The Era of Multi-Messenger Solar Physics
Proceedings IAU Symposium No. 372, 2023
G. Cauzzi & A. Tritschler, eds.
doi:10.1017/S1743921323000467

Long-term Evolution of Magnetic Field Proxies as Deduced from Archival Data

Dipankar Banerjee[1,2], Bibhuti Kumar Jha[1,2], Sudip Mandal[2], Subhamoy Chatterjee[3], Manjunath Hegde[1] and KoSO Digitization Team

[1]Arybhatta Research Institute of Observational Sciences, Nainital-263001, India
Email: *dipu@aries.res.in*

[2]Indian Institute of Astrophysics, Bangalore-560034, Karnataka

[3]Max Planck Institute for Solar System Research, Göttingen, Germany

[4]Southwest Research Institute, 1050 Walnut Street #300, Boulder, CO, 80302, USA

Abstract.
Regular observations of the solar magnetic field are available only for about the last five cycles. Thus, to understand the origin of the variation of the solar magnetic field, it is essential to reconstruct the magnetic field for the past cycles, utilizing the proxies of the magnetic field from other data sets. Long-term uniform observations for the past 100 yrs, as recorded at the Kodaikanal Solar Observatory (KoSO), in multi-wavelengths provide such an opportunity. Various automatic techniques have been developed to extract these features from KoSO data. We analyzed the properties of these extracted features to understand global solar magnetism in the past.

Keywords. Sun: magnetic fields, Sun: photosphere, Sun: chromosphere, catalogs

1. Introduction

The unavailability of solar magnetic field measurement before the 1970s makes the historical records of solar observation a crucial resource to understand the physics behind the solar activity and its long-term variability. Various solar features such as sunspots, plages, filaments/prominence etc., as observed in the multi-wavelength observation of the Sun, serve as proxies of the solar magnetic field. Therefore, understanding these features over the century will help us understand global solar magnetism over such a long period. In this sense, Kodaikanal Solar Observatory (KoSO) in India has a record of historical observation of the Sun, simultaneously in white light (1904 – 2017), Ca K (1904 – 2007) and H-alpha (1912 – 2007), over the century. In Figure 1, we show the number of observations per year for all these data sets. These data were initially taken on the photographic plates/films and have been digitized now, using 4k $\times$ 4k CCD, and made available for the community.

2. A Few Results from KoSO Digital Archive

The state-of-the-art techniques has been developed to detect the sunspot (Ravindra et al. 2013; Mandal et al. 2017; Jha et al. 2022), sunspot umbra (Jha et al. 2019), plages (Chatterjee et al. 2016), filaments (Chatterjee et al. 2017) and Ca-K prominence (Chatterjee et al. 2020) from these data sets. The latitude-time plot for all these data sets are shown in Figure 2a (sunspot), 2b (plages), 2c (filaments) and 2d (Ca-k

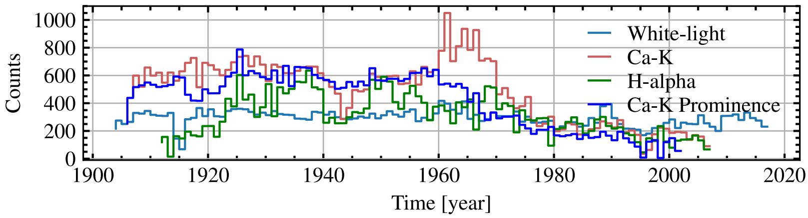

Figure 1. Number of observation per year as available in the KoSO digital archive.

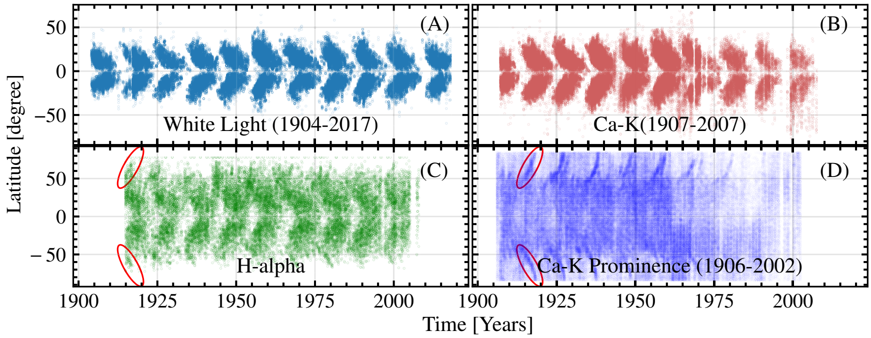

Figure 2. The butterfly diagram generated from (A) white-light, (B) Ca-k, (C) H-alpha and (D) Ca-k prominence. In Panel-(C) and (D) red ellipses are representing the pole-ward migration of filaments/prominence.

prominences). These digitized data sets have been extensively used (Mandal et al. 2017, 2020; Jha et al. 2019, 2021) to study the various aspects of long-term solar variability. Recently, Mordvinov et al. (2020) have reconstructed the magnetic butterfly diagram corresponding to the past cycle using the digitized data from KoSO.

Acknowledgements

DB and BKJ would like to thank IAU for providing the travel support to attend the IAUGA 2022 in-perosn in South Korea. All these data are accessible through `https://kso.iiap.res.in/new`.

Supplementary material

To view supplementary material for this article, please visit https://doi.org/10.1017/S1743921323000467.

References

Chatterjee, S., Banerjee, D., & Ravindra, B. 2016, ApJ, 827, 87
Chatterjee, S., Hegde, M., Banerjee, D., & Ravindra, B. 2017, ApJ, 849, 44
Chatterjee, S., Hegde, M., Banerjee, D., Ravindra, B., & McIntosh, S. W. 2020, Earth and Space Science, 7, e00666
Jha, B. K., Hegde, M., Priyadarshi, A., et al. 2022, Frontiers in Astronomy and Space Sciences, 9, 1019751
Jha, B. K., Mandal, S., & Banerjee, D. 2019, *Solar Phys.*, 294, 72
Jha, B. K., Priyadarshi, A., Mandal, S., Chatterjee, S., & Banerjee, D. 2021, *Solar Phys.*, 296, 25
Mandal, S., Hegde, M., Samanta, T., et al. 2017, A&A, 601, A106
Mandal, S., Krivova, N. A., Solanki, S. K., Sinha, N., & Banerjee, D. 2020, A&A, 640, A78
Mordvinov, A. V., Karak, B. B., Banerjee, D., et al. 2020, ApJ Letters, 902, L15
Ravindra, B., Priya, T. G., Amareswari, K., et al. 2013, A&A, 550, A19