ilya Usoskin, Prof. Kristof Petrovay, Prof Paul Charbonneau, Dr. Seiji Yashiro and all my collaborators for all of their guidance, contribution, and unconditional help whenever I needed them.

I thank the RPEC members for their valuable comments and suggestions for the betterment of my research work. I heartily thank Prof. Sandip Chatterjee and other

faculty members of the department for their support and guidance. I also acknowledge the contribution of the non-teaching staff of the department.

Since the uncertain times of our undergrad college days, through thick and thin, I have always found a beautiful soul firmly believing in me and making me believe in myself. I could never thank you enough Mouli, for all of your contributions and care towards my life and career! I am grateful to you beyond words or imagination.

I have been fortunate to have a team of bright-minded and kind-hearted people along with me throughout the journey. The unconditional support, and intellectual feedback of my work that I received from Pawan da, Vindya di, and Anu has been crucial in my growth as a researcher. There have been countless moments from day one to the very end of my PhD where their help and support saved the day for me. I will cherish the memories that we created!

If having good friends is a matter of luck, I have been extremely fortunate to befriend so many wonderful people like Jay, Shivam, Sripan, Tanushree, Chitradeep, Srikar, Shivangi, Saurabh, Harish, Pratikhsya, Shruti, Gargi, and my seniors and juniors who greatly enriched my life.

I extend my heartiest appreciation towards my seniors Bibhuti da, Satabdwa da, and Ritesh da for always being so kind to me for mentoring me in many crucial aspects and for shaping my thought process in the initial days of my career.

My time at NASA Goddard has been such a memorable and fun-filled one with the wonderful company of Yoshita, Sanchita di, Shanwlee di, Vidushi di, Anshu di, Arunabh, and Atul. There has never been a dull moment with them around. A foreign country felt like home and all of the credit goes to them!

I am sure I will never be able to do justice with this acknowledgement section of my thesis, no matter how hard I try. There are so many beautiful moments and the people involved in those memories that come to my mind as I reflect on my journey. I could only

mention a handful of them here. I would like to end this section with profound gratitude towards each one of you for your contributions towards my life!

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