Measuring Coronal Energy and Helicity Buildup with SDO/HMI

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Solar eruptions are driven by energy and helicity transported through the photosphere and into the corona. However, the mechanism by which energy and helicity emerge from the solar interior to form the observed coronal structures is poorly understood. SDO/HMI data are the first space-based full-disk vector field observations of the Sun with a near 100% duty cycle and, therefore, represent an unprecedented opportunity to quantify the energy end helicity fluxes through the photosphere. However, because of the SDO satellite's highly inclined geostationary orbit, the relative velocity of the instrument varies by ±3~km/s which introduces major orbital artifacts. We have developed a procedure for mitigating these artifacts and have applied this analysis to AR11084 to produce a cleaned data set. Our analysis procedure is described, in detail, and the results for AR11084 presented. We have also recast the Berger and Field (1984) helicity transport equation in manifestly gauge invariant form and derived the terms quantifying the injection of helicity into the corona by the emergence of closed field, versus helicity injection by the stressing of pre-emerged flux. The plasma velocity fields in the photosphere, necessary for computing energy and helicity fluxes are determined using an upgraded version of DAVE4VM that incorporates the spherical geometry of the solar images. We find that the bulk of the helicity into the corona is injected by twisting motions, and we discuss the implications of our results for understanding solar activity and especially for data-driven modeling of solar eruptions.

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