Three-Dimensional Potential-Field Source-Surface Modeling of the Evolution of Coronal Structures

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White-light images of the solar corona indicate that, during each solar cycle, the global structure of the corona evolves as a function of cycle phase. Building a three-dimensional potential-field source-surface (PFSS) model of the corona, we investigate how the longitude-dependence of coronal structure varies with cycle phase. Using white-light images of the corona from the Mauna Loa Solar Observatory (MLSO) as guidance, we derive the global three-dimensional corona from our model-output as a function of Carrington rotation, focusing on the most recent three solar minima in 1986, 1996, and 2008. Longitude-dependent coronal structures seen in white-light images are reproduced by a linear combination of spherical harmonics combined with a radial boundary condition at the source-surface, taken at 2.5 solar radii. The coefficients of spherical harmonics up to the fifth degree, as well as their phase, are deduced experimentally by comparing model-output with MLSO observations. We find that (i) during typical solar minima (such as 1986, 1996), although the axial dipole dominates, small, time-varying multipole contributions are present when analyzed over a few rotations. In addition, we find that (ii) the unusual minimum in 2008 is multipole-dominated in contrast to the solar minimum corona in 1986 and 1996. (iii) The signature of a quadrupole contribution in the 1996 corona and the further increase of multipole components in the 2008 corona indicate that the departure from dipole at minimum originated during 1996. Further analysis of the present corona is most likely going to indicate that the next solar minimum will be non-dipolar in nature. Our estimates of the variation of multipole contributions as a function of time can be used to constrain models of the three-dimensional solar dynamo.