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Implications of Coronal Observations for Solar Wind Acceleration

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The solar magnetic field is key to understanding the Sun and its atmosphere, but the lack of detailed measurements everywhere in the solar atmosphere except for the surface of the Sun has made progress challenging. Instead, our notions of the solar atmosphere are based mainly on density structure observed in white-light images and measurements of solar emission, all without the benefit of magnetic field measurements to provide insight into how the field interacts with the surrounding plasma to produce the observed coronal phenomena. This poor state of knowledge should serve to remind us that exploring the solar atmosphere is still an observational science and that our understanding is expected to evolve with the availability of new observations and new insight.

Starting with unexpected results from radio occultation measurements of the solar corona a decade ago, advances have been made by systematically synthesizing available solar and solar wind observations into a coherent picture of the solar atmosphere, and reporting them at the Solar Wind meetings. Radio occultation measurements of density structure showed that the corona was permeated by ubiquitous small-scale filamentary structures whose larger sizes were directly related to those in white-light images (Solar Wind 8). Quantitative profiles of white-light measurements reinforced what radio occultation measurements revealed earlier, that polar coronal holes extended radially into interplanetary space, thus implying that fast wind emerged from the quiet Sun as well as polar coronal holes (Solar Wind 9). Finally, combining in situ Ulysses solar wind measurements, Yohkoh soft X-ray observations, filamentary density structure of solar eclipse pictures, and coronal magnetic field direction deduced from polarization measurements, demonstrated that the coronal magnetic topology was dominated by open and predominantly radial magnetic field lines (Solar Wind 10).

This paper further unifies this picture, and its purpose is two-fold. The first is to explain why the density structure seen in solar eclipse pictures is not shaped by highly non-radial magnetic fields, as first impressions may suggest, and is, therefore, not in conflict with the preponderance of radial coronal magnetic fields. The second purpose is to discuss how the solar magnetic field, comprising closed fields at the base of the corona, ubiquitous and predominantly radial open fields in the corona, and the polarity reversal forming the heliospheric current sheet, gives rise to the observed variations in plasma properties of the corona and interplanetary space. Of particular importance is the insight into the variations in solar wind acceleration.