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Solar Energetic Electron Events Associated with Hard X-ray Flares

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We investigate 16 solar energetic electron (SEE) events measured by WIND/3DP with a double power-law spectrum and the associated western hard X-ray (HXR) flares measured by RHESSI with good count statistics, from 2002 February to 2016 December. In all 16 cases, the presence of an SEE power-law spectrum extending down to 65 keV at 1 AU implies that the SEE source would be high in the corona, at a heliocentric distance of >1.3 solar radii, while the footpoint or footpoint-like emissions shown in HXR images suggest that the observed HXRs are likely produced mainly by thick target bremsstrahlung processes very low in the corona. We find that in 8 cases (the other 8 cases), the power-law spectral index of HXR-producing electrons, estimated under the relativistic thick-target bremsstrahlung model, is significantly larger than (similar to) the observed high-energy spectral index of SEEs, with a positive correlation. In addition, the estimated number of SEEs is only □10-4 - 10-2 of the estimated number of HXRproducing electrons at energies above 30 keV, but also with a positive correlation. These results suggest that in these cases, SEEs are likely formed by upward-traveling electrons from an acceleration source high in the corona, while their downward-traveling counterparts may undergo a secondary acceleration before producing HXRs via thick-target bremsstrahlung processes. In addition, the associated 3He=4He ratio is positively correlated with the observed high-energy spectral index of SEEs, indicating a possible relation of the 3He ion acceleration with high-energy SEEs