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Relativistic Heliospheric Electrons – Source, Energization and Magnetic Topology

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Relativistic Solar Electrons are observed in conjunction with flares or coronal mass ejections (CMEs), however their origin, energization and the underlying topology seem elusive. The existence of non-thermal electrons in the solar atmosphere and along the heliospheric field lines is deduced through emission of electromagnetic waves and via direct in situ measurements. Magnetic reconnection at the flare sites may result in short term fluxes of energetic electrons, however it cannot explain the long-term relativistic fluxes as observed at 1 AU. In contrast to ions, electrons are not observed with MeV energies at the propagating CME shock. Their spectral shapes and the relative timing with respect to imaging and spectrographic observations may identify potential acceleration topology and processes controlling the formation of the (delayed with respect to a timing of a flare or initiation of CME) relativistic electrons. It is conjectured that the acceleration occurs along the stretched, closed coronal field lines, when an anisotropic seed population of low-energy electrons is injected in conjunction with the high frequency coronal radio bursts behind the large CME, as recorded by radioheliographs. This topology allows sufficient time for incubation of the accelerated electrons while the energization proceeds as a bootstrap process due to resonant interaction with oblique whistler waves, which are excited by the seed electrons. The flare serves mainly as a time reference for the electromagnetic emissions, while the CME subsequently opens an access for the relativistic electrons to the interplanetary medium. Power-laws of the energetic electron distributions are shown to be due to statistical interaction allowing discerning of the processes, which result in the observed non-Gaussian distributions, as well as time scales of their evolution.