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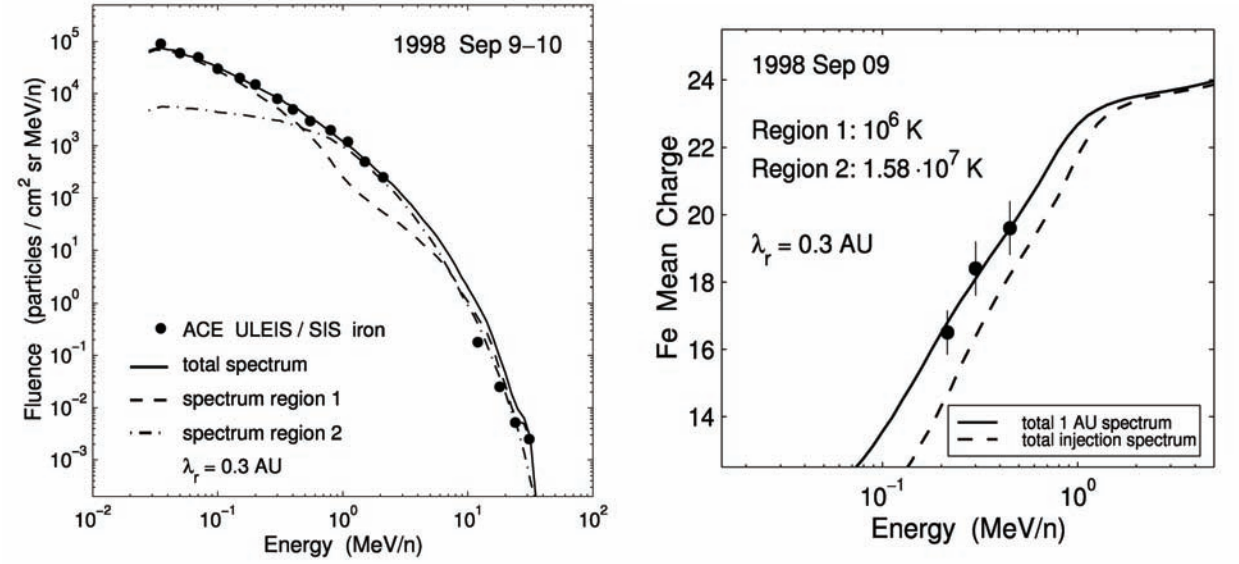
Energy-Dependent Charge States in Impulsive Solar Particle Events: A Clue to the Source Location and Conditions

It has been known for several years that the average charge state of energetic ions in impulsive energetic particle events is substantially higher than in CME-related solar particle events. ACE/SEPICA observations have demonstrated that all impulsive events observed during the time period 1997 to 2000 exhibit a strong increase in the ionic charge states of heavy ions in the energy range between 0.01 and 0.5 MeV/nucleon. This increase starts from a charge state typical for temperatures of 1-2 10^6 K, and is most pronounced for Fe (see ACE News #80 and Klecker et al., Adv. Space Res., 38, 493 – 497, 2006). This suggests that additional ionization of the more energetic ions occurs low in the corona. New model calculations that combine particle acceleration, charge stripping and coronal propagation with transport through interplanetary space (Dröge et al., Ap. J., 645, 1516 – 1524, 2006) can reproduce the observed energy spectra and ionic charge distributions of iron and thus provide constraints on the plasma parameters of the source region.

The figures show data from the impulsive solar energetic particle event of September 9-10, 1998, including fits to the energy spectra (left panel) and to the energy-dependent mean ionic charge state of iron (right panel). In this event the energy spectra and charge-state data are best reproduced by source plasma with an inhomogeneous temperature distribution, including contributions from plasma populations in the low corona with temperatures of 10^6 and 1.6 x 10^7 degrees, respectively. In order for the model to reproduce the observed energy dependence of the charge-state data the source region must be in the dense lower corona, at an altitude of less than 0.2 solar radii (see Klecker et al., Space Sci. Rev., in press, 2007).



Submitted by Berndt Klecker of the Max-Planck-Insitut für extraterrestrische Physik in Garching, Germany, and Eberhard Möbius of the University of New Hampshire. Address comments or questions to berndt.klecker@mpe.mpg.de. For additional ACE News items see http://www.srl.caltech.edu/ACE/ACENews_Archives.html.