SPA-Solar and Heliospheric Physics

SH11A MCC: 2008 Monday 0800h

Abundance Variations in the Solar Corona, Solar Wind, and Solar Energetic Particles I *(joint with SA)*

Presiding: **R F Wimmer-Schweingruber,** University of Kiel**; J Mazur,** The Aerospace Corporation

SH11A-01 0800h INVITED

Solar Coronal Abundance Variations

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Coronal abundances are found to vary among different coronal structures, within streamers, and along heliocentric heights. Characterizing its variations is essential in understanding the underlying fractionation mechanisms and the coronal origin of the solar wind. We will review recent measurements in solar coronal abundance and its variations with time and among coronal structures. In particular, we will present SOHO observations of abundances in active regions with a broad range of age and activity levels. Results that compare coronal abundances with in-situ measurements will also be reviewed.

SH11A-02 0820h INVITED

Probing Ion Acceleration and Ambient Abundances in Solar Flares with RHESSI

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Protons and heavier ions accelerated in solar flares to energies on the order of 1 MeV or more per nucleon can excite or even disrupt ambient nuclei in the solar atmosphere. These processes result in the emission during the flare of gamma-ray lines of characteristic energies. The ratios between the fluxes of different gamma-ray lines can reveal both the composition of the ambient medium and also the ratio between accelerated protons and alpha particles. Due to the recoil of the excited nuclei, the Doppler profiles of the de-excitation lines can be used to deduce the angular distribution of the accelerated ions as they interact. Accelerated nuclei heavier than helium produce very highly broadened lines from their own de-excitation after encountering ambient nuclei. These broad lines form a pseudo-continuum which, if carefully separated from the continuum due to electron bremsstrahlung, could provide a measure of the fraction of heavy nuclei in the accelerated population. I will review the results from two gamma-ray line flares observed with the Reuven Ramaty High Energy Solar Spectroscopic Imager (RHESSI) on July 23, 2002 and June 17, 2003. These results include 1) the first subarcminute-resolution image of a gamma-ray line in a flare (revealing that the ions interact at a considerable distance from the electron bremsstrahlung site – Hurford et al. 2003, ApJ Letters, in press), 2) the first energy-resolved spectra of the nuclear lines, showing their Doppler profiles (Smith et al. 2003, ibid), 3) significant and unexpected broadening of the positron annihilation line (Share et al. 2003, ibid), 4) a constraint on the photospheric 3He concentration from an analysis of the evolution of the line from neutron capture by hydrogen (Murphy et al. 2003, ibid), and 5) an apparent change in the ambient composition in the middle of the July 23 flare (Shih et al., in preparation).

SH11A-03 0840h INVITED

Solar wind composition measurements during one entire solar cycle

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The Solar Wind Ion Composition Sensors on Ulysses and ACE have provided the most comprehensive set of solar wind elemental composition data to date. Solar wind elemental compositional variations have been observed by these instruments since 1990 and 1997 respectively. All solar wind is observed to be fractionated throughout the entire solar cycle. However, the degree of fractionation varies as a function and time and location throughout the solar cycle. We will review these observations and discuss a theoretical model used to explain these fractionation patterns. We will also discuss the implications of these models on long-term averaged isotopic composition measurements, such as to be provided by Genesis.

SH11A-04 0900h

Charge states and abundances of heavy ions as signatures of interplanetary coronal mass ejections

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Interplanetary Coronal Mass Ejections (ICMEs) are not easy to recognise. Several signatures are used to identify such events: Counterstreaming electrons, magnetic field rotation and fluctuation, low kinetic temperature, etc. However, an individual ICME rarely shows them all, so identification remains a somewhat subjective art form. Composition signatures were long known to provide a useful identifier: An alpha-to-proton ratio of >8% is a sufficient criterion for the presence of an ICME. More recently, a high average Fe charge state was established as another sufficient (but not necessary) signature, as is probably the case for an increased C and O freezing-in temperature. Such signatures are particulary attractive because, unlike kinetic and magnetic ones, they remain largely unchanged throughout the entire heliosphere. Using data obtained with Ulysses-SWICS we evaluate the occurrence rate of composition signatures in ICMEs as identified by their classical signatures. The definition of the appropriate threshold values of these signatures will receive particular attention. Finally, the distribution of ICMEs with and without a compositional signature as a function of heliographic latitude will be evaluated.

SH11A-05 0915h INVITED

Elemental and Isotopic Composition in Impulsive Solar Energetic Particle Events: New Results from ACE

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Impulsive solar energetic particle (SEP) events, in which ion acceleration is thought to be associated with the energy release in solar flares, are characterized by large abundance enhancements of ^{3}He and heavy nuclei. Models proposed to account for these fractionation patterns generally invoke some form of resonant wave-particle interaction to selectively heat and accelerate species with specific charge-to-mass ratios. Due to statistical limitations associated with the relatively low particle intensities in impulsive events, few such events have been studied in which precise abundance measurements could be obtained for a large number of species. However, several impulsive events in August 2002 were sufficiently intense above 10 MeV/nucleon to permit measurements by the Solar Isotope Spectrometer (SIS) on the Advanced Composition Explorer (ACE) of elemental abundances for most elements with atomic number Z$\leq$ 30, as well as isotopic composition determinations for some of the more abundant elements such as Ne and Mg. Rather than having a fractionation pattern in which heavy ion enhancements increase monotonically with increasing Z, as is commonly ascribed to impulsive SEPs, these events exhibit some very significant enhancement differences between nearby elements (e.g., N/C, Ne/O, S/Ar, Fe/Ca) as well as between isotopes of individual elements (e.g., ^{22}Ne/^{20}Ne, ^{26}Mg/^{24}Mg) After reviewing the present understanding of composition in impulsive SEP events, we will present ACE/SIS observations of the August 2002 events, compare with previous observations of several events with unusual fractionation patterns, and discuss the constraints that these data place on models for particle acceleration. This research was supported by NASA at Caltech (under grants NAG5-6912 and NAG5-12929), JPL, and GSFC.

SH11A-06 0935h

Event Fluences of Energetic ^{3}He and ^{4}He: Different Behavior During the Rise and the Maximum of Solar Cycle 23

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The ACE/ULEIS instrument allows us to study the behavior of the ^{3}He/^{4}He ratio at low energies (0.4-2.0 MeV/nuc) in a large number of solar particle events (SEPs). We had previously investigated 27 ^{3}He-enhanced events between ACE launch in 1997 and the end of 1999 [Ho *et al.*, *ApJ.*, 552, 863, 2001]. The event fluences (F) varied by a factor ~30 for both ^{3}He and ^{4}He. They showed a reasonable correlation so that F(^{3}He)/F(^{4}He) lay predominantly within the range 0.1<^{3}He/^{4}He<1.0. We have now added 57 more events for the years 2000-2002. F(^{3}He) still varied by a factor of ~30, but F(^{4}He) now varied by ~300. Remarkably, in the lower range of F(^{4}He), the correlation with F(^{3}He) is about the same as before, but in the upper decade of the range, there is no correlation. Consequently, the ratio of event fluences (F) for the 84 events over the period 1997-2002 covered the range 0.004<^{3}He/^{4}He<20.0, but these ratios do not reflect the above-mentioned structure in the fluences. The data appear as if an additional component of larger ^{4}He events appeared during the maximum of solar activity that was not, however, accompanied by correspondingly larger ^{3}He events. As to why the upper range of F(^{3}He) is limited, we note that most of the events are short-lived (~10-20 hours) whereas the scatter-free transit time to 1 AU for these ions is ~5 hours. Thus the fluence is approximately proportional to the total number of ions released onto the field line to Earth. This suggests to us that there is a limit to the total number of ^{3}He ions in this energy range that can be released in an SEP event.