Space Science Seminar
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Characterizing and Modeling Magnetic Flux Transport in the Sun's Photosphere and Determining Its Impact on the Sunspot Cycle

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Characterization and modeling magnetic flux transport within the surface layers of the Sun are vital to explaining the 11 year sunspot cycle.

I have characterized the differential rotation (DR) and meridional flow (MF) and their variations since 1996 using a cross-correlation technique on magnetograms (maps of the magnetic field at the surface of the Sun). The MF is faster at solar cycle minimum and slower at maximum. Furthermore, the MF speeds that preceded the Solar Cycle 23/24 minimum were ~20% faster than the MF speeds that preceded the prior minimum. This faster MF has been suggested to have caused weaker polar field strengths and thus the subsequent extended solar minimum and an unusually weak cycle 24.

I have modeled surface magnetic flux transport with a model that advects the magnetic flux emerging in sunspots using the near-surface flows. These flows include the axisymmetric DR and MF and the non-axisymmetric cellular convective flows (supergranules), all of which vary in time as indicated by direct observations. At each time step, magnetic maps of the entire Sun are created. I have tested the predictability of this model using daily sunspot area data as sources of new magnetic flux. I found that the evolution of the polar fields can be reliably predicted many years in advance. The model was then used to determine the impact of MF variations on the sunspot cycle. One simulation included a MF that is constant, a second included a MF that has the observed variations in time, and a third included a MF in which the observed variations were exaggerated. The simulations show that the variations in the MF over cycle 23 produce polar fields that are ~20% stronger, rather than weaker. This suggests that the cause of the weak polar fields at the end of Cycle 23 should be attributed to the emergence of fewer active region sources, rather that the variation in the meridional flow.

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