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The Variable Width and Intensity of Solar Wind Suprathermal Electron Strahl: Scattering Differs with Solar Wind Conditions

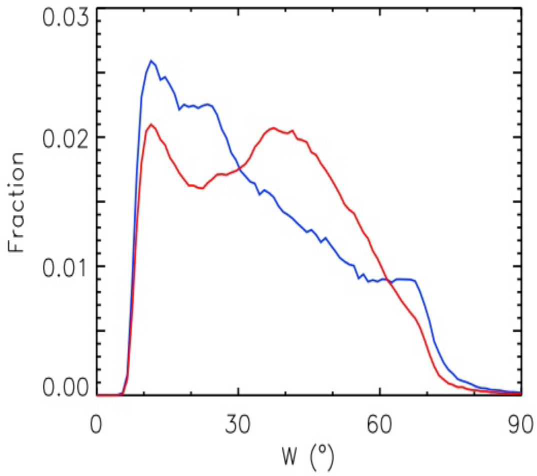

Figure 1

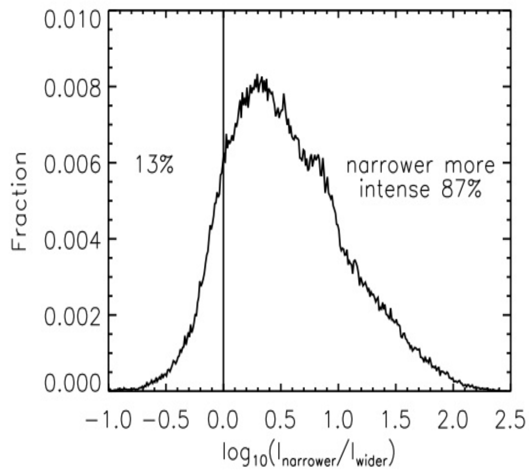

Figure 2

At suprathermal energies (greater than ~70 eV at 1 AU), the interplanetary electron distribution commonly includes an anisotropic magnetic field-aligned feature directed outward from the Sun, referred to as the electron strahl. The strahl width observed at 1 AU is a consequence of competition between focusing due to magnetic moment conservation as the interplanetary field strength weakens with distance from the Sun, and particle scattering that acts to broaden the strahl along its propagation path. In the absence of scattering the strahl width at 1 AU would always be ≤ 1°.

In a unique new large statistical study, we characterized the ACE SWEPAM electron strahl measurements for 1998-2002. We applied a fitting algorithm to the electron pitch angle distributions to identify unidirectional or counter-streaming strahl intervals, and quantify the beam widths and intensities. The algorithmic analysis indicated that an electron strahl was present ≥ 75% of the time, while counter-streaming strahls were indicated ≈10% of the time. Figure 1 shows the distribution of strahl widths at 272 eV, for unidirectional strahls (red), and counter-streaming strahls (blue). The strahl width ranges from 5º to 90º, and, importantly, we find that the strahl cannot be characterized by any typical width. Widths are similar at other suprathermal energies, and we find no systematic broadening or narrowing of the beam with energy. Counter-streaming strahls are most common in coronal mass ejection (CME) solar wind, with similar width distributions observed in both subsets of the data. This study demonstrated that narrow strahls (< 20º) are strongly associated with counter-streaming intervals, as well as with high-speed streams and intervals of low solar wind density as has been previously reported. The broad range of observed widths suggests that more than one scattering mechanism is likely operating in the solar wind, and that different scattering mechanisms may operate with roughly equal probability. The scattering is, however, more effective outside high speed streams or CME related solar wind.

Within counter-streaming intervals, the two strahls can have different widths and intensities, with the most probable ratio of the peak intensities being 2.0. Figure 2 indicates that peak intensity anti-correlates with the beam width, although the integrated fluxes of the two strahls are generally similar, within a factor of 2 for 75% of the counter-streaming periods. Results are consistent with a model in which the integrated strahl flux leaving the corona varies over a limited range, but the degree of strahl beam scattering along the propagation path to 1 AU varies widely. The differences between two concurrent counter-streaming strahls are likely due to different scattering profiles along the two different legs of a closed field line loop, both rooted in the same active region.

For additional details, see Anderson et al., JGR, 117, A04107, 2012 doi:10.1029/2011JA017269. Submitted by Ruth Skoug and John Steinberg, Los Alamos National Laboratory and Brett Anderson, Dartmouth University. Please direct questions or comments to rksoug@lanl.gov. For an archive of earlier ACE News items see http://www.srl.caltech.edu/ACE/ACENews_Archives.html .