# Cycle 3 Accepted Science Programs - Full Table

| PID | Title | PI | Country |
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| 2 | On the Physics of Prominence Cavities II | Benjamin Boe<br>Co-Is<br>Shadia Habbal (US), Sage Constantinou (US) | US |
| | Abstract<br>We propose to use Cryo-NIRSP to study a prominence cavity in the corona. Habbal et al. (2021) recently demonstrated with data from numerous total solar eclipses that prominences are invariably surrounded by a coronal cavity containing plasma at high electron temperatures (~2 MK), often form the base of helmet streamers, and commonly erupt into the solar wind. Despite the importance these structures have in the corona and solar wind, they are relatively poorly understood. The main obstacle to learning more about these structures has been a lack of comprehensive data throughout a prominence cavity. The existing observations are either too low in resolution or observe emission that is too tenuous in the outer cavity (in the case of EUV observations) to perform the requisite analysis to learn more about these structures. Only the high spatial and spectroscopic capabilities of Cryo-NIRSP at present are able to probe the density, electron and ion temperatures, and flows throughout a prominence cavity. Thus, we will take a collection of spectroscopic data in a scan through a prominence cavity on the solar limb with the Fe XIII line pair as well as the Si X and He I line. Equipped with the proposed dataset, we will be able to perform a more detailed and thorough analysis on the prominence cavity than has ever before been achieved. | | |
| 4 | On the magnetic origin of plasma heating and dynamics in plage regions | João M. da Silva Santos<br>Co-Is<br>Juan Martínez-Sykora (US), Bart De Pontieu (US), Momchil Molnar (US), Alexander Pietrow (DE), Thomas Schad (US) | US |
| | Abstract<br>Plage regions on the solar disk are areas of intense magnetic activity that play a crucial role in understanding solar atmospheric heating processes. In this study, we aim to investigate the heating mechanisms and atmospheric properties in plage regions using a combination of high-resolution observations from the Daniel K. Inouye Solar Telescope and numerical simulations with the Bifrost code. We will analyze calibrated and post-processed ViSP spectropolarimetry using inversion codes to determine the magnetic field vector and thermodynamic parameters of the plasma in a plage region. We will then compare these observations with radiative transfer synthesis based on 2.5D or 3D r-MHD simulations performed with the Bifrost code, which can account for non-equilibrium ionization and ion-neutral effects crucial in the chromosphere. The analysis will include investigating spectral diagnostics properties such as line intensities, line broadening, line shapes, and polarimetric signals to interpret observations and gauge physical conditions. By comparing inverted atmospheres from observations and simulations, we will learn more about the atmospheric stratification of plage regions. We will achieve this by observing the same plage region (or different) at two different viewing angles, using a combination of deep integration rasters and high-cadence scans. Through this comprehensive approach, we aim to shed light on the competing or overlapping physical mechanisms within plage | | |

regions, improve our understanding of radiative transfer properties, and enhance our knowledge of solar atmospheric heating and dynamical processes.

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| 6 | Oscillations in the Structured and Dynamic Solar Corona | Petra Kohutova<br>Co-Is<br>Nicolas Poirier (NO), Richard Morton (GB) | NO |

Abstract

Recent convection-zone-to-corona simulations challenge the traditional picture of coronal loops being well represented by thin compact strands, and suggest the strands are a result of a line-of-sight superposition of emission from warped turbulent structures. Studying coronal loop oscillations is one way to distinguish between the strand-like or veil-like structure of the corona. The goal of the proposed observation is to focus on the detailed characteristics of the oscillations in the active region coronal loops, taking advantage of coronographic capabilities of DKIST. The observation will provide spectral information in coronal lines, while keeping sufficient spatial and temporal resolution to detect coronal oscillations and their properties including the variation and evolution of velocities across the oscillating loop, the evolution of non-thermal broadening at the loop boundaries, and the magnetic field and density diagnostics. This will enable us to compare the signatures associated with oscillation evolution and damping to the signatures predicted by the idealised thin tube models and to the signatures of coronal oscillations in non-ideal waveguides present in the convection-zone-to-corona simulations. It will also enable us to test commonly used coronal seismology methods. As a result, the observation will help to constrain the coronal loop models and clarify whether coronal loops are better represented by compact isolated strands or diffuse, turbulent structures.

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| 8 | Diagnostics of Coronal Heating Based on the Shapes of Coronal Emission Lines | Michael Hahn<br>Co-Is<br>Alexandros Koukras (BE), Stefan Hofmeister (DE), Daniel Savin (US), Natasha Jeffrey (GB) | US |

Abstract

We propose to use Cryo-NIRSP measurements of spectral line shapes to constrain the processes that carry energy into the corona and heat the plasma. Spectral line shapes can provide robust diagnostics of coronal heating as they contain information about both fluid motions of the emitting plasma and the ion velocity distribution produced by the heating process. Moreover, they are robust measurements in the sense that they implicitly average over small spatial and fast temporal scales. Recent measurements of line shapes have suggested that non-thermal line broadening decreases with height, suggesting Alfven wave damping; that ion temperatures are larger than electron temperatures in a way that depends on charge-to-mass ratio, implying that there is a resonant ion heating process, and that the line shapes are non-Gaussian, which may be due to turbulence in the fluid or a signature of the heating process. Existing measurements have been limited by systematic uncertainties, particularly the spectral resolution of the instruments. DKIST Cryo-NIRSP offers an order of magnitude improvement in spectral resolution that will significantly reduce these uncertainties. Moreover, the recent upgrade of Cryo-NIRSP to measure ions of different masses (silicon and iron) will allow us to infer the contributions from fluid motions, which are the same for both ions, versus the ion velocity distribution, which can differ between ion species.

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| 17 | Identifying Network Jets and their Magnetic Properties | Aparna V.<br>Co-Is<br>Navdeep K. Panesar (US), Sanjiv Tiwari | US |

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| | | (US), João M. da Silva Santos (US) | |

Abstract

Network jets, found on the edges of network lanes where opposite minority-polarity might exist amongst the majority polarity, are more ubiquitous but smaller than typical coronal jets that are commonly seen in coronal wavelengths around coronal holes, active and quiet regions. While the trigger mechanism in coronal-jets have been observed to be a mini-filament at the base of these eruptions, those at the base of network jets or small-scale jets have not been observed. We propose to use high resolution and high cadence DKIST observations to look for such triggers and understand other physical mechanisms if any. In addition, flux cancellation with or emergence of opposite minority polarity which have been associated with small-scale jets in previous studies have not been directly observed due to magnetograms not having enough resolution. We expect that the high resolution magnetograms obtained from DKIST spectropolarimetric data will be useful for detecting such polarities.

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| 19 | Revealing the picture of coronal Alfvénic waves: exploring a new frequency regime with Cryo-NIRSP | Richard Morton<br>Co-Is<br>Rahul Sharma GB), Zihao Yang (CN) | GB |

Abstract

Alfvenic waves are thought to be a key mechanism for energy transfer in the Sun's atmosphere, providing the energy to meet the radiative losses of the dense chromosphere and hotter, tenuous corona, along with the demands required to accelerate the solar wind. In recent years there has been clear evidence for the presence of low-frequency (f<10 mHz) Alfvenic waves through the chromosphere and corona, and they are ever-present throughout the solar cycle. The low-frequency waves are difficult to dissipate without an additional process that can transfer the wave energy to small-scales (e.g., phase mixing, resonant, absorption, MHD Turbulence) where large gradients can develop to enhance diffusive and resistive processes. Hence, high-frequency Alfvenic waves are critical for efficient energy dissipation. Moreover, multiple Alfvenic modes are expected to exist in the corona, with only the kink mode having been identified routinely in the corona The high temporal and spatial resolution of Cryo-NIRSP offers an unprecedented opportunity to discover whether multiple Alfvenic modes and high-frequency Alfvenic waves are present in the corona. The unique data from Cryo-NIRSP will be compared with sythnetic observables derived from state-of-the-art 3D reduced MHD models of Alfvenic wave turbulence. This will open a new and exciting view into coronal wave physics and permit discoveries into wave energy deposition and the development of coronal wave turbulence.

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| 20 | Reversed polarity magnetic fields in sunspot penumbrae and their association with Ellerman bombs | Ryan Campbell<br>Co-Is<br>Mihalis Mathioudakis (GB), David Kuridze (US) | GB |

<table>
<tr><td></td><td colspan="3">Abstract<br>High resolution simulations predict the presence of reversed-polarity magnetic fields (RPMFs) throughout sunspot penumbrae, but most observations have found them only in the outer or middle penumbra in visible Fe I lines. We propose to use the very high spatial resolution provided by DKIST/ViSP to scan the penumbra in Fe I 630 nm to analyse the complex magnetic structure, focusing on the RPMFs. This analysis will require careful consideration of asymmetric, blue-humped and 3-lobed Stokes V profiles, for which we propose to use a novel machine learning technique to characterise the profiles. Recent observations have found ubiquitous Ellerman bombs (EBs) in H-beta and Ca II 854 nm observations in sunspot penumbrae. We propose to additionally include Ca II 854 nm and H-beta to asses the link between RPMFs and EBs.</td></tr>
<tr><td>25</td><td>Cryo-NIRSP Plasma and Magnetic Field Inversions for Coronal Jet Eruptions</td><td>Alin Paraschiv<br>Co-Is<br>Daniela Lacatus (US), Ryan French (US), Thomas Schad (US)</td><td>US</td></tr>
<tr><td></td><td colspan="3">Abstract<br>We propose a DKIST observation focused around a coronal jet usecase that is strongly suited to help progress in our understanding of small-scale coronal magnetic structures. Coronal jets, are impulsive and collimated plasma eruptions that originate mostly from two sources, one in coronal hole brightpoints and the other being parasitic pores at the periphery of active regions. Coronal jets are in general less complex and more straightforward to interpret than CMEs, that usually have more convolved structures along the LOS. We aim to utilize Cryo-NIRSP's potential for unprecedented diagnostics to scrutinize active region coronal jets, to produce the first set of magnetic measurements of a coronal jet's current sheet and/or reconnection region, in both pre and post flare eruption conditions. Additionally, reconnection processes can be probed by Cryo-NIRSP, by studying plasma current sheet destabilization regions following small-scale flares and eruptive events such as jets. The simplified complexity of jet structures makes them more feasible when first applying inversions needed to disentangle the physical parameters. We strive to infer plasma properties and full vector magnetic fields through inversions, which at this time we consider achievable but not guaranteed, considering available methodologies are still in their infancy. Significantly more work with observational and model tests will be required in order to fully assess the feasibility of these prototype methodologies.</td></tr>
<tr><td>26</td><td>Investigating small-scale flaring dynamics with Cryo-NIRSP Linear Polarization</td><td>Ryan French<br>Co-Is<br>Maria Kazachenko (US), Joel Dahlin (US), Marcel Corchado-Albelo (US)</td><td>US</td></tr>
<tr><td></td><td colspan="3">Abstract<br>We propose using Cryo-NIRSP to investigate plasma and magnetic parameters within a small, off-limb solar flare. Linear polarization measurements are able to provide insight into sub-pixel dynamics, at critical regions within the solar flare (such as the current sheet or flare loop tops). Supporting these measurements, simultaneous non-thermal velocity, Doppler velocity and plasma density measurements can provide context and further clues into the regions of energy release in flares, and the nature of magnetic reconnection within them. We propose comparing these observed parameters with those predicted by simulations. These observations would be optimal for an off-limb active region with a high likelihood of C-class flaring or above. Alternatively, the decaying post-flare loops of an X-class event (starting up to two hours after flare onset), would also be suitable.</td></tr>
<tr><td>28</td><td>Configuration of Vector Magnetic Fields in Multiple Heights along a Strong-Gradient Polarity Inversion Line of a Complex</td><td>Melissa Bierschenk</td><td>US</td></tr>
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| | Active Region | Co-Is: Jie Zhang (US), Eleni Nikou (US), Suman Dhakal (US) | |
| | Abstract: This proposal aims to obtain advanced DKIST data to analyze the magnetic structure along and surrounding the main and/or strong-gradient polarity inversion line (PIL) of a complex active region (AR). PILs are special locations where non-potential magnetic energy accumulates and eruptive magnetic structures form. However, it remains a mystery how such an energetic state is achieved. It has been proposed that it may form through flux cancellation due to shearing/converging motions in the photosphere along the PIL, or through the emergence of helical flux tubes already residing below the photosphere. This proposal seeks to determine the vector magnetic field in multiple heights that span the lower photosphere and into the chromosphere, and to understand/discern different models on the formation of energetic structures in ARs. The proposal requires the observation of a complex AR that is located close to the disk center, and follow it for one day using the ViSP, and VBI instruments. The unprecedented spatial resolution of ~0.05 arcsec along with the layered spectropolarimetry in Fe I (525.0 nm), Fe IAndrew Hillier, Tetsu Anan (630.2 nm), Ca II (854.2 nm) will provide unique data to address the issue of magnetic field structure along PILs. Further, this proposal and the analysis of the obtained data is a critical part of the dissertation of the PI which focuses on understanding the structure and evolution of AR magnetic fields that may lead to solar eruptions. The DKIST data will play a major role in this study, through addressing the initial conditions of source regions. | | |
| 30 | Heating and Cooling due to Partially Ionised Shocks in Sunspots | Ben Snow<br>Co-Is: Andrew Hillier (GB), Tetsu Anan (US) | GB |
| | Abstract: A regular feature of sunspots are umbral flashes; shock driven phenomena that manifest as transient, bright bursts in contrast to the dark umbra. Since shocks are sharp features with rapid changes in physical properties, they are often studied in the context of heating, where they provide a direct mechanism for converting wave energy into heating. To quantify this heating we need to understand the shocks we are observing, however, the behaviour of shocks observed in sunspots is far from understood. Shocks are usually classified by type through fitting the Rankine-Hugoniot (RH) shock jump conditions, which allow the shock to be classified as slow, intermediate (Alfven) or fast. However the shock jump conditions are considerably different in the presence of strong radiative cooling, where they can become highly compressed and even cool the media. As such, applying the RH shock jump conditions to observations may lead to a shock being incorrectly classified, and shocks may be cooling the sunspot not heating it. Here we investigate how shocks manifest in partially ionised sunspots, and the consequences for shock heating and cooling. We use high-resolution observations of penumbral regions to classify the shocks using both the RH and radiative RH conditions, and analyse the non-adiabatic heating and cooling that occurs in partially-ionised shocks in sunspots. The results of this observational study will be used to inform numerical simulations to provide a complete analysis of the heating and cooling of shocks in sunspots. | | |
| 31 | Multi-line electric-field diagnosis | Tetsu Anan<br>Co-Is: Jeffrey Reep (US), Yukio Katsukawa (JP), Ben Snow (GB), Roberto Casini (US), Sanjiv Tiwari (US), Ayumi Asai (JP), | US |

Valentin Martinez Pillet (ES), Andrew Hillier (GB)

Abstract

Diffusion of the magnetic fields can trigger magnetic reconnection, changing the topology of the magnetic field. It causes plasma movements, plasma heating, and particle accelerations. In general, the spatial scale of the magnetic diffusions had been predicted to be <1 km in the solar chromosphere (Khomenko et al. 2014). Nevertheless, an electric field signal felt by neutral hydrogen and associated with an Ellerman bomb, which the magnetic diffusion could trigger, was discovered by the Visible SpectroPolarimeter (ViSP, de Wijn et al. 2022) of the US National Science Foundation's Daniel K. Inouye Solar Telescope (DKIST, Rimmele et al. 2020). The spatial scale of the observed magnetic diffusion was 1 arcsec, i.e., 700 km on the sun. The previous measurements were based on Stokes profiles in the H-Epsilon line. We request follow-up observations using multiple neutral-hydrogen lines to support that magnetic-diffusion regions are so large that we can spatially resolve it.

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| 35 | Fine-scale dynamics in sunspot penumbra | Ryohtaroh T. Ishikawa<br>Co-Is<br>Hideyuki Hotta (JP) | JP |

Abstract

Sunspot penumbra is a unique region where we can observe the magneto-convective motions in strongly magnetized plasma. The unpreceded spatial resolution of DKIST enables us to investigate the fine-scale dynamics and interactions within the thin filamentary structures in penumbrae. Despite the great advances in MHD simulations, the formation mechanism of penumbrae is still unclear. The recent numerical simulation found that the uncombed structures and the Evershed flows develop only in a high-resolution simulation and they do not in lower resolutions. This numerical study suggests that the small-scale magneto-convective motions play an important role in forming the penumbrae. Thus, the primary objective of the proposed observation is to understand the role of small-scale magneto-convective motions in penumbra. We will obtain spectro-polarimetric profiles of the Fe I 630 nm, Na I D1/D2, and Ca II 854 nm lines with ViSP to obtain flow velocities and magnetic fields in the photosphere and the chromosphere.

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| 37 | The Origin of Extreme Broadening of the Hydrogen Emission Lines in Solar Flares | Cole Tamburri<br>Co-Is<br>Adam Kowalski (US), Maria Kazachenko (US), Isaiah Tristan (US), Ryan French (US), Yuta Notsu (US), Alexandra Tritschler (US) | US |

Abstract

We propose to use high-cadence ViSP spectroscopy in the Ca II H, H-Alpha, and Na I D1 regions to investigate the relative broadening of hydrogen and calcium in bright solar flare kernels and the timing of flare evolution throughout the photosphere and chromosphere. We will determine whether broadening in the narrow Ca II H and broad hydrogen Balmer lines occur at different locations and times within the flaring area. These high resolution spectra will provide much-needed constraints on the current modeling approach for stellar flares. We will compare model spectra calculated from a new semi-empirical flare modeling code to determine the electron charge density and optical depth in chromospheric condensations. Then, the ViSP spectra will be used to test the detailed time evolution of the pressure broadening of hydrogen predicted in RADYN+RH simulations of high-flux electron beam heating. We will explore the extent to which flare activity extends into the photosphere with the Na I D1 line, and search for white-light flare kernels in the blue continuum images from VBI.

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| 38 | Wavefields in Magnetized Low Solar Atmosphere | Shah Mohammad Bahauddin<br>Co-Is<br>Mark Rast (US) | US |

Abstract

Simulations from the MURaM photosphere and observations from DKIST OCP Cycle I have revealed numerous local wave fields propagating in the photosphere and low chromosphere. While recent observations have confirmed the existence of these waves, the impact of localized magnetic fields and the broader ambient magnetic environment on their generation and propagation remains unclear. In this observation proposal, we aim to investigate the magnetic influence on the generation, propagation, and statistical characteristics of these waves. We propose fast measurements of the deep photosphere and low chromosphere in (1) a quiet sun region (with minimal magnetic activity), (2) an active network, and (3) a plage region. Using DKIST/VBI's Red Continuum and Ca II K channels, we request the fastest possible (~3 s) cadence and high-resolution (<0.02 arcsec/pixel) observations, which are critical for studying wave emission, scattering, and absorption at very small scales in varying magnetic environments.

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| 45 | The nature of coronal Alfvenic waves bound for the solar wind | Richard Morton<br>Co-Is<br>Munehito Shoda (JP), Steven Cranmer (US) | GB |

Abstract

Alfvénic waves are thought to be a key mechanism for energy transfer in the Sun's atmosphere, providing the energy to meet the radiative losses of the dense chromosphere and hotter, tenuous corona, along with the demands required to accelerate the solar wind. In recent years there has been clear evidence for the presence of low-frequency (f<10 mHz) Alfvénic waves through the chromosphere and corona, and they are ever-present throughout the solar cycle. The low-frequency waves are difficult to dissipate without an additional process that can move the wave energy to small-scales (e.g., phase mixing, resonant absorption, MHD Turbulence) where large gradients can develop to enhance diffusive and resistive processes. Hence, high-frequency Alfvénic waves are critical for efficient energy dissipation. MHD turbulence is leading candidate to explain the heating and acceleration of flows from open field regions, however it requires counter propagating waves packets. While counter propagating waves are prevalent in loops, it is unclear if they are present in open field regions. The high temporal and spatial resolution of Cryo-NIRSP, along withs its excellent signal to noise levels, offers an unprecedented opportunity to discover the nature of high-frequency Alfvénic waves in open field regions.

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| 46 | Formation Heights of Flare Ribbons in the Lower Solar Atmosphere | David Kuridze<br>Co-Is<br>Ryan French (US), Rahul Yadav (US), Marcel Corchado-Albelo (US), Cole Tamburri (US), Adam Kowalski (US), Mihalis Mathioudakis (GB), Yuta Notsu (US) | US |

Abstract

Multi-wavelength observations of flare can provide direct information on the formation height of emission sources (ribbons/kernels) in different spectral lines. These are crucial to our understanding of the physics of solar flares and are vital diagnostics for the processes of energy transport and dissipation. The main observing goal of the proposal is to measure the spatial separation between flare ribbons in different spectral lines. We plan to perform simultaneous spectroscopy in Na I D1 589 nm, Ca II 854 nm and Hβ 486 nm with ViSP. Of particular interest are the Hβ and Ca II 854.2 nm line wing ribbons, as a previous study indicates a large separation between them. Observations will be combined with the numerical and semi-empirical models. This will help us to investigate the formation heights of flare ribbons and the energy deposition depth in the flare atmosphere.

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| 47 | Exploring the propagation and dissipation of high-frequency waves throughout the lower solar atmosphere | Momchil Molnar<br>Co-Is<br>Robert Jarolim (US), David Afonso Delgado (US), Roberto Casini (US), Kevin Reardon (US) | US |

Abstract

The solar chromosphere is dominated by radiative losses, which are a few kW/m^2 larger than the sum of all of its heating sources. There are have been many proposed theoretical explanations for the origin of the heating, but none have satisfactory observational constraints. One of the most prominent candidates for chromospheric heating is the dissipation of high-frequency waves driven from the convective overshoot at the base of the photosphere. Recent work has provided evidence in both directions, as authors disagree if high-frequency waves could provide the required energy flux to sustain the quiescent chromosphere. We propose observational program with DKIST that could provide better observational limits to the high-frequency flux carried in the chromosphere by observing two regions -- one close to disc center and one close to the limb. Furthermore, the polarimetric capabilities of DKIST could provide us with the first observational estimate of the role of the magnetic field in the propagation and dissipation of waves in the lower solar atmosphere. A parallel project based on the observational data obtained from this project would be to study the signatures of the Hanle and magneto-optical effects on the observed polarization in the Ca II K line close to the limb.

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| 52 | Evolution of flaring chromosphere on elementary scales | Spencer Riley<br>Co-Is<br>Lucas Tarr (US), Jiong Qiu (US), Dana Longcope (US) | US |

Abstract

Spectroscopic observations of the flare chromosphere provide a critical diagnostic of the dynamical evolution of the flare atmosphere in response to energy deposition at the feet of flare loops. This proposal aims to investigate the height-dependent evolution of chromospheric spectral features with ViSP observations of Ca II (854 nm), H-alpha, and Na I lines over the progression of a flaring event on an unprecedented spatial scale (<0.1) and high time cadence (~1s). From these measurements, we will characterize spSarahectral properties in different evolutionary stages of flare heating, use them to explore physical mechanisms heating the flare chromosphere, and probe the relevant temporal-spatial scales at which these heating processes occur.

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| 54 | Reconstructing Active Region Currents near PILs Based on Multi-Height Magnetograms | Johnathan Stauffer<br>Co-Is<br>Sarah Jaeggli (US), Maria Kazachenko | US |

(US), Kevin Reardon (US), Lucas Tarr (US), Kalman Knizhnik (US), Brian Welsch (US), Peter Schuck (US)

Abstract

Electrical currents are the fundamental source of the magnetic field in the solar atmosphere, and should be present wherever strong field gradients occur. This is especially true in active region polarity inversion lines (PILs), which show the strongest horizontal magnetic gradients on the solar surface. These regions invariably serve as the source regions for the strongest solar flares and coronal mass ejections, which are driven by the non-potential magnetic field produced by atmospheric current systems – however, these are difficult to measure directly since they lack direct, spectroscopic signatures. A new technique – CICCI – allows for the robust detection of current systems in the solar atmosphere by separating magnetograms into “components” based on where the source current lies in relation to the height of the magnetic field measurement. We propose DKIST observations of one or more active region PILs in three spectral lines (Fe I 630.2 nm, Na I D1 589.6 nm, and Ca II 854.2 nm) which span the photosphere and chromosphere. These lines will be used to infer the active region magnetic field as a function of optical depth, which will be decomposed by CICCI to infer the current structures which lie between each pair of magnetograms. When applied to these multi-height magnetograms, CICCI will permit for the detailed reconstruction of 3D, active region current systems, promising to greatly improve our understanding of active region structure.

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| 58 | Investigating Sunspot Fine-structures Using High-resolution Spectropolarimetry | Rahul Yadav<br>Co-Is<br>Maria Kazachenko (US), Ryan French (US), David Kuridze (US), Kevin Reardon (US) | US |

Abstract

One of the important topics in solar physics is understanding the formation, stability and decay of sunspots. At the solar photosphere, sunspots are the largest and strongest concentrations of the magnetic field embedded in a turbulent medium comprising convective plasma motions. While convection is strongly suppressed in the central dark core of the sunspot umbra, which harbours a magnetic field strength more than 2 kG, the observed brightness is insufficient to be attributed to radiative losses alone. Hence convection, reduced significantly, is necessary to explain the brightness in the umbra. This transport of energy by convection, is responsible for the small, bright structures called umbral dots, that populate the dark umbral background as seen in high resolution images. Umbral dots and their fine structure are thus fundamental to the determination of the thermal budget and in turn, the stability of sunspots. This is essential for constructing a realistic and consistent sunspot model which unifies all the different small-scale features in sunspots, namely, penumbral grains, penumbral filaments, and light bridges. We propose a study of sunspot fine-structures using high resolution spectropolarimetric observations from the DKIST telescope. This will enable us to investigate the thermal, magnetic, and kinematic properties of umbral dots with unprecedented spatial resolution which will constrain existing numerical magneto-convective models of sunspots.

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| 60 | Probing the Photospheric Conditions for Spectral Line Scattering in Sr 4607 | Ivan Milic<br>Co-Is<br>Rebecca Centeno (US), Gianna Cauzzi (US), Momchil Molnar | DE |

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| | | (US), Kevin Reardon (US) | |

Abstract

Scattering polarization in the Strontium 4607 spectral line at the center of the solar disk has been theoretically predicted but only statistical detection has been reported so far. Clear detection of these signals will help validate numerical simulations and radiative transfer calculations that involve scattering polarization and the Hanle effect. More importantly, they will allow us to diagnose weak magnetic fields with mixed polarity on very small scales, that are undetectable via the Zeeman effect. With this proposal, we will attempt to detect scattering polarization in the Sr 4607 line and to constrain, using a complementary set of spectral lines, physical conditions in the photosphere where Sr 4607 takes place. This will open possibilities for performing 3D modeling on semi-empirical models of the solar atmosphere and thus open possibilities for developing Hanle inversion codes for the photosphere. Finally, we will be able to constrain the properties of very weak, possibly tangled magnetic fields on very small spatial scales in the solar photosphere. It is only with the large collecting area of DKIST, combined with its multi-line philosophy, that we can achieve these goals.

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| 62 | Observing coronal Alfvén-like waves with Cryo-NIRSP | Momchil Molnar<br>Co-Is<br>Richard Morton (GB), Kevin Reardon (US), Chris Gilly (US), Alin Paraschiv (US) | US |

Abstract

We propose to observe the signatures of the Alfven-like waves in the low solar corona with the Cryo-NIRSP instrument. These waves, which have been previously detected with CoMP, could be energetically important for maintaining the corona in its thermodynamic state. The improved resolution of DKIST will allow for the more precise constraints on the wave energy fluxes carried by these waves, which is an important astrophysical question with implications to stellar coronae.

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| 64 | Spatial and Temporal Structure of the Flaring Chromosphere | Samantha Cook<br>Co-Is<br>Christopher Osborne (GB), Lyndsay Fletcher (GB), Sargam Mulay (GB) | GB |

Abstract

We propose DKIST observations using VBI-blue and ViSP to determine the spatial offset between chromospheric sources in a solar flare. Radiation hydrodynamic modelling of flare energy input, assumed to be directed along the magnetic field, predicts that sources at different wavelengths should form at different heights in the atmosphere, with separations of a few hundred km predicted for prominent chromospheric lines. Thus with knowledge of the magnetic field orientation, any observed offsets can be interpreted as a physical distance and compared with model predictions. A further measurement of relative source heights can be made using the radiative backwarming effect, which results in a radiatively-excited lower atmosphere source separated vertically from the source of exciter radiation. The magnetic field measurements that are needed to fully interpret the source offsets can also be used as a secondary goal to study magnetic field variations during the flare, including potentially those due to the 3-minute chromospheric oscillations.

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| 65 | Combining SpectroPolarimetry with Cool and Hot Emission for Accurate Coronal Diagnostics | Patrick Antolin<br>Co-Is<br>Thomas Schad (US), Lucia Kleint (CH), Ramon Oliver (ES), Frédéric Auchère (FR), Prateek Sharma (IN), Cooper Downs (US), Joten Okamoto (JP), Seray Sahin (GB), Moira Jardine (GB), Clara Froment (FR), Jeffrey Reep (US), Max Gronke (DE) | GB |
| | Abstract<br>The coronal magnetic field handles the puzzlingly high million-degree temperatures, the morphology and variability of the solar corona. A major obstacle in our understanding of this extreme environment is the difficulty in measuring and mapping the magnetic field. Spectro-polarimetric inversions in the coronal Fe XIII forbidden lines have greatly advanced in recent years, but provide significantly smaller values compared to direct methods. Another important physical quantity is turbulence, on which many coronal heating mechanisms rely. Turbulence is often assumed to hide in the non-thermal line widths. Line-of-sight superposition due to the optically thin hot coronal emission greatly impedes accurate determination of these essential physical quantities. However, the solar corona also hosts a large amount of cool material in the form of coronal rain, which can help disentangle the line-of-sight confusion. This DKIST observing programme proposal is based on the dual cool-hot nature of the solar corona to accurately diagnose the coronal environment and strongly constrain coronal heating mechanisms and global coronal models. We propose sequential spectro-polarimetric observations of the hot (Fe XIII 1074) and cool (He I 1083) emission to accurately measure the coronal magnetic field and turbulence levels in the off-limb active region corona. In turn, the results will also help constrain theories of multiphase plasma formation in other astrophysical environments, such as the interstellar and intracluster medium. | | |
| 66 | Understanding Physical Mechanisms that Drive Solar Wind with DKIST Coronal Magnetometry | Soumyaranjan Dash<br>Co-Is<br>Xudong Sun (US), Thomas Schad (US) | US |
| | Abstract<br>The solar wind, a supersonic stream of charged particles emanating from the Sun's outer atmosphere, is driven by mechanisms that are still under active investigation. Alfvén waves and interchange magnetic reconnection are two primary processes proposed to explain its formation. However, direct observations elucidating the formation and energy transfer processes in the lower solar corona remain elusive. The turbulent Alfvén wave-driven in-situ formation scenario aligns with various observational constraints, while interchange reconnection provides a compelling explanation for the observed ionization degree and elemental abundance in the solar wind. Indicators of interchange reconnection include presence of strong current sheets at the interface between open and closed magnetic fields, enhanced temperatures, and confined upward plasma flows. These processes facilitate energy transport across magnetic fields, driving the solar wind in the low solar corona. To further investigate these mechanisms, we propose targeted spectropolarimetric observations using the DKIST/CryoNIRSP instrument. . By inferring magnetic topology and examining the spatial distribution of temperature and Doppler shifts, these novel observations will enhance our understanding of the underlying physics governing solar wind formation and its driving mechanisms. This proposal | | |

aims to provide crucial insights into the dynamics of solar wind generation and energy transfer in the Sun's atmosphere.

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| 67 | Inclined Sunspot Oscillations | James Crowley<br>Co-Is<br>Ryan French (US), Kevin Reardon (US) | US |

Abstract

In this proposal, we aim to answer open questions about the 3-minute oscillations and associated umbral flashes by using high-resolution and multi-wavelength observations of an inclined sunspot. Oscillations in the solar atmosphere are an interesting and important phenomena because they transport substantial energy as well as probe the structure of the atmosphere they propagate through. Umbral flashes are the coherent shock fronts of the 3-minute oscillation and are observed as blue-shifted emission in the core of chromospheric lines. Despite having been observed for nearly half a century, many properties, such as the height, heating, magnetic properties of the umbral flash are still unknown. By utilizing DKIST's impressive spatial resolution and the ability to cotemporally observe multiple spectral lines, we have designed an observing proposal that focuses on the oscillations of an inclined sunspot. By observing sunspot far from disk center and taking advantage of DKIST's high spatial resolution, we plan to use a highly inclined viewing angle to give a new perspective on the height and properties of the umbral oscillations.

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| 68 | 3D Coronal Magnetic Structures: Streamer-Pseudostreamer region and Possible pre/post CME Configurations. | Maxim Kramar<br>Co-Is<br>Thomas Schad (US) | US |

Abstract

Solar coronal magnetic fields play a key role in the energetics and dynamics of coronal heating, solar flares, coronal mass ejections (CME), filament eruptions, and determine space weather processes. The magnetic fields also serve as the storage of the free energy; the reorganization of the coronal magnetic fields and the release of magnetic free energy are directly responsible for the occurrence of energetic and explosive solar eruptions, which are the primary driver of space weather. However, the details of the physical processes that trigger the release of the magnetic free energy leading to eruptions have not been resolved. Therefore, precise knowledge of the coronal magnetic field configuration, and how these fields interact with the coronal plasma and evolve before, during, and after eruptions, is key for understanding the physics of the corona and the drivers of space weather. The ultimate goal of this proposal is to reconstruct in 3D the coronal magnetic field around pseudostreamer and streamer regions for several carrington rotations with chances to observe the pre/post CME structures which could be associated with these regions (e.g. sympathetic CME). We will use off-limb Cryo-NIRSP polarimetry observations as a data source for the vector tomography inversion. It has been shown that even limited in time and FOV polarimetric observations can improve 3D magnetic field reconstruction in the observed region compared to commonly used extrapolation techniques (e.g. PFSS or MHD extrapolations).

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| 69 | High-Resolution Observations of the Sun's Polar Fields | Gordon Petrie<br>Co-Is<br>Valentin Martinez Pillet (ES), Serena Criscuoli (US), Sanjay Gosain (US), Alexandra Tritschler (US) | US |

Abstract

Reliable observations of the Sun's polar fields are therefore a necessary condition for understanding the magnetic structuring of the corona and heliosphere, the acceleration of the solar wind, and the solar dynamo. The true strength and structure of the polar field can only be determined by high-resolution vector observations that have sufficient spatial resolution and spectro-polarimetric sensitivity. Precise measurement of the magnetic Stokes vectors is needed to deduce the solar vector magnetic field accurately. An accurate measurement in the visible and near infrared at 0.1″ resolution and 5-second integration time requires DKIST's 4m aperture. Reliable full-Stokes multi-wavelength measurements for the photosphere and chromosphere with DKIST would therefore transform our understanding of the polar fields and their effect on the global solar atmosphere.

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| 75 | Zooming in on Kilogauss Magnetic Elements in a Near-Limb Open Flux Region | Bryan Yamashiro<br>Co-Is<br>Xudong Sun (US), Rebecca Centeno (US), Ivan Milic (DE), Lucas Tarr (US), Milan Gosic (US), Sarah Jaeggli (US), Shah Mohammad Bahauddin (US) | US |

Abstract

The magnetic fields in the solar coronal holes root in photospheric flux elements a few arcseconds across with an intrinsic field strength in the kilogauss range. Their exact nature remains unclear due to the limited spatial resolution and polarimetry sensitivity of the existing facilities. The weaker fields of the internetwork regions are not well constrained. We propose to obtain high-resolution observations (~0.1″) of these magnetic elements in open flux regions near the limb using ViSP with the Fe I 630.2 nm, Mg I b2 517.3 nm, and Ca II 854.2 nm lines. We aim to address the following questions: (1) what is the nature of the fine-scale field vectors inside/outside the magnetic elements? (2) how much magnetic flux does each component provide? (3) How much do the flux tubes expand in the lower chromosphere? These observations will help correct several systematic biases in the magnetic field inference process, allowing for a better understanding of the near-limb fields.

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| 76 | Revisiting the force-free height of the photospheric magnetic field | Ayla Weitz<br>Co-Is<br>Kevin Reardon (US), Ryan Hofmann (US) | US |

Abstract

Magnetic field extrapolations are essential to comprehend magnetic topologies in the solar atmosphere, which are vital to understanding events like solar flares and coronal mass ejections. In typical extrapolation methods, the three-dimensional topology of the magnetic field is inferred using photospheric magnetic observations as a boundary condition to an approximate magnetic model. However, these extrapolations require the boundary condition to be force-free, and this condition generally does not hold in the lower photosphere where the field is usually measured. The canonical measurement of the height at which the force-free approximation becomes valid is that of Metcalf et al. 1995, which uses polarimetric observations of an active region in the Na I 5896 line. This finding has not been adequately revisited with our improved observational and interpretative tools. DKIST provides the instrumentation and observational capabilities to reexamine the force-freeness of the magnetic field in the upper photosphere. We propose to make multi-line measurements of a relatively small active region. We will scan three lines with ViSP — Fe I 6302 Å, Na D1 5896 Å, and Ca II 8542 Å — to probe from the photosphere into the low chromosphere. We will perform full-Stokes inversions of these lines to obtain the depth-stratified magnetic field vector. We will then compute the relative magnitude of the Lorentz force as a function of height to ultimately determine at what geometrical height the magnetic field of the target active region becomes effectively force-free.

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| 78 | Distinguishing Coronal Cavity Models using DKIST CryoNIRSP Observations | Samaiyah Farid<br>Co-Is<br>Sarah Gibson (US), Yuhong Fan (US), Suman Dhakal (US), Susanna Parenti (FR), Jie Zhang (US), Urszula Bąk-Stęślicka (PL), Joel Dahlin (US), Mari Paz Miralles (US), Nour E. Raouafi (US) | US |

Abstract

The mechanism for the release of stored magnetic energy in coronal mass ejections (CMEs) is an unsolved problem of solar physics and one of the objectives in the DKIST Critical Science Plan. CME onset models predict various scenarios, including magnetic reconnection below the erupting structure (tether-cutting) or above a quadrupolar structure (breakout) as well as ideal processes such as the magnetic torus instability. Distinguishing between trigger mechanisms requires knowledge of CME precursor magnetic topologies such as coronal prominence-cavity systems. By determining the existence and location of magnetic O- and X-points relative to the cavity, we can distinguish between flux rope and sheared arcade models. The goal of this proposal is to use the full Stokes vector measurements in the corona obtained by CryoNIRSP to probe magnetic field and direction from linear polarization, and line of sight magnetic field (Blos) from circular polarization — a measurement enabled by the large-aperture DKIST — identifying the location of magnetic O-points and choosing between models. Coronal cavities are particularly good candidates for using DKIST Cryo-NIRSP Stokes V observations to obtain coronal magnetic field (Blos), because cavities that appear sharply defined on the coronal limb are oriented along the line of sight and thus can provide a magnetic field that is robust to LOS integration. Motivated by recent observations after the DKIST CryoNIRSP calibration update, we propose (primary) full Stokes vector observations of coronal cavity systems in the FeXIII 1074.7 nm line and (supplemental) an intensity-only scan in FeXIII 1079.8 nm for a density ratio.