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Sub-second Imaging Observations of Decametre Solar Radio Spikes

Solar radio spikes observed as narrow-bandwidth, sub-second bursts are indicative of rapid, small-scale energy release in the corona, yet localising the site of electron acceleration is a significant challenge. Using millisecond imaging from the LOw Frequency ARray (LOFAR) between 30-45 MHz, we present a statistical analysis of solar radio spikes associated with a coronal mass ejection (CME). At fixed frequencies, individual spikes collectively exhibit superluminal, non-radial source motions across the sky plane, expanding on millisecond timescales. These temporal and spatial characteristics are consistent with the radiation propagating through strongly anisotropic density turbulence such that the apparent source motion traces the unobserved magnetic field of a closed loop structure. Consequently, the observed burst locations do not correspond to the sites of radio emission, indicating that acceleration occurred along the loop leg and CME flank. Disentangling the propagation effects not only offers a unique diagnostic to probe the magnetic field geometry and localise the emission site, but also reveals that the energy release timescales are far shorter and more intense than assumed from observations.

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