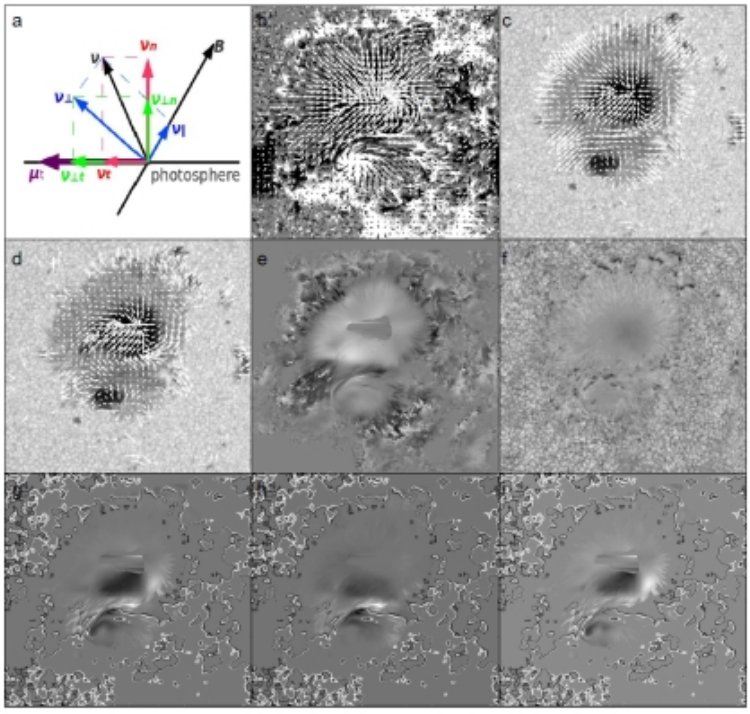
Magnetic Helicity Transported by Flux Emergence and Shuffling Motions in Solar Active Region NOAA 10930

We present a new methodology which can determine magnetic helicity transport by the passage of helical magnetic field lines from the sub-photosphere and the shuffling motions of footpoints of preexisting coronal field lines separately. It is well known that only the velocity component, which is perpendicular to the magnetic field ($v \perp B$), has contributed to the helicity accumulation. Here, we demonstrate that $v \perp B$ can be deduced from a horizontal motion and vector magnetograms under a simple relation of $v_t = \mu_t + (v_n/B_n)B_t$, as suggested by Démoulin & Berger. Then after dividing ($v \perp B$) into two components, as one is tangential and the other is normal to the solar surface, we can determine both terms of helicity transport. Active region NOAA 10930 is analyzed as an example during its solar disk center passage by using data obtained by the Spectropolarimeter and the Narrowband Filter Imager of Solar Optical Telescope on board Hinode. We find that in our calculation the helicity injection by flux emergence and shuffling motions have the same sign. During the period we studied, the main contribution of helicity accumulation comes from the flux emergence effect, while the dynamic transient evolution comes from the shuffling motions effect. Our observational results further indicate that for this active region the apparent rotational motion in the following sunspot is the real shuffling motions on the solar surface.



References: Zhang, Y., Kitai, R., Takizawa, K., 2012, ApJ, 751, Issue 2, id85.

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