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The Total Irradiance Monitor (TIM) on NASA's SOlar Radiation and Climate Experiment (SORCE) is the most recently launched instrument to monitor the total solar irradiance (TSI). We present results from the first of the TIM's five years of operations and discuss the current knowledge of the instrument's accuracy. To date, we find the four instrument channels in good agreement and extremely robust against solar exposure. Such instrument characterizations and measurement accuracies influence the observational scenarios appropriate for determining long-term solar variability, and currently favor overlapping measurements of very stable TSI-monitoring instruments.

URL: http://lasp.colorado.edu/sorce/

SH32A MCC: Level 2 Wednesday 1330h

Total Solar Irradiance Monitoring: Results and Strategies Posters *(joint with A, SA, GC)*

Presiding: **R C Willson,** Columbia University**; J M Pap,** University of Maryland Baltimore County

SH32A-1098 1330h POSTER

NIST evaluation and calibration of several key parameters for the SORCE Total Irradiance Monitor (TIM): aperture area, diffraction effects, and cavity reflectance

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TIM measures total solar irradiance E, through the ratio of total power Φ, recorded by an active-cavity radiometer, to entrance aperture area A. The as-measured power and area have uncertainties and corrections because of many complicating effects. Here we consider uncertainties in aperture-area measurements, diffraction, and cavity reflectance, all of which were analyzed at NIST. TIM has an entrance aperture that limits its radiation reaching the radiometer. Geometrically, all radiation passing through should land on the cavity opening. Thus, an entrance aperture area is a critical parameter. Areas were measured by two methods: a non-contact (optical) technique that located points on an aperture perimeter, fitted the points to a circle, and calculated the area, and a relative technique that equated the ratio, of the area to the area of a standard aperture, to the ratio of measured flux transmitted through the two apertures. We will discuss aspects of uncertainty in these measurements. Knowing the area of the entrance aperture is insufficient to know the instrument throughput, however, partly because of diffraction effects. Diffraction at the entrance aperture causes some light that geometrically would enter the cavity to miss it. Also, three non-limiting baffles between the entrance aperture and cavity can cause radiation diffracted at the entrance aperture to be re-scattered onto the cavity opening. We considered all of these diffraction effects in detail, and will discuss the diffraction correction on measured power and its uncertainty. Radiation reaching the cavity can be absorbed or reflected by the radiometer cavity cone. NIST performed directional hemispherical spectral reflectance measurements on several auxiliary TIM radiometer cones from 1 μm to 18 μm. The NIST system combines a custom infrared integrating sphere, unique absolute reflectance measurement method, and Fourier-transform spectrophotometer. These data augment the primary reflectance measurements done at seven discrete wavelengths in the visible, near- and mid-infrared, verifying discrete wavelength measurements in the infrared and spectral continuity across the infrared.

SH32A-1099 1330h POSTER

Magnetic Field and Long-Term Solar Irradiance Variations Over Solar Cycles 21 to 23

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Total solar and UV irradiance has been measured from various space platforms over the last two and half solar cycles. Results based on these multi-decade measurements have demonstrated that both total and UV irradiances change on time scales of days to decades, confirming that our Sun is indeed a variable star. High spatial and temporal resolution photometric and magnetic field observations conducted by the SOHO/MDI experiment and also from the ground have demonstrated that the surface of the Sun and its outer atmosphere are highly variable on almost all spatial scales. To understand the physical causes of irradiance variations, it is necessary to study the spatial and temporal characteristics and evolution of the solar magnetic fields and to establish to what extent solar magnetic features may contribute to irradiance variations. In this paper we analyze the total solar and UV irradiance composites compiled from various space measurements starting in late 1978. To establish the effect of surface magnetic activity on irradiance variations as a function of the solar cycle, we show the association of the absolute value of the full disk magnetic field strength data measured and compiled at the National Solar Observatory at Kitt Peak for the time interval of 1978 to date. Using various pattern recognition techniques, we compare the observed irradiance variations with solar features (sunspots and faculae), derived from the MDI and Kitt Peak magnetograms from 1996 and 1992, respectively.

SH32A-1100 1330h POSTER

Long-Term Total Irradiance Composites and Models

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Accurate long-term total and spectrally resolved solar irradiance measurements are required for full understanding of the response of Earth's atmosphere and climate to irradiance changes. Space-based irradiance observations over the last two and a half solar cycles span a time interval too short to reveal secular changes and/or to establish conclusively whether there are significant changes in the amplitude or the character of irradiance variations on longer time scales. Since the time period of interest far exceeds the lifespan of any single experiment, continuous measurement programs must be formulated to compile composite irradiance time series from data of several experiments. Because the absolute accuracy of the current measurements is limited ($\pm$0.2%) in case of total irradiance, overlapping and redundant measurements are needed to ensure that the resulting composite data sets represent the "true" solar behavior. However, the largest obstacle in creating the current long-term total irradiance composite is the two-year gap between the SMM/ACRIM I and UARS/ACRIM II measurements. Adjustment of the ACRIM I and ACRIM II data now must be made through the Nimbus-7/ERB and/or the ERBE measurements. While using the published Nimbus-7/ERB data set, Willson (1997) concluded that the minimum of cycle 22 was higher than the minimum of cycle 21, while Fröhlich and Lean (1998) claim that no trend can be seen in total irradiance within the current measurement accuracy. In this paper we compare various total irradiance time series and composites. Specifically, we will compare the Nimbus-7, ERBS, ACRIM II and EURECA total irradiance data for the 1991-1993 time frame and the ACRIM II, and VIRGO data for the time frame of 1996-2000 to clarify whether the minimma of cycles 21 and 22 are the same or they are indeed diffferent. Fröhlich, C. and Lean, J.: 1998, In *Proceedings of the IAU Symposium 185*, (ed. F.L. Deubner), Kluwer Academic Publishers, p. 89. Willson, R.C.: 1997, *Science* **277**, 1963.

SH32A-1101 1330h POSTER

First Results Of The Solar Bolometric Imager

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On September 1 2003, the Solar Bolometric Imager (SBI) successfully observed the Sun for several hours while suspended from a balloon in the stratosphere above New Mexico. The SBI represents a totally new approach in finding the sources of the solar irradiance variation. The mission provided the first bolometric (integrated light) maps of the solar photosphere, that will allow to evaluate the photometric contribution of magnetic structures more accurately than has been achievable with spectrally selective imaging over restricted wavebands. The more accurate removal of the magnetic features contribution will enable us to determine if solar irradiance variation mechanisms exist other than the effects of photospheric magnetism. The SBI detector was an array of 320 x 240 thermal IR elements whose spectral absorptance has been extended and flattened by a deposited layer of gold-black. The telescope was a 30-cm Dall-Kirkham with uncoated primary and secondary pyrex mirrors. The combination of telescope and bolometric array provided an image of the Sun with a flat spectral response between 0.28 and 2.6 microns, over a field of view of 917 x 687 arcsec with a pixel size of 2.8 arcsec. The observing platform was the gondola previously used for the Flare Genesis Experiment (FGE), retrofitted to house and control the SBI telescope and detector. During the 9 hours of flight the SBI gathered several thousand bolometric images that are now being processed to produce the first maps of the total solar irradiance. The SBI flight is also providing important engineering data to validate the space worthiness of the novel gold-blackened thermal array detectors, and to verify the thermal performance of the SBI's uncoated optics in a vacuum environment. In this paper we will briefly describe the characteristics of the SBI, its in flight performance, and we will present the first results of the analysis of the bolometric images. This work was funded by NASA under grant# NAG5-10998.

SH32A-1102 1330h POSTER

Solar irradiance variation during rapid sunspot growth

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Large sunspot areas correspond to dips in the total solar irradiance (TSI), a phenomenon associated with the local suppression of convective energy transport in the spot region. Observations show a strong correlation between spot area and TSI. During the growth phase of a sunspot, though, other physics might conceivably affect this correlation. In this study we analyze the growth phase of NOAA active region 8179, in which large sunspots suddenly appeared near disk center at a time when few competing sunspots or plage regions were present on the visible hemisphere. The spot area of AR 8179 increased by a factor of two in less than 12 hours on March 13, 1998. The study makes use of the continuum images from SOHO/MDI and total-irradiance data from SOHO/VIRGO. We find that the area/TSI correlation does not significantly differ from the expected pattern of correlation, a result consistent with high thermal conductivity even at small depths below the photosphere. We have also searched for localized irradiance variations (transient bright rings) associated with the period of rapid growth. We discuss the significance of this lack of irradiance signatures of spot formation.

SH32A-1103 1330h POSTER

Variations of Solar Radius Observed with RHESSI

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The Solar Aspect System (SAS) of the rotating (at 15 rpm) RHESSI spacecraft has three subsystems. Each of these measures the position of the limb by sampling the full solar chord profile with a linear CCD using a narrow bandwidth filter at 670 nm. With a resolution of each CCD of 1.7 arcsec/pixel, the accuracy of each of the 6 limb positions is theoretically better than 50 mas using 4 pixels at each limb. Since the launch of RHESSI early 2002, solar limbs are sampled with at least 100 Hz. That provides a database of currently 4 x 10^9 single radius measurements. The main function of SAS is to determine the RHESSI pointing relative to Sun center. The observed precision of this determination has a typical instantaneous (16 Hz) value of about 200 mas (rms). We show and discuss first results of variations of solar radius observed with RHESSI.

SH32A-1104 1330h POSTER

Coronal heating and the appearance of the solar corona

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The details of the dependence of coronal heating on the conditions within the corona determine the appearance of the corona as viewed by different instruments. For example, strong fields at the base of short loops cause relatively hot, X-ray bright loops, whereas the much weaker fields over the quiet Sun result in cooler, EUV bright loops. Any dependence of the volume heating rates on local conditions (such as height or field strength) has a signature in the thermal profiles along the loops, translating into an appearance that depends on the instrumental pass band. In this preliminary study, we explore how such dependences of coronal heating on coronal conditions affect the appearance of the solar corona, and investigate the consequences for the global EUV and X-ray spectral irradiance. These results will eventually be used to compute the solar spectral irradiance in the EUV and X-rays for quiescent conditions throughout the solar cycle.

SH32B MCC: 2000 Wednesday 1340h

Roles of Electromagnetic Waves in Reconnecting Space and Laboratory Plasmas II *(joint with SM)*

Presiding: **G Lapenta,** Los Alamos National Laboratory**; T Lui,** Applied Physics Laboratory, Johns Hopkins University

SH32B-01 1340h INVITED

The Importance of Electrostatic Instabilities in Magnetic Reconnection

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Recent simulation studies of kinetic instabilities in reconnecting plasmas suggests that investigation of electromagnetic waves, such as the drift-kink-instability (DKI) and the Kelvin Helmholtz instability (KHI), may yield a theory of reconnection. However, the combined results of linear theory, and explicit and implicit plasma simulations fail to support a direct link between kinking and reconnection. Instead, the surprise has been the unexpected importance of the lower-hybrid-drift instability (LHDI). This electrostatic instability, which simulations suggest saturates at a level that is too low to provide the anomalous resistivity necessary for reconnection, alters current sheets in several important ways. The LHDI causes velocity shear, current sheet thinning, and anisotropic heating of electrons. The velocity shear drives a KHI mode, which explains current sheet kinking at high mass ratios, and the current sheet thinning and anisotropic heating significantly enhance the growth rate of the tearing instability, which may explain onset. Clearly, there is strong motivation for studies of the LHDI under magnetotail conditions.

SH32B-02 1400h INVITED

Reconnection in Thin Current Sheets With Sheared Magnetic Field: Three-Dimensional Particle Simulations

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Reconnection in thin current sheets is investigated by means of three-dimensional full particle simulations. Reconnection is allowed to develop out of the numerical noise. We do not impose symmetry about the midplane and we use a relatively high mass ratio of $m_i/m_e = 160$. The initial state is a Harris current sheet with a superimposed guide field. The lower hybrid drift instability develops at the boundary of the current layer with wave vectors perpendicular to the local magnetic field. This leads to an interference pattern of the inductive electric field in the center of the current sheet. Acceleration of the electrons by the inductive electric field leads to a patchy appearance of localized neutral lines on a time scale of about 10 inverse ion gyro-frequencies. These neutral lines merge and reconnection becomes eventually two-dimensional. Only in the case of exactly 90 degree shear reconnection is essentially two-dimensional from the beginning. We have determined the dependence of the reconnection onset time on the amount of shear, and we will present a run with a small initial magnetic field component normal to the current sheet.

SH32B-03 1415h

Lower-hybrid-drift and modified-two-stream instabilities in current sheet equilibrium

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The present paper discusses the stability of thin current sheet against lower-hybrid-drift (LHDI) and modified-two-stream (MTSI) instabilities. It is demonstrated that MTSI is driven by the cross-field current, implying that MTSI should also be most effective at the neutral sheet, while LHDI is driven by the density gradient. It is shown that under a normal Harris current sheet condition, $V_i/|V_e| = T_i/T_e$, LHDI completely dominates the MTSI, which implies that current-driven instability cannot penetrate to the center of the Harris current sheet. However, if the Harris current sheet condition is relaxed to $V_i/|V_e| > T_i/T_e$, then MTSI is shown to gradually overtake LHDI. The present finding demonstrates the potentially more important role of MTSI in the ion-dominated thin current sheets.

SH32B-04 1435h INVITED

Magnetic fluctuations and fine magnetic structure in MRX

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In the Magnetic Reconnection Experiment (MRX), reconnection has been observed to proceed at a rate much faster than the predictions of the Sweet-Parker model. The two leading explanations for this phenomenon are based on either two dimensional laminar structures due to Hall terms in the generalized Ohm's Law or enhanced resistivity perhaps caused by three dimensional turbulent wave particle interactions. In an attempt to explore these two possibilities, new diagnostics have been developed on MRX. A "Hodogram" probe, which measures all three components of the fluctuating magnetic field with high time resolution ($\approx$ 40 MHz), and a fine structure probe with pickup coils spaced 1.25 mm apart have been constructed. The hodogram probe has measured electromagnetic fluctuations in the lower hybrid frequency range within the reconnecting current sheet (in contrast to previously detected electrostatic fluctuations which occur outside the current sheet). The fluctuation amplitude correlates with the enhanced resistivity and reconnection rate, and the fluctuations have been identified as obliquely propagating whistler waves. The fine structure probe has a spatial resolution which is less than the electron skin depth ($\approx 2-3$ mm). It has been installed, and is taking data. Details of the electromagnetic fluctuations and new measurements from the fine structure probe will be presented. MRX is jointly supported by DOE, NASA, and NSF.

SH32B-05 1450h

Comparison of Laboratory Measurement of Electromagnetic Waves during Reconnection with Theory, Simulations and Space Observations

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Magnetic reconnection plays an important role in determining the topology of magnetic fields in solar flares, solar wind interactions with Earth magnetosphere, and relaxation processes in laboratory plasmas. A major puzzle of magnetic reconnection concerns why the observed reconnection rates are much faster than predictions by classical theories such as the Sweet-Parker model. Recently new measurements in MRX (Magnetic Reconnection Experiment) have revealed presence of strong electromagnetic waves during fast reconnection in the low-collisionality regime. In this paper, the measured wave characteristics are compared to linear theories based on either simple models (e.g., local and two-fluid models) or more complete models (e.g., global and full kinetic models). Initial assessments suggest that the observed waves are consistent with the so-called Modified Two-Stream Instability driven by large drift speeds compared to the Alfven speed in high-beta plasmas. Comparisons with 3D nonlinear simulations as well as recent measurements by space satellites will be presented. This work is supported by DOE, NASA, and NSF.

URL: http://mrx.pppl.gov

SH32B-06 1505h

The Effect of the Guide Field on the Developement of Turbulence in 3-D Reconnection

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Recent 3-D simulations of magnetic reconnection have shown that the presence of a guide field (a component perpendicular to the reconnection plane) strongly effects the development of turbulence. With no guide field the inflowing electrons become demagnetized inside the current layer, leading to an effective heating that suppresses shear flow instabilities even in the limit of small asymptotic temperature [Zeiler et al., 2001]. Drake et al. (2003) showed that a large guide field magnetizes the electrons and stops this thermalization, allowing the Buneman instability to drive turbulence (in the form of electron holes) at the X-line and along the separatrices. We show that, in fact, quite small values of the guide field are sufficient to keep the electrons magnetized and hence allow the development of turbulence. An examination of the distribution functions at the X-line of a series of 2-D simulations shows a clear transition when the guide field is about one-tenth the asymptotic reconnection field, a result consistent with both analytic arguments and further 3-D simulations. These results imply that electron hole turbulence may be ubiquitous at reconnection sites in nature.