Wednesday Dec 1

8:30am - 8:50am [PST]

Nat Gopalswamy

Radio investigations with MOST: the Multiview Observatory for Solar Terrestrial Science

This presentation will provide an overview of the Multiview Observatory for Solar Terrestrial Science (MOST) mission and discuss magnetic field measurements in the corona/interplanetary medium relevant to radio physics.

08:50am - 09:10am [PST]

Hazel Bain

Research to Operations Processes for Space Weather Applications: A NOAA SWPC Perspective

A well-defined process is required for space weather forecast centers to capitalize on the innovation of the scientific research community. As new predictive models and observational capabilities are developed, these applications need to be assessed and validated in a real-time environment before being transitioned to space weather forecasting operations. This presentation will cover plans for a formal Research to Operations and Operations to Research (R2O2R) Framework and a new Space Weather Prediction Testbed. Together these initiatives aim to accelerate the transition of research models and applications to NOAA's Space Weather Prediction Center.

09:10am -09:30am [PST]

Nicole Vilmer

Prospects and Plans for Addressing the Science of Space Weather: a European Perspective

10:15am -10:35am [PST]

Bin Chen

Microwave Studies of Solar Flare Energy Release: Outlook for FASR

A long-term goal of the solar and space physics community is to understand the fundamental physical processes underlying solar flares and the often-associated coronal mass ejections (CMEs), as well as their space weather implications. Pertinent outstanding challenges include a quantitative understanding of the magnetic energy storage and release processes, as well as a detailed examination of physical mechanisms responsible for efficient particle acceleration and the highly coupled particle transport processes. Microwave observations provide a wealth of diagnostic tools to probe such processes in the low solar corona. In the past decade, exciting new results have emerged with the operation of new/upgraded instruments such as EOVSA and JVLA. However, solar-dedicated instruments currently operating or being commissioned do not have sufficient bandwidth, dynamic range, time cadence, and resolution to fully unleash the unique diagnostic power of microwave observations. In this talk, after a brief overview, I will use examples from recent studies and realistic flare simulations to discuss new insights expected from the superior broadband microwave imaging spectropolarimetry capabilities of a next-generation radio heliograph, such as the Frequency Agile Solar Radiotelescope (FASR) concept.

10:35am - 10:55am [PST]

James Drake

Electron acceleration in solar flares

Magnetic reconnection is a significant driver of energetic particles in flares both on the sun and the broader universe. I will discuss the emerging understanding of electron acceleration in solar flares and discuss measurement requirements to diagnose energy gain of electrons. Single x-line models fail to explain the large number of energetic electrons seen in flares. However, simulations reveal that reconnection becomes turbulent in the flare environment, consistent with observations of non-thermal broadening of spectral lines. Magnetic energy release and particle acceleration therefore take place in a multi-x-line environment. A major surprise is that the energy gain of the most energetic electrons is dominated by Fermi reflection in growing and merging magnetic flux ropes rather than parallel electric fields. Conventional particle-in-cell models have failed to produce the extended powerlaw distributions seen in observations because of the inadequate separation of kinetic and macroscales. A new computational model, {\it kglobal}, has been developed that blends MHD dynamics with electron particles but eliminates all kinetic scales. Feedback of the energetic electrons on the MHD fluid is included. Simulations of reconnection in a macro-scale system reveal electron powerlaw distribution that extend nearly three decades in energy and that the dominant control parameter is the ambient

out-of-plane magnetic field. This means that the direct measurement of the magnitude and direction of the magnetic field during energy release in the corona is required. The electron spectral indices in the model match those measured by RHESSI and EOVSA for the September 10, 2017, flare. Major challenges are to understand how relativistic electrons are ""confined"" as they gain significant energy. The results also suggest that modeling of particle acceleration in realistic macro-scale flare geometry will be possible.

10:55am -11:15am [PST]

Eoin Carley

New frontiers in flare and CME science with low frequency radio instruments

Flares and coronal mass ejections (CMEs) are associated with the acceleration of particles to non-thermal energies, resulting in a variety of types of radio emission. Examining where, when and how this radio emission occurs during eruptive activity provides insight into both the particle acceleration mechanisms and the nature of the flare/CME process itself. In particular, low frequency radio observations (below a few 100 MHz) provide observations of the middle-to-upper corona and hence the early-to-advanced phases of flare/CME development. In this talk, I will review recent advances made available by the arsenal of new low frequency radio instruments, including the ground-based LOFAR, OVRO-LWA, NenuFAR and MWA, and the space-based PSP and SoLO, among others. I'll show how these instruments are pushing forward our understanding of flares/CME physics and the related particle acceleration processes. High resolution imaging-spectroscopy in this domain is also providing advanced knowledge of radio emission and scattering mechanisms, leading to novel and important diagnostics of turbulence in coronal plasma. Finally, the current decade will see the development of exciting new instruments in the low frequency domain, such as LOFAR2.0, SKA-low and SunRISE. I'll touch on these new frontiers in solar radio instrumentation, and the outstanding challenges in solar physics such instruments will allow us to tackle in the near future.

11:15am -11:35am [PST]

Fan Guo

Particle Acceleration and Transport at Coronal Shocks

Major solar eruptions are observed to be the drivers of large solar energetic particle events. The production of highest energy particles starts low in the solar corona, and the diagnostics of the process are rare and challenging. At the same time, these energetic events drive electron acceleration and subsequent emission processes that are observable by current and future

radio telescopes. One particularly relevant, but often overlooked aspect is the tight correlation between energetic electrons and ions in large solar energetic particle events. We will briefly review the problem of particle acceleration and transport at coronal shocks. While most studies are concerned with ion acceleration, we emphasize the importance of considering electron acceleration by shocks to resolve current debates. Future radio telescopes may hold the key to understanding particle acceleration and transport at coronal shocks, by establishing the origin of energetic electrons from coronal shocks and further identifying the roles of shock geometry and large-scale magnetic structures.

12:20pm - 12:40pm [PST]

Costas Alissandrakis

Quiet sun structure, limb brightening, and the bridge to ALMA

Solar observations with ALMA have opened a new, hitherto underexplored, spectral window for the study of the solar chromosphere. So far a number of studies of the quiet sun, both with single dish and interferometric data, have given interesting new results on the temperature structure of the chromosphere, as well as on the differences between network and intranetwork regions, while serving as tests of traditional atmospheric models. In this report I will review these results and extend to longer mm and cm wavelengths, discussing how an instrument like FASR could expand such diagnostics in the upper chromosphere and the transition region.

12:40pm -01:00pm [PST]

Samuel Schonfeld

Imaging F10.7: microwave emission mechanisms and coronal elemental abundances

The solar F10.7 index is a daily measurement of the 10.7 cm (2.8 GHz) solar microwave flux density used prominently in space weather forecasting and atmospheric modeling due to its correlation with solar extreme ultraviolet (EUV) and long observation history. However, both bremsstrahlung (free-free) and gyroresonance emission contribute to solar microwave emission. This complicates F10.7's use as an EUV proxy since only the free-free emission relates directly to EUV. Comparing single-frequency microwave and EUV imaging, it is possible to split the bremsstrahlung and gyroresonance components which has important implications for space weather modeling. We present an initial study using Very Large Array (VLA) imaging where we identify the emission components of the F10.7 emission on a single day. Importantly, the technique to accomplish this requires knowledge of coronal elemental abundances, which also means that it can be used to measure those same abundances. These methods become even more powerful with polarimetric and spectral observations and we discuss the investigations

enabled by the expanded Owens Valley Solar Array (EOVSA) and a future Frequency Agile Solar Array (FASR).

01:35pm -01:55pm [PST]

Gregory Fleishman

Coronal magnetic field measurements using radio observations

Solar radio emission is highly dependent on the magnetic field strength and direction in the corona. At the microwave range, the main radiation mechanisms contributing to the emission are the free-free and gyroresonant processes in case of non-flaring corona and the gyrosynchrotron process in case of flares. All these are sensitive to the magnetic field and can be used for the coronal magnetic field measurements. The key to accessing the inherent diagnostic power of radio emission is to have multi-frequency radio images of sufficient quality, resolution, and polarization purity, with which to confidently identify and separate the different emission mechanisms, to remove the ambiguities that have limited many past radio studies. In this talk I review the available measurements, measurement strategies that employ multi-frequency microwave imaging data, and conclude about the perspectives of the measurements with the existing and future radio interferometers.

01:55pm -02:15pm [PST]

Enrico Landi

Coronal magnetic field measurements with Hinode/EIS

The magnetic field of the solar corona is one of the most critical parameters in solar physics, as it lies at the core of most manifestations of coronal physics and Space Weather. Despite its importance, it has proved to be one of the most elusive quantities to be directly measured. Recently, we have developed a novel diagnostic technique that capitalizes on the effects that the coronal magnetic field has on the intensity of an Fe X EUV spectral line routinely observed by the Hinode/EIS high resolution spectrometer, and is capable of measuring the strength of the coronal magnetic field in active regions. In this seminar, I will describe the diagnostic technique, its limitations, and its application to EIS observations.

02:15pm - 02:35pm [PST]

Tom Schad

O/IR coronal magnetometry and a cooperative view of the 3D solar atmosphere

Spectropolarimetric measurements of optical and infrared forbidden emission lines is one of our critical and still burgeoning tools for inferring the properties of the solar coronal magnetic field, which lies at the heart of understanding coronal heating, the extended solar wind, and solar eruptions. Through resonance polarization and the Zeeman effect, O/IR lines uniquely provide vectorial diagnostics of the magnetic field as well as diagnostics of densities, temperatures, velocities, and potentially abundance measurements. This toolset has been proven to give critical information for mapping the global coronal field and for understanding the propagation, storage, and release of energy injected from the lower atmosphere into the corona and inner heliosphere. Pioneering telescopes like Solar-C and COMP have widened this frontier, making way for upcoming breakthroughs from UCOMP and the Daniel K Inouye Solar Telescope. One fundamental challenge, though, remains the reliable interpretation of the observations, which can only be achieved coronagraphically off-limb, especially as the polarized emissivities are coupled to both the magnetic and thermal state of the plasma along the line-of-sight. Cooperative efforts for mapping the evolution of lower atmosphere and the corona on-disk and at different lines of sight greatly complements the utility of the O/IR diagnostics. This talk will highlight the capabilities of and science addressed by O/IR coronal lines and further discuss the benefits of cooperating with inner heliospheric missions and future facilities like COSMO and FASR.

Thursday Dec 2

08:00am -08:20am [PST]

Linghua Wang

Solar Energetic Electron Events and Associated HXR flares

Solar energetic electron events are one of the most common particle acceleration phenomena at the Sun. Here we investigate 16 solar energetic electron (SEE) events measured by WIND/3DP with a double-power-law spectrum and the associated western hard X-ray (HXR) flares measured by RHESSI with good count statistics, from 2002 February to 2016 December. In all the 16 cases, the presence of an SEE power-law spectrum extending down to <~5 keV at 1 AU implies that the SEE source would be high in the corona, at a heliocentric distance of >~1.3 solar radii, while the footpoint or footpoint-like emissions shown in HXR images suggest that the observed HXRs are likely produced mainly by HXR-producing electrons via thick-target

bremsstrahlung processes very low in the corona. We find that for all the 16 cases, the estimated power-law spectral index of HXR-producing electrons is no less than the observed high-energy spectral index of SEEs, and it shows a positive correlation with the high-energy HXR-producing electrons at energies above 30 keV. In addition, the estimated number of SEEs is only ~0.0001-0.01 of the estimated number of HXR-producing electrons at energies above 30 keV, but with a positive correlation between the two numbers. These results suggest that in these cases, SEEs are likely formed by upward-traveling electrons from an acceleration source high in the corona, while their downward-traveling counterparts may undergo a secondary acceleration before producing HXRs via thick-target bremsstrahlung processes. In addition, the associated 3He/4He ratio is positively correlated with the observed high-energy spectral index of SEEs, indicating a possible relation of the 3He ion acceleration with high-energy SEEs.

08:20am - 08:40am [PST]

Stuart D. Bale

Parker Solar Probe radio measurements of flares, active regions, and the quiet Sun

I will give an overview of PSP radio measurements and some expectations for solar maximum and lower perihelion altitudes.

08:40am - 09:00am [PST]

Christina Cohen

Solar energetic particle events observed by PSP/Integrated Science Investigation of the Sun (IS⊙IS)

Although the Sun was in a quiet mode when Parker Solar Probe was launched on August 12, 2018, the energetic particle suite, IS⊙IS, was poised to measure ions from H to Fe at ~20 keV to >100 MeV/nuc and electrons from 15 keV to 6 MeV. Within the first year, IS⊙IS had measured several small SEP events, including ones at 0.17 AU and 3He-rich events also seen by ACE/ULEIS. As solar activity has increased the variety of solar energetic particle (SEP) events measured by IS⊙IS has expanded dramatically with several large events, including the multi-spacecraft November 2020 event and the recent ground level enhancement event at the end of October 2021. This talk will review the capabilities of the instruments and present a sampling of the interesting SEP measurements observed to date.

09:45am - 10:05am [PST]

Rachel Osten

Stellar Radio Science and FASR

The recent release of the Pathways to Discovery in Astronomy and Astrophysics for the 2020s report laid out a science theme of "Worlds and Suns in Context" as one of the three major science drivers for the coming decade. The Sun of course is our nearest star, and provides much of the detailed context in which stellar astrophysics takes root, however it is only one star at a singular point in its evolutionary phase. I will address the synergy and complementarity between open questions in solar radio physics and those in stellar radio physics. I will pay particular attention to the science drivers for FASR and how they can influence and interact with the breakthroughs expected in stellar radio science over the next decade plus. I will also touch on potential stellar science applications for FASR.

10:05am - 10:25am [PST]

Joe Lazio

Space Weather: From the Sun to Other Stars

A stable (secondary) atmosphere is recognized as one of the many potential factors that determine whether a planet is habitable. Whether such an atmosphere can persist over geological time scales is determined in part by interactions with and feedbacks driven by the host star. For instance, a star's ultraviolet emissions can ionize and change the composition of a planet's atmosphere, while a star's stellar wind can erode an atmosphere. The latter case has been observed in the Solar System, as a coronal mass ejection impacted the Martian atmosphere. Over the next few decades, a census of terrestrial-mass, and potentially habitable, planets in the solar neighborhood will be constructed; plausibly even some planets with biosignatures (or technosignatures) will be detected. Characterizing the properties of these planets, and their host stars, will be critical. A multi-wavelength approach will be required. In this presentation, I outline how future space-based radio astronomy missions, in concert with FASR, will provide some of the critical measurements for characterizing terrestrial-mass planets and their host stars.

02:10pm - 02:30pm [PST]

Keith Bannister

Investigating radio propagation in the interstellar medium with wideband radio telescopes

The interstellar medium causes wavelength-dependant variability of radio sources. Investigations of this variability has revealed a number of intriguing properties. For example, Extreme Scattering Events are thought to be caused by AU-sized clouds 1000 times more dense than the average ISM, and may be responsible for a significant fraction of the Milky Way mass. Recently, five radio scintillating radio sources were found in a 2 degree x 1 arcminute straight line, indicating the existence of a perfectly-straight filament in the ISM with an aspect radio of 120:1. How such structures can be created and maintained in the ISM is unclear. I will present some of the science, and how it can be solved with wideband well-stampled time series.

Friday Dec 3

08:00am - 08:20am [PST]

Dale Gary

The Science Driven Specifications for FASR circa 2010 and the EOVSA Experience

I will connect the science drivers to specific design requirements for FASR as they existed at the time of the last full design in 2010, on which the EOVSA design was based, and give a few examples of experience gained from EOVSA. I will discuss what worked well and what needs further thinking, and I will emphasize how earlier limitations in technology may have changed as we envision the next generation instrument.

08:20am - 08:40am [PST]

Sander Weinreb

wideband Feeds and High-Dynamic Range LNAs for FASR

Review of existing feed design and dynamic range requirements.

08:40am - 09:00am [PST]

Gregg Hallinan

The DSA-2000

I will summarize the DSA-2000 science case, design and proposed site/infrastructure requirements. I will in particular focus on aspects of the project that may have technical synergies with the proposed FASR array.

09:45am - 10:05am [PST]

Jonathon Kocz

FPGA and GPU Based Correlator Development

In this talk we (Hickish/Kocz/Werthimer) will present an overview of some correlators and other radio telescope back ends under construction, and discuss some of the hardware options available for a FASR correlator.

09:45am - 10:05am [PST]

Dan Werthimer

Options for nextgen FASR Correlator

Jack Hickish, Jonathan Kocz, and Dan Werthimer will discuss options for FASR correlators, both stepping through the 2 to 20 GHz band every few milliseconds, or covering the whole band simultaneously. Jack and Jonathan will also present some of the recent correlators they've developed.

10:05am - 10:25am [PST]

Robert Selina

ngVLA Technical Overview & Solar Observing Capabilities

A brief overview of the ngVLA technical concept and status as the project approaches the system conceptual design review. Design features relevant to solar observing will be highlighted, as well as some of the known feature gaps that a solar-dedicated radio telescope could aim to address.

10:25am - 10:45am [PST]

Sergey Lesovoi

Design and imaging performance of the Siberian Radioheliograph (SRH)

The SRH is solar dedicated muti-frequency (3-24 GHz) radio telescope. The construction of the SRH is complete. It is currently being tested. The SRH consists of three T-shaped antenna arrays for frequency ranges 3-6, 6-12, 12-24 GHz. The design of arrays (antennas, RF over fiber links, receivers and correlators) is presented. The calibrations and imaging results obtained with 3-6 and 6-12 GHz arrays are discussed.