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Strongly Under-wound and Near-Radial Magnetic Fields in the Solar Wind

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Observations of the magnetic field orientation in co-rotating rarefaction regions (CRRs) reveal that they are often significantly under-wound compared to the expected Parker spiral, sometimes being almost radial. In particular, CRRs sampled by the Ulysses and Pioneer spacecraft beyond 4 AU from the sun often show average field orientations deviating by more than 30° from the expected Archimedian spiral. These steady state structures last many days, with very little variance in the magnetic field magnitude or direction. The observations are explained by a model combining footpoint motion between fast to slow solar wind streams at the source surface, with the effects of velocity shear across coronal hole boundaries. Using reasonable values for the thickness of and the rate of footpoint transport across the coronal hole boundary, the model reproduces our observations. It also predicts that the magnetic field will evolve asymptotically to a fixed angle and not continue to become more tightly wound with distance.

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