Topic: Understanding Global-scale Solar Processes and their Implications for the Solar Interior

Project Title:
Study of Global-Scale Surface Flows and Migration of Polar Crown Filaments of the Sun in Past 10 Solar Cycles in Comparison with Helioseismology Results in 2 Recent Cycles

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Project Information:
Scientific Objectives: In response to the FST call of "Understanding Global-scale Solar Processes and their Implications for the Solar Interior", we propose to combine surface flow measurements and helioseismology inversion to derive the meridional flows, differential rotation and zonal flows in multiple solar cycles, as well as their connection with other signatures of the solar dynamo, such as filament distribution/migration. We focus on two specific science issues: (1) Provide global flow measurements as input for dynamo and solar cycle modeling. The derived pattern of filament migration can be used for the validation of models. (2) As our study covers 10 solar cycles, we will investigate the effects of global-scale flows and polar crown filament migrations on different amplitudes of solar activity.

Methodology: In addition to the analyses of HMI and MDI data, NJIT group has digitized and will analyze full-disk Halpha images from 1956 to 2000 obtained by National Solar Observatory (NSO) and Big Bear Solar Observatory (BBSO) with a nominal cadence of 1 minute. All data are publicly accessible. Independently, co-I Institute Kodaikanal Observatory of Indian Institute of Astrophysics has digitized daily Halpha and Ca~K images since 1914, extending synoptic data to 105 years. From 2000 onward, we are also obtaining 1-minute cadence full-disk Halpha images with the 8-station Global Halpha Network (GHN), which has become an important resource for the solar physics community. We will focus our research on two key science topics using this unique data set in combination with modern NASA satellite data, aiming at understanding global-scale flows and linked magnetic properties of solar cycles.

(1) We will track the flows using features from Halpha images as proxy for magnetic features. The most important components include differential rotation, meridional flows, and zonal flows, which are closely related to the dynamo signature of solar cycles. We understand that advanced observations of SoHO and SDO provide better image quality for this purpose; however, their data are limited to cycles 23 and 24, which may be atypical in respect to relatively low level of activity. The 1-minute cadence Halpha data cover 6 recent cycles (19 to 24) of various activity amplitudes. The recent two cycles will be compared with flow tracking results of SOHO/MDI and SDO/HMI data as validation and quality control. Helioseismologic data analyses in cycles 23 and 24 to be carried out by the Stanford group will derive near and sub-surface global flows to be compared with surface flow tracking in Halpha. Derivation of flows of cycles 15 to 18 will be attempted, but with much lower accuracy.

(2) We will study long-term variation and properties of filaments that carry important information on the magnetic signature of the solar cycles. Daily images will be sufficient for this purpose, therefore the study covers nearly 10 solar cycles. We will emphasize the study of the statistical and cycle dependent properties of filaments. In particular, polar crown filaments are related to the interface between new and old solar cycles. Their migration and disappearances may indicate underlying physics of solar cycles.

Significance: This is a joint effort of NJIT and Stanford group to combine the expertise in surface flow tracking with helioseimology inversion to understand evolution of the global-scale flows, filament migration, and potential sub-surface effects over nearly 10 solar cycles which matches the key goal of this FST. Therefore, our study will be highly relevant and importance to this FST. The team has developed most of the data analysis tools such flow tracking, helioseismology inversion, filament identification and characterization. Therefore, the study is feasible and low-risk. The detailed relevance will be elaborated in box 33 of Program Specific Data: Proposed Contribution to the FST Effort.

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Citations: